CULTURAL BUILT HERITAGE'S TANGIBLE AND INTANGIBLE DIMENSIONS AND DIGITALIZATION CHALLENGES

by

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Abstract

This research is based on the ongoing debate on the strengths and challenges brought about by the so-called ‘digital revolution’ in the field of the conservation of Cultural Built Heritage. Within this framework, this study analyzes how the dynamic relationship between tangible and intangible heritage strongly affects the understanding of a site as cultural heritage. This relationship influences the conservation actions adopted by conservators and decision makers and shapes the values that drive, and impact on, conservation choices.

The complex relationships between tangible and intangible dimensions of cultural heritage have been, until recently, surprisingly underestimated in scientific research. A possible explanation lies in the limited amount of multidimensional and interdisciplinary approaches applied by scholars of different disciplines, often interested in sectorial analysis of either the tangible or the intangible dimensions of cultural built heritage. The research moves in the direction of integrating such dimensions through a comprehensive approach. The project aims at demonstrating that an understanding of the role of intangible dimensions of built heritage can orient the conservation process, moving towards a more inclusive approach based on the respect for different context-based perspectives and interpretations of the cultural dimensions of heritage conservation, preservation and restoration .

The research hypothesis is that digital documentation workflows have a strong potential for integrating different sources of information, based on both qualitative and quantitative analysis, by processing and integrating knowledge about tangible and intangible dimensions of built heritage. The research proposes an enhanced approach, called WikiBIM, which builds on a combination of rapid ethnographic appraisal methods and IT-supported techniques for data acquisition, processing and management.

The research approach is tested on the concrete case of the Loka-hteik-pan temple in Bagan, Myanmar. Conclusions about the effectiveness of the approach highlight the importance of integrating local knowledge, sometimes transmitted only through oral means, in mainstream digital design tools, such as Building Information Modelling (BIM), in order to improve the social, cultural and environmental sustainability of built heritage conservation.

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Executive Summary

Methodology of the research

The research defines a methodology to integrate the concepts of authenticity, participation and sustainability of the conservation processes.

Considering the opportunities of digital documentation tools and web platforms, the research addresses two main clusters of issues:

1. How to document the inner structure of a building and its associated technical aspects?
2. How can experts and local communities collaborate to this process by making conservation processes more inclusive? What are the best modalities for local people to promote the sharing of living heritage associated with the built one?

The loss of skills needed for conservation and the growing shortage of craftsmen and materials in built heritage conservation (Feilden, 1985) is an important factor addressed by this research.

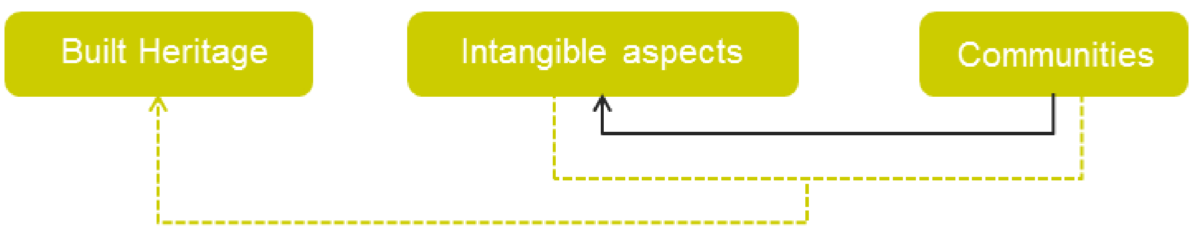

Figure 1 Diagram depicting the connection between intangible aspects and communities for built heritage conservation. Image source: Author.

In articulating the theoretical foundations of the present analysis, the research criticizes the somewhat nostalgic views of the past often attributed to such authors as Heidegger and Ruskin. It stresses the importance of a harmonious evolution in the architectural field, whereby sustainable techniques and constructive systems can be emulated from the past and innovated through the employment of new materials or revisited construction systems. The recovery of the past know-how and of the 'traditional' methods and systems in architecture does not pretend to be the best option. It is meant to provide possible solutions potentially useful for the conservation of shape, materials, potential unity (Price, Talley, Melucco Vaccaro, 1996), colors, values, significance and sustainable features of the cultural built heritage.

The research focuses also on the inclusiveness of conservation processes by testing direct methods (i.e. direct observation, transect walks, participant observation, personal communications, behavioral mapping, etc.) and analyzing the potential role of digital tools. The criteria for the selection of the case study, chosen in a non-Western geographical and social/economic context, included:

- The richness of intangible aspects associated with the built heritage.
- The limited availability of recorded archives providing a solid body of analysis and evidence useful for conservation purposes. The scarcity of (or lack of) written information and documentation that represents a serious challenge to the preservation of built heritage.
- The 'living' features of Bagan built heritage that constitute an important condition for the mobilization of local traditional expertise for conservation activities.
- The vulnerability to natural disasters that provide additional challenges to effective conservation strategies.
- The incidence of important macro-level threats that jeopardize the preservation of built heritage, like the impact of globalization and its challenges in terms of sustainability of the social and economic development of the site. Such threats are increasingly affecting Bagan and make the proposed experimental approach particularly relevant in view of

the challenges faced by the site, extending the scope of the proposed approach from the architectural to the urban scale.

Furthermore, the case of Bagan was significant since it provided:

- A challenging environment for testing digital techniques, tools and workflows of data acquisition and data processing on irregular shapes and complex geometries.
- An ideal case for testing eethnographic methods (REAP analysis) to understand and collect the intangible aspects associated with construction and maintenance of built heritage.
- A socio-economic and cultural context useful for rethinking a West-driven approach towards heritage conservation.

The vision is to collect data relevant to the understanding, execution, learning and diffusion of manual skills and knowledge related to specific craftsmanship and techniques associated with built heritage for the development of an information repository able to grasp, collect and disseminate memory and transmission of building processes. The project also aims at proposing a technical platform based on a participatory approach through a Wiki logic combined with a spatial information system such as BIM.

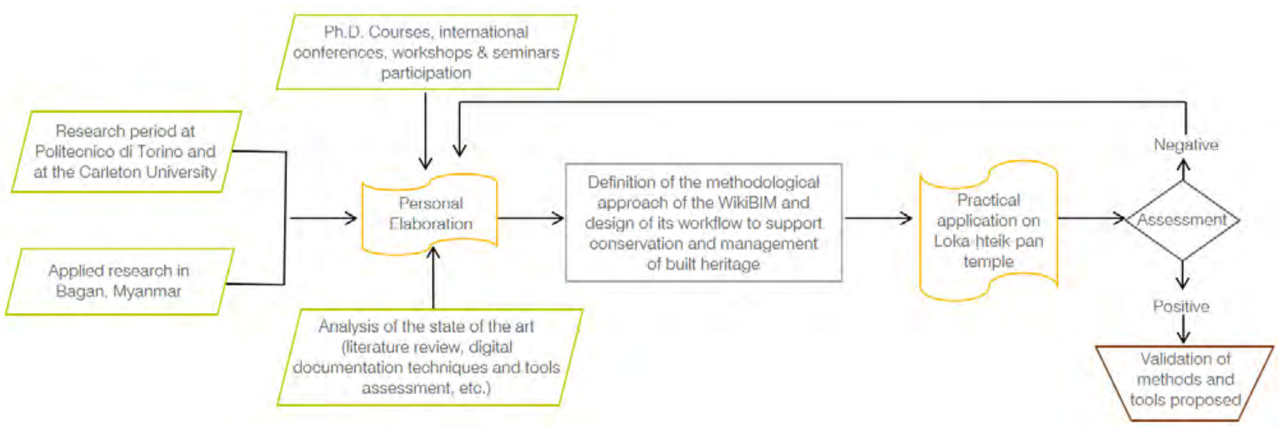

Figure 2 Flowchart representing the research methodology. Image source: Author.

Key findings

In line with these considerations, the key research findings are as follows:

- An analysis of the state of the art of ongoing documentation initiatives to safeguard and promote intangible aspects shows that IT-supported solutions may decisively enhance the effectiveness of conservation approaches through an integration of tangible and intangible aspects of heritage. The results of these analyses evidenced that open web platforms, online geo-data base, and online interactive inventories are mainly employed. The basic principle of these IT-supported applications is 'preservation through access', stressing that effective conservation actions should allow constant open access to users who become engaged actors.
- An updated awareness of the state of the art of on-going projects and initiatives can be potentially used to preserve and promote intangible cultural heritage. The areas of interest of these projects range from cultural heritage promotion to storytelling, built heritage risk preparedness, social cohesion, documentation, inventory and archiving. Intangible elements are embedded in all of these fields and can potentially play a key role if more considered.
- Potential applications for the recognition and documentation of intangible heritage through participatory approaches can be identified by exploiting photo-sharing applications, microblogging websites, social networks based on images and video sharing.
- The complex relationship between documentation and good conservation decision-making needs to be better understood. This awareness derived from the review of the strengths and limitations of the employed recording techniques. These allowed to

analyze the elements that attribute value to Bagan's built heritage and to assess its conditions (state of conservation).

- Participatory approaches to data gathering should be used, so as to gain bottom-up information on both tangible and intangible aspects associated with built structures. The proposed approach tested the effectiveness of the REAP methods and outlined possible strategies to take advantage of the potential of the social networks and web platforms analyzed and assessed. This was tested on the site of Bagan, included in the World Heritage Tentative List since 1996, which presented several challenges in conserving its built structure and its living components.
- The challenges and limitations of digital recording techniques (including laser scanning, digital photography, photogrammetry and electronic distance measurements) and BIM systems applied to built heritage, should be explored. Diverse digital workflows have been tested to capture, generate, visualize and manage a built heritage structure, in this particular case a historic religious building. The research tested the use of BIM on the XII century Loka-hteik-pan temple, in order to show its potential for the conservation of built heritage structures that are usually irregular and unique in each architectural element. This test evidenced that the manual process to reconstruct the geometry of the temple in the AutodeskRevit 2016 BIM software, from the imported point cloud, was very time consuming and costly, showing the challenges posed to this technology by the current lack of automation in modelling historic structures. For instance, in the case of the Loka-hteik-pan temple, components (such as windows, doors, stupas, dintel, etc.,) were created from scratch, since pre-defined components were not suitable for this monument and for many existing historic buildings. Furthermore, it implied several subjective choices in the model making phase, thus affecting model accuracy. The

modelling a Buddhist temple from the XII century evidenced limits and constraints of BIM software to accurately represent such irregular shapes and complex geometries (i.e. walls out of plumb, irregular walls curve, or vaults path, decorative elements, etc.). All of these aspects evidenced the need for more advanced workflows and tools in the modelling of irregular and complex geometries that characterize historic buildings. Regardless, the research verified some advantages of BIM in terms of interoperability and of semantic modelling, since this tool can characterize built heritage structures and document their embedded intangible aspects.

Research conclusions

The research proposes an approach to integrate intangible aspects in heritage conservation actions by exploiting the relevance of traditional local knowledge associated with built heritage.

In applying the research approach, this study constantly questions when technological innovation in heritage recording is relevant for heritage conservation and assesses the possibility of its integration with other methods and tools. The research analyzes both limits and potentialities of digital documentation workflows that employ photogrammetric and laser scanning techniques as well as BIM systems in the modelling phase.

At the same time, the study verifies the opportunities of BIM for built heritage by giving particular attention to its potentialities in terms of semantic characterization.

Furthermore, the research identifies the main benefits of the proposed WikiBIM approach in case of available historical sources and efficient archives as well as in situations of natural emergencies.

The study provides recommendations addressed to an audience of key actors. They include:specialists in the field of heritage conservation and documentation, experts in the heritage field, international organizations (such as the Islamic Educational Scientific and Cultural Organization – ISESCO, the Council of Europe – COE, the United Nations Educational, Scientific and Cultural Organization – UNESCO, International Council of Monuments and Sites and its advisory bodies – IUCN, ICCROM, ICOMOS and its International Scientific Committees such as CIPA Heritage Documentation and ISPRS, etc.), private foundations and Non-Governmental Organizations – NGO (for example the Getty Conservation Institute – GCI, the Aga Khan Trust for Culture, the Fondo per l'Ambiente Italiano – FAI, National Trust, Global Heritage Fund, World Monuments Fund – WMF, etc.), public sector managers, academics and local private stakeholders such as conservators, architects, artisans, masons, craftsmen, etc. involved at different levels in the conservation of the built environment and local development initiatives.

INTRODUCTION

Cultural Built Heritage conservation means much more than preserving a past inheritance. It is a statement about the present, which aims at shaping the future. Social institutions and cultural values mediate the relationships between forms and meanings of any built heritage. As such, the latter are at the same time subject to, and product of, the dynamics of continuity and change that characterize social and cultural transformations.

In this constant change, different interpretations have appeared over time that influenced conservation practices by promoting social and scientific values, rather than aesthetic ones.

The research proposes an approach for recovering social and scientific values, - including skills and know-how embedded in built heritage structures, also intended as *tacit knowledge* (Polanyi, 2009) - so as to re-evaluate them in the present context. Reinterpreting Muratori’s concept of *storia operante* (working history) (Muratori, 1959) and the principles of the *bauforschung* (De Mattia, 2012) in a participatory logic, the potential of ethnographic methods in this process is analyzed.

Hence, the research explores the relevance of alternative approaches to integrate conservation, by placing emphasis on both the role of intangible aspects of cultural built heritage and its associated social meanings and technical aspects. The study addresses such issues by assessing the innovative technological opportunities available for policy makers and practitioners in cultural built heritage conservation.

The thesis argues that alternative digital documentation workflows - based on 3D recording, Spatial Information Systems such as Building Information Modelling (BIM), and web communication platforms - may allow the embodiment of traditional skills that were instrumental in the production of the built heritage and their combination with modern skills by building on the potential of Information and Communication Technologies (ICTs).

Furthermore, such an approach may help bridge the gap between cultural and built heritage conservation, by focusing on the relations between their tangible and intangible dimensions.

This doctoral dissertation is produced in fulfilment of a Ph.D. in cotutelle between the Politecnico di Torino and the Carleton University. The Ph.D. in cotutelle is a doctoral program offered by two academic institutions. In my specific case, such institutions are based in Italy and Canada, respectively.

Within my doctoral studies, I have attended courses in both academic institutions that strengthened my theoretical background, deepened my understanding of the main multidisciplinary orientations in the field of built heritage conservation and allowed me to define and test an innovative research methodology, grounded on the use of digital workflows for heritage enhancement and conservation.

In line with this transnational background, my research combines different contributions by Italian scholars to the debate on built heritage conservation, with North-American approaches to heritage preservation and dissemination.

During the period of study at Carleton University, I had the opportunity to apply and test the analytical and methodological tools developed within my doctoral research for the assessment of several cases in countries other than Italy and Canada. Initiatives of applied research, developed within the Carleton Immersive Media Studio (CIMS), exposed me to conservation practices in different social and cultural contexts, other than the European and North American ones.

More specifically, I had the opportunity to understand, study and deepen approaches to heritage conservation in South-East Asia through fieldwork carried out in the site of Bagan, Myanmar. The case of Bagan resulted particularly interesting in relation to the issues addressed by the thesis, i.e. the recovery and conservation of the intangible aspects associated with a built site. Bagan provided an ideal opportunity to test the proposed approach in an ‘unconventional’ case study, far from a western-driven approach to heritage conservation, and to innovatively adjust western conservation approaches to a local South-Asian environment.

Organization of the research

The research is structured into five main sections. The first one consists of the present introduction, which summarizes the research argument and structure.

The second section provides the conceptualization of the problem and includes three chapters. It establishes a conceptual framework for the value assessment of tangible and intangible heritage. The importance of considering heritage as "*product of multiple strategies and unforeseen agents, accumulated through history"* (Vit-Suzan, 2014), p. 204, is subject of reflections and considerations that explain objectives and goals of the research.

Chapter 1 critically reviews of the theoretical positions of such representative authors in the conservation field including, but not limited to, Jukka Jokilehto, Bernard M. Feilden, Cesare Brandi, Marco Dezzi Bardeschi, Mario Dalla Costa, and Salvatore Settis. It examines the different aims in heritage conservation, by focusing on how the perceptions of temporal dimensions have contributed to the definition of heritage as a social construct. It then takes into account how investments allocated in heritage conservation enhance its social aspects and values, by analyzing the positions expressed by the main international stakeholders in heritage conservation.

The chapter addresses the role of the tangible and intangible aspects and the associated social meanings, scientific aspects, and aesthetic values in the interpretation of new paradigms in the conservation field.

The dynamic relationship between past and future in heritage conservation is analyzed by underscoring that the relation with the past, seen through the lens of built heritage, has brought about a constant change in the goals, purposes, modalities of intervention, actors and focus on conservation processes. In line with these issues, the chapter analyzes the role of the intangible aspects in the redefinition of heritage values and consequently of the conservation modalities and derived possible impacts.

Chapter 2 introduces the topic of Cultural Intangible Heritage. Starting from the analysis of the 2003 UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, the key role of intangible factors in featuring the identity of places, and making heritage conservation actions meaningful, is analyzed. Then, this section clarifies that the focus of the research is limited to the intangible intended both as 'knowledge and practices concerning nature and the universe' and as 'traditional craftsmanship'. These two domains in which intangible dimensions can be manifested, according to the 2003 UNESCO Convention, require in-depth investigation of their potential role in built heritage conservation. Focusing on the Cultural Built Heritage, intangible aspects are intended as knowledge, skills, and know-how associated with building construction phases, assembly of materials, building techniques employed, adaptive systems to local weather conditions, spatial design, decorative elements with different functions (pedagogic, symbolic, functional, structural[1], environmental[2], etc.), building orientation and localization, etc.

Conscious of the elusive nature of the intangible, this section prepares the ground to set up strategies for the documentation of intangible aspects associated with built heritage. These issues are faced by considering how intangible aspects affect built heritage conservation from a technical as well as social and economic point of view.

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[1] For instance the pinnacles used in the Gothic cathedrals, which had the function to verticalize the loads.

[2] Examples can be found worldwide. In the Middle East, characterized by hot and dry temperatures, smart ventilation systems were developed, like wind towers, used to ventilate the room below them or by badger (splits in the wall that allow the wind to be funneled down into a room, refreshing it with natural ventilation).

Chapter 3 stresses the strong relationship among conservation and sustainability. The pivotal role of intangible knowledge and skills associated with the maintenance and conservation of built heritage is stressed by underlining its relevance in term of social and cultural sustainability.

Within this framework, the reasons to document intangible aspects associated with built heritage are presented and argued by stressing their connection with innovation in the architectural field and economic, environmental, cultural and social development. Furthermore, knowledge, capabilities, and skills still existing and perpetuated in local territories are fundamental for the resilience of local communities while coping with gentrification effects. Finally, possible methodologies for the documentation of the intangible aspects associated with built heritage are outlined. These include on-field direct investigations (for example, through the use of Rapid Ethnographic Assessment Procedures, REAP) as well as alternative strategies employing the support of social media and digital platforms to gain information by means of a bottom-up logic.

The third section addresses the research approach within the framework of digitalization challenges for cultural heritage. It explores how the Digital Revolution can provide innovative approaches and solutions to the documentation, conservation and management of tangible and intangible dimensions of built heritage. This section, composed of two chapters, analyzes initiatives, web-based applications and digital tools aimed at the identification and safeguard of intangible aspects embedded in cultural built heritage.

Chapter 4 pays particular attention to the analysis of the situations and/or contexts in which ICT solutions provide effective support for heritage documentation, design, management and monitoring. Within this study, the potential of Information Technology (IT) supported recording techniques and web platforms which enable interactions between information providers, heritage specialists, and project managers, is discussed. Then, this section analyzes the state of the art of Spatial Information Systems and their most relevant applications in the built heritage field. Focusing on the BIM fields of applications, advantages and further developments in the domain of built heritage are presented to understand how BIM systems are affecting built heritage conservation workflows. On one hand, these reflections allow to identify challenges related to the constraints of 3D modelling parametric software, to time-consuming aspects in the model development phase, in terms of training and workflow change, and to lack of international conventions on Level of Detail (LoD) and on model uses. On the other hand, the analysis of the state of the art emphasizes the potentials of the BIM as an integrated tool in support of the organic and integrated management and conservation of built structures.

Chapter 5 defines the theoretical framework for the development of participatory documentation approaches and spatial information systems to effectively manage information gathered through bottom-up logics.

Therefore, this section explores the knowledge management requirements to define a Wiki approach for participative documentation of built heritage sites. The outlined participatory documentation of built heritage sites considers and illustrates the limits and potentials of the proposed approach in terms of openness and accessibility.

After that, potential digital workflows, usability and effectiveness of BIM systems in the management of this information are illustrated in order to justify the employment and the choice of AutoDesk Revit 2016 software.

Then, the chapter explains how the Wiki approach aims at gathering crowdsourced information about various dimensions of Cultural Built Heritage, allowing at the same time to elaborate such information in a Building Information Model.

The fourth section applies the research approach by testing it on an evidence-based project, thus questioning opportunities, challenges, limits and future perspectives of the research topic. The section is composed of three chapters. **Chapter 6** introduces the geographical and territorial and historical framework as well as the socio-cultural and economic context of the selected site of Bagan, Myanmar. This site provides an interesting case study with conservation dynamics and challenges that are quite different from those typically addressed in a Western context. Testing the relative strengths of various conservation approaches, the research stresses that different conservation paradigms can be validated by community involvement. In addition, the case of Bagan is relevant for the research as it shows that local communities can provide useful information related to historical buildings, their components, construction processes and materials (i.e. bricks fabrication processes of the masonry structures of the monuments) that are not recorded and are only orally transmitted. In this living religious heritage site, building techniques and construction systems are scarcely documented in any archives. Conservation efforts thus rely almost exclusively on the knowledge and skills transmitted by local workers and craftsmen as the keepers of such intangible common good, relevant for the maintenance, recovery and compatible conservation of these structures.

Furthermore, the choice of a site where these values and meanings are still strongly rooted in the community makes conservation matters even more relevant, because it opens up possibilities and opportunities based on an active interest and willingness of engagement and participation by local actors in the choices pertinent to the conservation-design phase.

Chapter 7 deals with the strategies adopted for the documentation of the tangible and intangible aspects of the Loka-hteik-pan temple in order to support integrated conservation, management and local development actions. The monument was selected because it is a representative example of the meanings and values of constructive elements deployed in the Bagan area. For instance, the use of bricks in the temple is relevant for many reasons, spanning from the religious significance of the building materials [bricks were donated by the neighboring villages as a form of devotional practice (Falconer et al., 1998)] to their functionality for constructive solutions (i.e. the thickness of the joints, with thinner exterior joints and thicker joints in the core of the wall, so as to allow to protect the mortar from heavy rains during the monsoon) and mechanical properties (i.e. primary bricks components, bricks cooking procedures and temperatures of the original bricks compared to current ones)[3]. Hence, the documentation processes proposed for the Loka-hteik-pan temple covered a whole range of connotations, both drawn from expert assessments (in a ‘conventional’ conservation perspective) and as perceived by local communities and stakeholders, of such variables as constructive techniques, materials, spatial design and architectural elements.

[3] Other examples of integration between intangible local knowledge and tangible built structures are the meaning of the design, inscriptions, decorations (stucco and plaster works, wall paintings, etc.) and shape of the religious buildings that are the consequence of each donor (Falconer et al., 1998).

Starting from recording geometry and shape of the temple, technology-supported analyses were tested. These included image based and non-image based techniques and tools. In the data acquisition as well as in data processing phase the tools to gain the data and the software to process the information were selected according to skills required, costs, time, results' accuracy and final requirements. Considered aspects in the documentation included also information about the material composition and physical aspects of building elements, developed through non-destructive and destructive techniques.

In order to collect information from local informants and with their active engagement and participation, REAP techniques were employed. More specifically, the REAP methodology carried on in Bagan included analysis that generated and tested information from different sources and subsequently "triangulated" it (E. Avrami, Mason, & De La Torre, 2000), p. 37, for a comprehensive understanding of the temple, its components and its surrounding context. Information collected was processed, cross-checked (triangulated) and employed to develop informed conservation proposals that took into account local values, material compatibility and the construction systems originally employed.

An additional step consisted in structuring an efficient method of organization of the information collected by integrating it within a Spatial Information System such as the BIM employing the Autodesk Revit 2016 software. As illustrated in **Chapter 8**, all this information was used to develop and characterize the BIM model of the temple. Metric survey was used to develop the geometric modelling of the BIM while information on materials, techniques, conservation stakeholders, etc., have been used to characterize the model. The result of such integration is a reliable platform of embodied knowledge that enables communities, specialists and other stakeholders to learn and at the same time act, make judgments and contribute to the conservation process. The BIM developed according to the proposed workflow, could effectively support the documentation, management and dissemination of cultural information related to intangible aspects and tacit knowledge associated with historic buildings, such as methods of construction, materials selection, maintenance strategies, etc. A further step consisted in identifying and outlining alternative ways to collect information obtained through the REAP methodology by adopting a Wiki logic supported by a web-based platform and social networks. In this way, it was outlined an approach that can take advantage of the availability of mobile communication devices, access to internet and level of user-friendliness of local communities with such communication systems.

The fifth and last section outlines the **Conclusions** of the research and assesses the flexibility, effectiveness and replicability of the proposed approach. This section highlights the problematic issues that need to be addressed in planning any conservation project, by proposing methods and approaches to preserve embedded and symbolized values of built heritage sites. The results of the adopted research workflow for context-sensitive solutions, consistent with a comprehensive approach to cultural built heritage conservation and at the same time grounded on the complex and diverse range of local knowledge and skills, are assessed. Considerations on the potential applications and opportunities of the designed approach are illustrated focusing on heritage sites affected by natural disasters, such as Bagan.

The conclusions also reflect on the potentials, limitations and constraints of digital documentation and visualization technologies in the built heritage field, highlighting the importance of a theoretical framework defining the scope of what should be achieved through its deployment. Methodological challenges and technical constraints of the Autodesk Revit 2016 software, limits related to the social challenges and the economic feasibility of the proposed approach as well as further perspectives are outlined. This section also stresses the awareness that the digital technologies used in this study cannot be considered thorough solutions since they provided some tentative answers to the research questions, opening up new areas of inquiry and investigation. Therefore, future perspectives and recommendations of the BIM systems in their application to the built heritage are mentioned.

The core argument of the thesis

The thesis proposes an alternative point of view for conservators that recognizes the important role of local knowledge on techniques and built systems for planning and designing sustainable conservation actions.

Recognizing the relevance of a socio-technical approach that combines, at the same time, humanities and hard sciences, as common in the architectural field, the research outlines possible solutions to the following issues:

1. How to bridge the knowledge of the past with the vision of the future in the architectural field? Which is the role of cultural built heritage in this challenge?
2. How can alternative conservation strategies brew humanities and socio-technic innovation scenarios through the support of new technologies?

Considering the pace of technological innovation and how it is affecting cultural heritage documentation this study addresses its strengths and possible contribution to local development by making community and built environment more resilient. New tools have appeared in the last decades including: 3D scanning, rapid prototyping, high dynamic range spherical and infra-red imagery, affordable drone photography, computer rendering in multiple dimensions and integrated spatial information systems. The potential of these tools gives increasing opportunities in support of built heritage contexts, in the face of the threats caused by socio-economic dynamics (globalization, gentrification, pressures determined by tourism development in poor and destitute communities), and by natural causes (catastrophic events, such as earthquakes that recently highly affected cultural heritage places in Italy and Myanmar).

Opportunities provided by the digital revolution include not only their contribution to the physical conservation of tangible heritage assets but also their role for safeguarding intangible aspects that play a crucial role for the growth of a place. To identify measures and document intangible values associated with built heritage the research explores new areas. Actors who have access to intangible values and knowledge are taken into consideration when presenting strategies, techniques, and tools used in other fields such as anthropology, ethnography, sociology and informatics.

The research argues in favor of an integration of traditional approaches and tools from different fields and disciplines. The combination and employment of methods and tools from different disciplines provide an interdisciplinary approach to heritage conservation in the attempt of making it relevant to the society.

The research stems from the recognition that organizations specialized in the field of conservation and management of built heritage resources, despite their technical expertise, often fail to gather and organize documentation in a comprehensive and organic manner (in terms of technical solutions, institutional capacity, financial and social resources, etc.) so as to meet the needs of effective conservation initiatives. Hence, the research proposes a comprehensive approach to:

- The design and implementation of informed and participatory conservation actions;
- The increase of social involvement and engagement in heritage conservation;
- The support to sustainable forms of local development through the recovery of the skills, know-how and generally the productive sector, including small medium enterprises and individual professionals (i.e. bricks and plaster producers, local

craftsmen, wood manufactures, workmen, masons, etc.) associated with built heritage conservation;

- The improvement of the management of heritage sites, in terms of both effectiveness and efficiency.

Considering the constant changes of heritage values, the proposed approach suggests a method for the integration of expert advice provided by heritage specialists and criteria and opinions expressed by local communities and stakeholders, as well as other experts. The research has two objectives: to promote heritage engagement by involving communities in heritage choices; and to identify and test rigorous modalities for taking into account local knowledge. Both objectives aim to inform interventions on the basis of a thorough understanding of the local context, as a critical factor for the (socially and culturally) sustainable conservation of built heritage.

From the theoretical point of view, the research methodology reflects on 'elitist' approaches in the built heritage conservation debate. The research evidences that the current historic context manifested the limits of this kind of top-down approaches where criteria and modalities of intervention on damaged or collapsed built sites – as in the case of the destructions caused by the last seismic events in Bagan, Myanmar[4] or in central Italy[5] – are imposed by a restricted number of theorists and specialists without any forms of consultation on the real needs of the 'final users'[6] of these buildings to be restored, reconstructed or retrofitted.

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[4] On August 24, 2016, an earthquake with 6.8 magnitude struck central Myanmar strongly damaging the archaeological site of Bagan (BBC News, n.d.). According to the local department of Archaeology the damaged monuments are 453 out of 3658.

[5] In August 24, 2016, an earthquake with 6.2 magnitude struck the Italian territory 100 km north-east of Rome. The losses in terms of human lives and built heritage were huge. The earthquake, with the epicentre about 4km north-east of Norcia, affected, the Lazio, Marche, Umbria and Abruzzo regions, destroying entire historic towns and villages, such as Amatrice (BBC News, 2016).

[6] An example consists in the Italian debate after the August 2016 earthquake that proposed reconstruction *com'era dov'era*, retrofitting with anti-seismic solution, new edification etc., without consulting local stakeholders and failing to listen to the real needs

Therefore, the research tested the ethnographic[7] methods as possible approaches, to empower communities in the conservation choices.

From the technical point of view, the innovative aspect of this study consists in creative uses of digital technologies that can potentially translate the theoretical assumptions of the research into operational routines and tools that can be applied in everyday conservation practice. Exploring integration among digital recording techniques[8], indirect[9] and direct[10] researches and surveys and BIM applications, the proposed approach aims at improving interaction between citizens, policy-makers as well as practitioners and specialists involved in conservation processes.

Further, the research explores the potential of the concept of Internet of Things (IoT)[11] (the extension of Internet to the world of material objects) in built heritage knowledge. Within this framework, the research challenges consist in testing workflows and outline strategies to identify the intangible aspects associated with tangible heritage objects. The application of an Internet of Things logic[12] can provide, for example, information on how an object or a building has been realized, with which techniques, by whom and with what skills and tools. This information can then be collected in a BIM model that provides a

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and requirements of the potential inhabitants. Similar situations can be found in the Bagan case where worshippers of the religious buildings are not consulted, thus employing the conservation and restoration choices oriented by west-driven approaches.

[7] By ethnography it is meant both a process of analysis and its product, i.e. a text. Ethnography as process is based on fieldwork and the so called participant observation, i.e. a method of data collection used in qualitative research in the social sciences. Ethnography as product consists in the ethnographic writings produced by anthropologists and other social scientists who use ethnographic methods (Agar, 1980).

[8] Including photogrammetry, terrestrial laser scanning, total station and digital photography.

[9] Indirect researches consisted in the study of historical and archival materials and of demographic and socio-economic data.

[10] Direct methods included on-the-field survey and interaction with local stakeholders and actors. The information collected ranged from oral and audio-visual records to behavioural observations.

[11] This definition mainly used in the IT field indicates the possibility to *"make 'things' […] part of the Internet environment."* (Buyya & Dastjerdi, 2016), p. xxi. This opens up to innovative types of interaction between things (intended as a generic set of entities including, for example, building components) and humans. The terms Internet of Things was firstly used by Kevin Ashton, in 1999. The English engineer explained that 'things' aspects as well as the interaction modalities needed to be reconsidered according to the Internet development and computing innovations (Buyya & Dastjerdi, 2016).

[12] According to the American business and technology journalist and writer Samuel Greengard, the opportunities offered by the Internet of Things are huge, ranging from *"[…] a telescope and a microscope into the one invisible world between people, […] and physical objects. […] with Internet connectivity it's suddenly possible not only to track the objects and collect new types of data but also combine these data to generate a greater level of information and knowledge."* (Greengard, 2015), p. xiv.

3D semantic database for informed management, repair, conservation, restoration, design as well as monitoring actions.

These aims are addressed in the research by producing an evidence-based project, testing opportunities of the designed WikiBIM approach. It consists in the design of a geometric and semantic database of a historic architectural object and its embedded social, technical and cultural values gathered also through participatory approaches. The designed epistemic object produces several operational outputs that can contribute to the conservation and management of built heritage. These can be grouped as follows:

- The WikiBIM approach is very relevant in case of lack of written archives or whenever these have been damaged or lost. In case of existing archives, it is useful to collect updated information on the current socio-cultural values of a building and more generally to integrate the archival available data.
- As regards the promotion of heritage engagement, this approach is relevant to develop updated and shared value assessment of built structures. It allows recognizing current and potential or unexpressed values of heritage structures, by promoting understanding of, and participation in, heritage structures conservation at the same time.
- The proposed approach provides analytical instruments to address critical policy choices, related to what to conserve and how to do it (through more efficient approaches, either traditional or new ones). In order to achieve this outcome, the approach follows a methodological path that prioritizes what to document and identifies unconventional sources of information, for example by engaging key informants who can supply data on both the tangible and intangible dimensions of built heritage.

The analytical framework of the research is consistent with the orientations and principles adopted by the United Nations (United Nations, 2015a), European Union (European Commission, n.d.) and World Bank (World Bank Group, 2016) which underscore several changes that are re-shaping the ways of living, moving, producing and working. These include demographic dynamics, climate change, migrations, new ways of production that are designing new challenges, threats and opportunities that are also affecting the architectural and cultural heritage fields.

Within the framework of these *global challenges*, the research proposes an integrated approach to the cultural built heritage conservation issues, employing an interdisciplinary approach involving humanities, technologies and social sciences.

An initial overview of the conceptual framework

The research stems from concerns about the modalities and scope of heritage conservation, its role in current social contexts and its relevance in terms of sustainable development and inclusive growth. The thesis proposes and tests on the ground a methodology to preserve, integrate and communicate the memory of the tangible as well as intangible aspects associated with Cultural Built Heritage, such as the knowledge and skills associated with craftsmanship in the architectural field. Therefore, the research studies the combination of digital workflows and anthropological investigations to carry out a comprehensive "progetto di conoscenza" (knowledge project) (Dalla Costa, 2000) to support the knowledge of *"[...] what is important and understanding how that importance is vulnerable to loss."* (Matero, 2003), p. viii. In this process, intangible aspects play a key role in conservation processes. They consist of knowledge, skills, beliefs, ideals, values, schemata and mental models which are deeply ingrained in society and are vulnerable to oblivion and manipulation (Vit-Suzan, 2014), even if their resilience is often taken for granted. Although such knowledge is used by all people, key actors in the preservation process are not necessarily able to easily articulate it (Vit-Suzan, 2014). While difficult to articulate, this cognitive dimension shapes the way heritage is perceived.

A key organizing principle of the proposed approach consists in the establishment of information-enriched environments developed by digital means. Such spaces aim at engaging, promoting and safeguarding traditional knowledge associated with built heritage, in planning and carrying out conservation actions. The proposed approach is designed to expand into a comprehensive information repository so as to enable to capture, preserve and make available to interested stakeholders the intangible dimensions of artisanal design and production processes that would be relevant to future conservation initiatives.

The objective of the research is the development of a coherent model that integrates both the tangible and the intangible dimensions of cultural built heritage combining IT-supported techniques, traditional conservation methods and innovative approaches based on participatory assessment methodologies.

Figure 1 The metaphoric depiction of traditional knowledge is here represented by the mythological figure of Hephaestus, god of the art related to engineering, sculpture and iron making according to Greek mythology. Hephaestus was worshipped in all the Greek cities (particularly in Athens) known for their activities related to craftsmanship. Image source: (Piroshow, n.d.).

In order to meet this objective, the research analyzes in depth the role and possible integration of a range of information and data sources, like archives, web platforms, databases, pointclouds, measured drawings, oral information and 3D modelling systems, by conceptualizing their contribution to the conservation and management of cultural built heritage through the traditional knowledge associated with it.

Such knowledge, threatened by the

ongoing globalization processes, can play a key role in sustainable[13] conservation supporting local development and contributing to making communities and settlements more resilient. Such investigation, questioning the value of traditional architectural knowledge and craftsmanship in a mechanical quantitative society (Sennett, 2008), is consistent with international policy frameworks, like the UNESCO Operational Guidelines for the Implementation of the World Heritage Convention (UNESCO, 2016), the Sustainable Development Goals enshrined in the 2030 Agenda (United Nations, 2015b) and the European Programs 2014 – 2020.

Through a Gestaltic approach the research considers the different elements that contribute to the unique features of Built Heritage. Starting from the tangible aspects of a heritage building, the research aims at identifying the configuration of the different elements that originate the harmony and the potential unity, according to Cesare Brandi's theories, of a heritage site. Indeed, the Gestalt theories underscore that the combination of different elements – consisting in the architectural field of material and constructive techniques, decorative apparatus, cultural, historic, social and religious values, architectural, natural and geographical features – generates the significance of a site. In line with this approach, the focus is on the intangible aspects associated with materials and constructive techniques employed, in order to re-evocate the relation between built heritage (for instance the Loka-hteik-pan Buddhist temple, in the site of Bagan), intangible aspects (for example the knowledge and skills related to brick masonry structures), and the economic relations at play within local communities (local workers and craftsmen in charge of maintenance and repairing).

[13] The term 'sustainable' is here intended as social, economic and cultural sustainability of the conservation process.

More specifically, by recovering the Nara document[14] recognizing the value of the continuity of intangible heritage (Jerome, 2008), p.4, the research addresses the issue of the protection of traditional knowledge related to built architecture. However, the safeguarding of such knowledge is not considered as a value per se; the research rather focuses on the interlinkages between social inclusion, the involvement and engagement of the keepers of this knowledge within conservation projects, and the ultimate effectiveness, sustainability, and relevance of conservation interventions[15].

Hence, particular consideration is paid to understanding the openness and accessibility of digital technologies and how current models of public participation can be improved to gather information related to the intangible aspects of built heritage. This framework addresses the issue of the sources and management of information. More specifically, the processing of information from different formats (i.e. from personal communication, texts, links, charts) is defined and tested in a practical case[16].

Since digital documentation techniques (such as photogrammetry, laser scanning, total station, digital photography, etc.) usually acquire information only related to the (interior and exterior) surfaces of the recorded structures/objects, the proposed approach outlines a more comprehensive methodology aimed at gathering information also on the inner structure of a building. The experience of the *bauforschung*[17] is relevant in this regard.

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[14] In 1994, as consequence of the Nara Conference on authenticity in relation to the World Heritage Convention, held in Nara, Japan, the Nara document on authenticity was developed. The document stresses the attention in exploring and respecting the expression of cultural diversity worldwide. The document intends diversity including several areas, ranging from monuments and sites through cultural landscapes and intangible cultural heritage (UNESCO, 1994).

[15] This approach finds inspiration in several scholars such as Frank Matero, who asserted that *"Conservation is predicated on the belief that memory, knowledge, and experience are tied to cultural constructs, especially material culture".* (Matero, 2003), p. vii.

[16] The practical application considers that *"Currently, crowdsourcing in cultural heritage is mostly focused on using the capacity of interested publics to transform existing content from one format to another, and exploring the 'wisdom of crowds' through crowd-curation".* (Ridege, 2014), p.8.

[17] *Bauforschung* literally means scientific research/investigation on construction. It is a scientific method to study and analyze historic architecture. This method integrates concepts of archaeology and architecture in analyzing and understanding existing architectures. The term *bauforschung* was coined by the Russian-born archaeologist Armin Gerkan (Schuller, 2002) in 1924 in his article "*Die gegenwartige Lage der archäologischen Bauforschung in Deutschland*" (De Mattia, 2012). This scientific method allows to perform

A documentation based on the *bauforschung* approach allows the understanding of a historic architecture through the reconstruction of the building processes and techniques integrating philological (such as archival research and comparisons of types and morphologies) and scientific (i.e. excavations and surveys) analysis (De Mattia, 2012). This method, developed within the positivistic framework of the end of the XIX and the beginning of the XX century, integrates philology, archaeology, and architecture in the documentation of historic structures generating a solid base of scientific and concrete information for the development of conservation processes as well as monitoring and management actions.

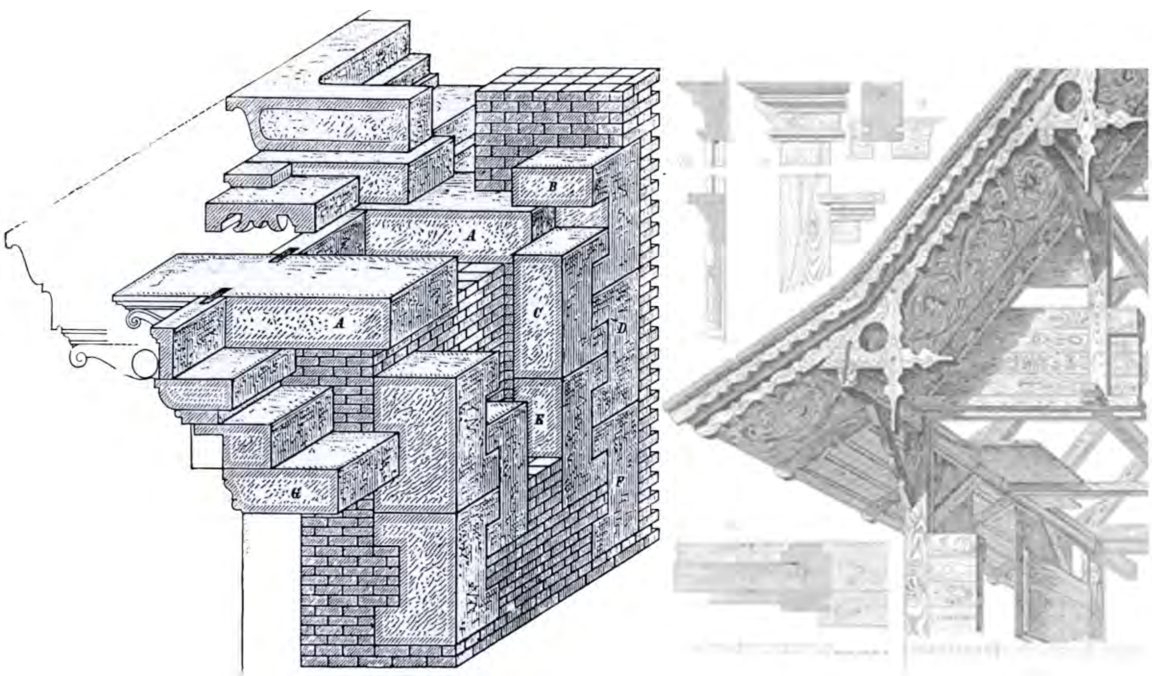

Figure 2 Example of building analysis based on the bauforschung concept, which literally means scientific research/investigation on construction, an approach that implies a scientific and analytic study of the architecture to understand technical and constructive aspects of a building. On the left decorative moulding of Strozzi Palace, Florence, image source: Mario Dalla Costa (Dalla Costa,

complex analyses like stratigraphical exacavation, surveys, graphical rendering, data collection and interpretation, development of reconstruction hypotheisis and of conservation/reconstruction plans of historic architectures (De Mattia, 2012). These analyses can be carried out by professional profiles such as architects and archaeologists with an in-depth knowledge of history of architecture, historic constructions techniques, philology, epigraphy, archaeology and design, just to mention some. The combination of all these disciplines is required to perform researches on historic structures (De Mattia, 2012).

2000), p. 25. On the right wooden roof of a private residence, image source: Knut Stegmann (Knut Stegmann, n.d.).

The *bauforschung* proposes a full understanding of a building and its values, ensuring the dissemination of its message. Fundamental in the *bauforschung* are the survey parameters and the deduced representation (in 2D, or 3D) at the different scales as well as the history of architecture, history of construction, constructive techniques of ancient architecture, notions of geotechnics and topography.

Recalling the *bauforschung* approach, the proposed methodology, supported by the opportunities of semantic 3D modelling offered by BIM systems, is able to document how assemblies and details (e.g. the masonry of bearing walls, vaults, etc.) are constructed, despite some constraints and limitations still posed by the software functions[18]. This is fundamental for a full understanding of a building and its values, ensuring the dissemination of its structural, mechanical and energy savings solutions as well as the meanings associated with the decorative apparatus. This concept has been also stressed by such scholars as the archaeologist Fiorelli – who designed a *'rebours'* process aimed at understanding the whole constructive process and designing choices of a site[19] - and Marco Dezzi Bardeschi who underlined the importance of a survey of the geometrical as well as material features of a building for a full understanding of its pathologies, structural elements and construction techniques (Dezzi Bardeschi & Gioeni, 2004).

[18] Indeed, the BIM systems have been designed for new constructions. This presents some limitations when applied to an existing structure, usually irregular and featured by the unicity of its components.
[19] Giuseppe Fiorelli (1823 – 1896), even if graduated in Law, worked in the archaeological sector in Naples and in the nearby areas (Pompei in particular). Within the recently established Reign of Italy, he performed important institutional roles (Vice-president of the Commission of the Naples monuments, member of the Council for the Arts in the Reign of Italy, President of the Commission for the preparation of the Law on the Conservation of Artistic Masterpieces and Antiquities, Professor of Archaeology at the University of Naples, Senator of the Reign of Italy) (Kannes, 1997). Already in the last decades of the XIX century, he stressed that, for a perfect understanding of a monument or a site, it is necessary to grasp the mental process that designed and produced it. Hence, it is significant to re-make the creative process of the people who made it (Dezzi Bardeschi & Gioeni, 2004). In his career, Fiorelli pursued the aim of developing policies of openness toward foreign scholars and stressing the State responsibility in the dissemination and communication of the technical data of the archaeological sites (Kannes, 1997).

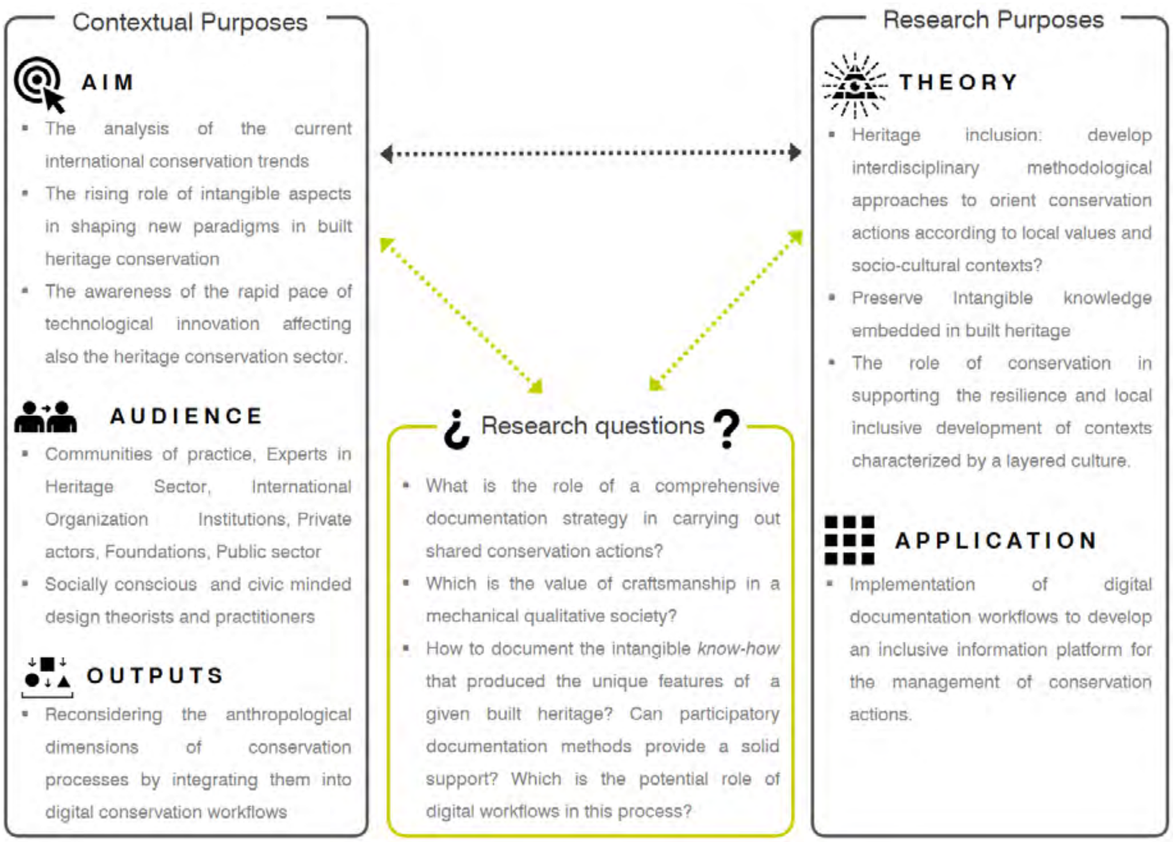

Figure 3 Research main issues. Image source: Author.

The relevance of cultural built heritage conservation: memory of the past, light of the future

The conservation of cultural built heritage deals with the coexistence of different temporal dimensions. While it operates in the present, it negotiates values and meanings from the past in order to make them available in the future. The concept of coexistence of past, present, and future in built heritage can be symbolized by a masterpiece of Christian iconography: the Veronica veil, an allegorical symbol of memory, past and future[20].

[20] Indeed, the Veronica veil symbolizes the death of Christ and consequently the memory of his martyrium. At the same time, it is an icon of Christ's resurrection and therefore an image of the future. Federica Goffi explains in depth this concept when she notes that: *"Veronica's cloth was not just perceived as the memory of Christ's likeness but also an epiphany of his future presence"* (Goffi, 2013) p. 57.

The myth of the ship of Theseus (Lerner, 2016)[21], contained in Plutarch's *Lives***,** exemplifies the complex relationship between continuity and discontinuity in the conservation of historic architectures. Indeed, it opens up the issue of the persistence of the original identity for any entity, in this case, a ship whose components are inevitably bound to deteriorate, thus requiring restoration. The ship, that can be seen as a metaphor of cultural built heritage, well illustrates the shifts in meanings, due to the changing historical, social and economic contexts that affect a structure, influencing the changes brought about by its conservation.

Figure 4 The representation of the Veronica veil, an allegorical symbol of memory, past, and future. Il Velo della Veronica. Author: Pontormo, 1515. Technique, affresco. Dimensions, 307 × 413 cm. Location, Cappella dei Papi, Firenze. Image source: ("Il velo della Veronica," n.d.).

[21] According to the tradition, the ship on which the mythical greek hero Theseus travelled was kept intact, by substituting its wooden parts deteriorated over time, until all the parts used to build it were eventually replaced, although the ship had kept exactly its original shape (Dryden, n.d.).

Henceforth, how are these multiple temporal dimensions and the connected socio-cultural aspects managed for the conservation of built heritage? According to which parameters is conservation convenient and meaningful?

If any intervention of conservation implies, to some extent, the deployment of techniques that impact on the original identity of cultural built heritage, what are the main motivations of heritage conservation, and how do they guide and orient action? The coexistence of different temporal dimensions and the tension between continuity and discontinuity in conservation practices are critical elements for the definition of conservation policies in the domain of cultural built heritage. Not only shifting values and continued negotiations of social and cultural meanings among different stakeholders shape the social dimensions of the conservation of heritage. They also influence, as I argue in this research, the technical dimensions of conservation. The integration between social and technical dimensions of the conservation of cultural built heritage is the result of a delicate assessment of the theoretical foundations and the practical implications of a comprehensive approach to conservation, aiming at addressing both the tangible and intangible elements of heritage.

For English Heritage *"Building conservation […] is an attitude of mind, a philosophical approach, that seeks first to understand what people value about historic building or place beyond its practical utility"* (English Heritage, 2013), p. 3.

Figure 5 Examples of valuing ruins and more generally the tangible memory of the Classical Antiquity in the Middle Age, in the Renaissance, in the Baroque period and in the XIX century. Clockwise from the image on the bottom left: 1) The arrival of Cardinal Francesco Gonzaga, by Andrea Mantegna 1465-74. Part of the fresco from the Camera degli Sposi in the Palazzo Ducale, Mantova. Image source: ("The arrival of Cardinal Francesco Gonzaga," n.d.); 2) Arch of Septimius Severus, by Giambattista Piranesi, 1759. Graving on copper, cm 37,8 x 59. Image source: ("Arch of Septimius Severus," n.d.); 3) Casa dei Crescenzi, XI century, ennobled by the Crescenzi family through the employment of classical elements such as lintels, columns, capitals, cantilevers, etc. Watercolor by Ettore Roesler Franz, 1884. Image Source: ("Watercolor," n.d.).

According to former UNESCO Assistant Director General for Culture, Lourdes Arizpe, *"new global cultural commons"* (Arizpe, 2000), p. 32 are changing the perception of Cultural Heritage. Indeed, there is a shift from an elitist concept of cultural heritage to a more democratic one, stressing the worth of heritage sites according to the values and shared meanings that people associate with them. Consequently, according to Arizpe "*more and more, the concept of cultural heritage is opening up to cultural landscapes, popular cultures, oral traditions"* (Arizpe, 2000) p. 32. She underlines that *"the world is not made up of objects but is instead made up of states that may change their functioning and appearance according to the way in which they are being observed. An anthropologist today also knows that ethnographic description is but a transitory, fleeting glance at a reality by an observer bound by his or her culture and location in a certain time and a certain place"* (Arizpe, 2000) p. 32. Hence, cultural heritage values are constantly changing. Conservation processes are sped up by the development of new, fast and affordable modalities of transportation that increased migration, tourism, and globalization, and by new technologies of communication and information-sharing that implement ideas, exchanges and cultural interactions.

In line with these considerations, how to define a shared perception of cultural built heritage that could orient design choices in conservation projects? How are intangible values, associated with architectural features of built heritage, related to global cultural commons? Do these issues contribute to developing different ways of conserving cultural built heritage?

Finally, how can the latest developments in telecommunication and audiovisuals, as well as the diffusion of affordable and user-friendly communications devices, be harnessed to orient choices and processes in built heritage conservation? How do these new IT solutions interact in the relationship between past and future in heritage conservation? Which is their (potential) role?

The following sections provide possible answers, by breaking up the analysis of these issues into different parts.

Figure 6 Example of how the concept of ruins and antiquity is extended to not - Classical Antiquity. French Engraving from 1860, Pagan Temple Ruins, Burma. Image source: ("French Engraving from 1860, Pagan," n.d.).

Why should intangible dimensions orient the documentation and conservation process?

The affirmation of the importance of intangible values of Cultural Heritage is one of the current goals of the World Heritage List (WHL) (reinforced by the adoption of the 2003 UNESCO Convention) as well as one of the objectives of many governments that aim at developing a sense of national or local identity.

Furthermore, in the general phenomenon of increasing globalization, the safeguard of intangible heritage is becoming a priority. Indeed, identity, cultural diversity and sustained growth are strictly connected to intangible heritage. Evidence of the relevance of this issue can be found, for instance, in the *Societal challenge of the European* *program Horizon 2020*, and more precisely in the action *Europe in a changing world - inclusive, innovative and reflective societies*. As the name suggests, the initiatives of reflective societies consist in sensitizing people in the perception of a world in constant change and empowering them to be able to understand their current context through the understanding of their past in terms of social, cultural and scientific legacy.

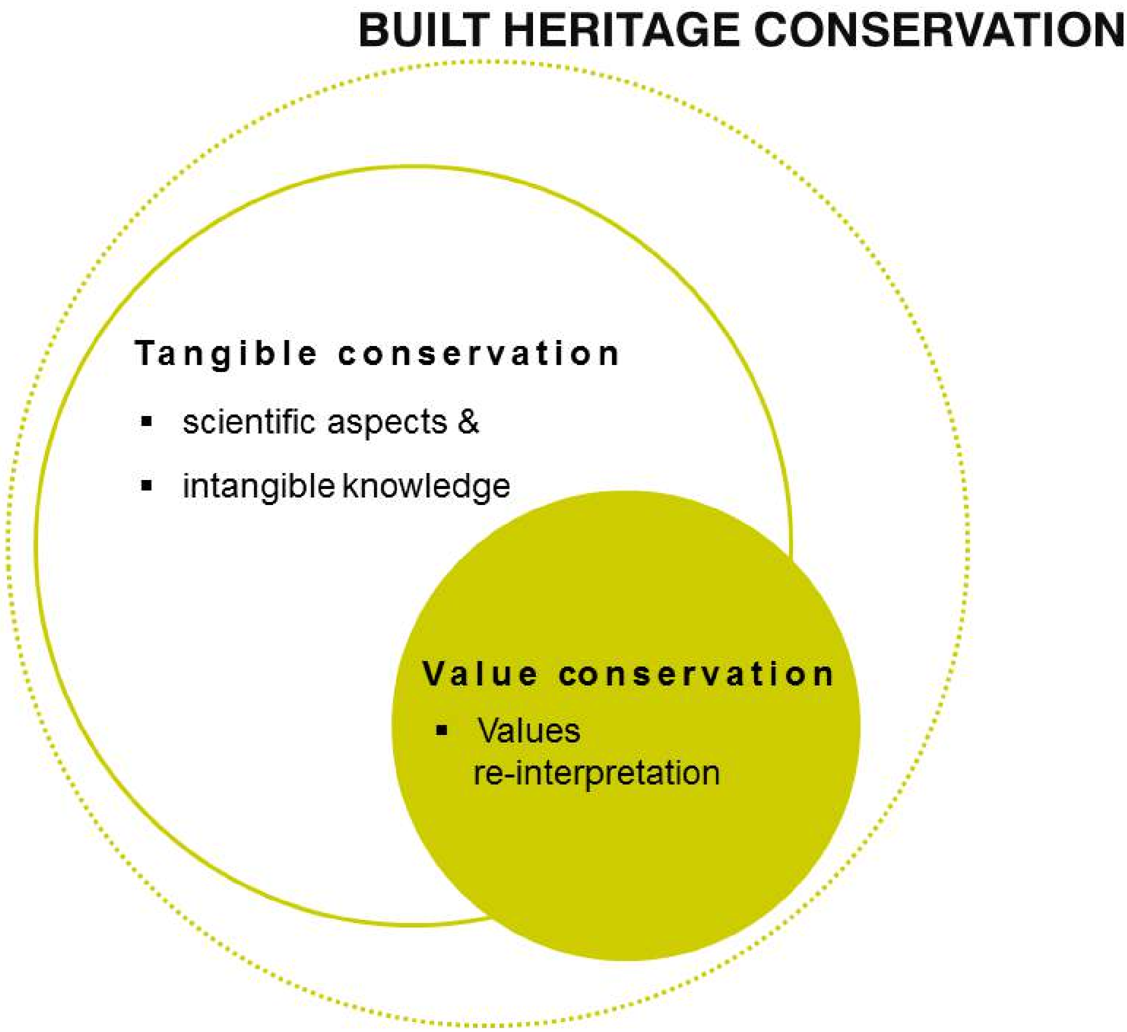

Figure 7 Diagram exemplifying the close relationship between the conservation of tangible and intangible aspects of built heritage and the conservation and re-interpretation of its values, a fundamental factor in order to make meaningful the conservation action itself. Source: Author.

This approach suggests that people are not only users but also producers of cultural heritage. Hence, the understanding of the relationship between tangible and intangible dimensions of heritage becomes even more significant to understand how to preserve meanings and values of cultural built heritage. In this framework, one of the main objectives of the research is the involvement and interaction of different actors and stakeholders in the conservation processes. This can improve and increase the understanding and comprehension of built heritage. Indeed, communities need to be connected to their built heritage that requires conservation and constant maintenance, as well as re-interpretation, to make meaningful the conservation processes, by overtaking mere aesthetic and elitist approaches. The linkage between tangible and intangible aspects is fundamental to these intertwined approaches.

To correlate these two aspects in built heritage conservation, it is necessary to work on the information phase to increase the knowledge of a site, and to develop alternative approaches by employing IT-supported documentation techniques, 3D modelling and digital tools and participatory strategies of data gathering. This integrated and interdisciplinary approach, tested and illustrated in this research, would produce additional knowledge to orient conservation choices. It would create added value for more inclusive actions on cultural built heritage[22], within the general goal of a sustainable and sustained growth of the site and its surroundings. Within this framework, social and technical intangible aspects play a pivotal role in the interpretation of a site, consequently orienting its maintenance, conservation or reconstruction actions. An example of intangible aspects associated with built heritage structures is provided by the site of Bagan, in Myanmar (see Chapters 6 and 7). This case provides several examples of integration between intangible local knowledge and tangible built structures, that can

[22]The Rapid Ethnographic Assessment Procedures (REAP) developed in Bagan outlined the detachment of common local people from their cultural built heritage, evidencing the relevance and need of the proposed approach for an increasing inclusiveness of the conservation strategies. This concept is developed in Chapters 6, 7 and 8 using the case study of Bagan as a practical example of the proposed theoretical assumptions.

be found in the meaning of the design, inscriptions, decorations (stucco and plaster works, wall paintings[23], etc.), shape of the religious buildings and materials provenance, that are the consequence of each donor *"[…] wishing to outdo his or her predecessor in order to accumulated ever-greater merit, or they may be a result of religious preferences"* (Falconer et al., 1998) p.32.

Why are intangible dimensions important?

The creativity and innovation embedded in the intangible aspects associated with the built heritage determine their relevance. Indeed, they derive from the integration of cultural exchange, tangible heritage, history and material culture.

Furthermore, it is now commonly accepted that a mere material and technical conservation is not sufficient anymore, if it has to be meaningful for a broad community. For instance, Ilan Vit-Suzan noted that: *"monuments conservation focuses on objects, heritage engagement concentrates on subjects"* (Vit-Suzan, 2014). Conservation is irrelevant if not combined with the promotion and transmission of the intangible factors that have generated built heritage and contributed to its dynamic (re-)interpretation within conflicting identity politics. Also, the recovery of these factors will generate *know how* that can prove extremely valuable in a sustainability perspective.

The delay in recognizing the intangible dimension of built heritage is probably a result of its immaterial features[24]. These features make it incompatible with the prevailing

[23] Paintings were applied to dry plaster walls. Colors came from available natural sources such as lime, ochres and charcoal mixed with other material - of animal and vegetal origins – mixed with the pigments for a better cohesion to the wall. Mural paintings in Bagan mainly present scenes from the life of the Buddha. (Falconer et al., 1998) P.32.
[24] This claim has got a double meaning. Firstly, intangible aspects have been neglected for long time or, at best, silently and implicitly assumed in the heritage definition. Secondly, intangible aspects have been perceived in a limited perspective, as simple ideal aspects of heritage associated with their ideal representation, usually corresponding to the intellectuals' one. Therefore, aspects associated with a more anthropological concept of culture, such as knowledge and skills, focus on the relationship between social and technical aspects in building maintenance and construction.

interests of our society because they are difficult to quantify and devoid of immediate economic value (Settis, 2014).

Nevertheless, in the attempt to define/conceptualize the relevance of intangible heritage, many scholars stressed the tight connection between intangible knowledge and sustainability issues. For instance, in his book, Ilan Vit-Suzan reports that: *"the pursuit of sustainability could find a powerful ally in the reassessment of inherited ideologies"* (Vit-Suzan, 2014).

Figure 8 Intangible Cultural Heritage. The three engravings are taken from "Roman Alphabet against architectural backgrounds", from G. P. Zanotti's "Il Claustro di San Michele in Bosco di Bologna" (The MET, n.d.), engraved by the Italian artist Pio Panfili (1723-1812) and re-elaborated by the Author.

This thesis demonstrates the relevance – from a social, economic, environmental and cultural point of view – of the conservation and reassessment not only of "*inherited ideologies"* but also of knowledge, concepts, and skills related to social and technical aspects of building maintenance and construction. Within this framework, researching and adopting new methodologies, developing strategies and tools for the safeguarding and promotion of intangible heritage, within an integrated approach to the ‘classic’ conservation of the tangible heritage, are crucial matters.

Hence, relying on the assumption that concrete-tangible entities and abstract-intangible components constitute form and content of heritage (Vit-Suzan, 2014), this study analyzes how to take both of them into account in the conservation practice, and the extent to which they shape it, since their interaction is at play in the very definition of conservation policies.

PART I PROBLEM CONCEPTUALIZATION

1 Chapter: New interpretation paradigms in the conservation field

As anticipated in the introduction, built heritage conservation has been constantly a subject of reinterpretation according to different historical, cultural social and economic variables.

Exemplary is the Italian case, where the conservation debate of the last eighty years saw the thrive of contrasting theories. Luca Beltrami theory exemplified as '*dov'era com'era*' ('where it was and as it was') found its full accomplishment in the reconstruction of the bell tower of St Mark's Basilica, in Venice. Cesare Brandi, despite the psychological and aesthetic instance, conceived the possibility of interventions that could include reconstructions. Alternative theories appeared simultaneously in the following years. Marco Dezzi Bardeschi proposed the total conservation[1] of the existing structure in divergence with Paolo Marconi, who considered legitimate reconstruction[2] of missing or damaged parts of built heritage sites[3]. Giovanni Carbonara's '*restauro critico-conservativo*'[4] ('critical and conservative restoration'), strongly influenced by Renato

[1] Dezzi Bardeschi claimed the importance of the "effective conservation […] of the material culture layered on an artefact" (*"effettiva conservazione […] della cultura materiale depositata sul manufatto")* (Dezzi Bardeschi, 1986). He applied this approach also to the social dimensions of the conservation act intended as a didactic action to let people understand the real history of a building and therefore the collective history associated with it without misleading interpretations. Conservation should "neither betray the building, nor deceive those who approach it; (it should) neither alter the monument-document […] nor discredit the objective of the permanence, that is the effecive conservation of the physical context that has arrived to us" (*"non tradire la fabbrica, non ingannare chi a essa si avvicina, non alterare il monumento–documento […] non screditare l'obiettivo corretto della permanenza, ossia della effettiva conservazione del contesto fisico arrivato fino a noi")* (Caponetto, 2012), p. 18.

[2] Marconi argued that a philological approach, based on meticolous analysis of the building, is necessary to integrate and/or reconstruct the damaged or missing parts of a historic structure: "in case a house or a church were 'ruined', […] [by] reintegrating them or restoring them thanks to an adequate knowledge of their language" (*"nel caso in cui una casa o una sua chiesa fossero "rovinate", [...] reintegrandole o ripristinandole grazie ad una adeguata conoscenza del loro linguaggio")* (Torsello, 2005).

[3] On this Paolo Marconi argued that "embalming is easy, (while) restoring is complex" (*"imbalsamare è facile, rifare è difficile")* (Torsello, 2005).

[4] Carbonara outlined the social role of conservation and its didactic function, thus underlining the importance of a scientific approach in dealing with it: "(restoration is an) act of culture and at the same time a highly specialized one. Restoration looks at the future instead of the past, […] (it) has educational and memory functions, for the future generations, for the youth; it does not concern, after all, complacency for studies 'per se', but the training of every citizen and his/her quality of life, intended in the wider sipritual and material sense" [*"(il restauro è un) atto di cultura e al tempo stesso altamente specialistico. Il restauro guarda al futuro e non al passato […] ha funzioni educative e di memoria, per le future generazioni, per i giovani; riguarda, in fondo, non il compiacimento per gli studi in sé ma la formazione d'ogni cittadino e la sua qualità di vita, intesa nel senso spirituale e materiale più esteso"]* (Carbonara, 1976), p. 27.

Bonelli, proposed a compromise between the theories of Marconi and Dezzi Bardeschi, recalling the method '*caso per caso*' ('on a case by case basis'), theorized by Ambrogio Annoni[5], recognizing the impossibility of standard guidelines to operate on heritage since any site is characterized by unique features.

In the next paragraphs, I examine three sets of variables - social, technical and aesthetic factors - that contributed to the consolidation of the main trends and approaches to heritage conservation and fomented the development of the Italian debate in the XX century.

1.1 Social meanings, scientific aspects, and aesthetic values

To understand current trends and approaches in the field of cultural heritage an analysis of the main international actors, is necessary. This analysis is aimed at understanding approaches, aims and goals, of the main international stakeholders in heritage conservation, identifying which are the mainly supported aspects - social, scientific or rather the aesthetic dimensions - and the associated values.

Recently, the number of the main international organizations dealing with heritage conservation grew considerably. Since the second half of the XX century, UNESCO and its advisory bodies - IUCN, ICCROM, ICOMOS and its International Scientific Committees such as CIPA Heritage Documentation and ISPRS - were established. Soon after, international institutions, foundations and NGOs dealing with culture and its conservation in different geographical and social contexts were also established.

5 Ambrogio Annoni, architect and Professor at the Polytechnic of Milan, recognized the limits of standards in cultural heritage conservation. Therefore, he theorized the 'caso per caso' ('on a case by case basis') adapting conservation actions according to the needs and specificities of any single project.

In Europe, the Council of Europe[6] includes in its actions "*the promotion of the know-how in culture and heritage*"(Council of Europe, n.d.-a), and Europa Nostra[7] advocates for high standards in cultural heritage conservation.

In the Islamic world, the Aga Khan Trust for Culture[8] implements, among its initiatives, cultural heritage conservation projects through various programs and initiatives with the main aim of supporting social cultural and economic development of Muslim communities (Aga Khan Trust for Culture, n.d.-b). In the same social and geographic context, the Islamic Educational, Scientific and Cultural Organization (ISESCO)[9] promotes initiatives in the fields of education, science and culture to preserve Islamic identity and culture with the goal of integrating Muslims in the general political, economic, social and cultural context of the host societies (ISESCO, n.d.-b).

In North America, the Getty Conservation Institute, renowned centre for conservation projects and applied research in the Cultural Heritage field, as well as the Global Heritage Fund[10] and the World Monuments Fund[11] support and implement projects and capacity building activities for conserving heritage sites, the latter with a focus on endangered ones (Orbasli, 2008).

[6] The Council of Europe is an international organization aimed at promoting human rights, democracy and the rule of law in Europe. It is composed of 47 member states in the European region. Its foundation dates back to the 1949; its initiatives include, among the others, cultural policies in terms of promotion of cultural diversity and intercultural dialogue (Council of Europe, n.d.-a).

[7] Europa Nostra is a non-political organization with the aim to safeguard Europe's cultural and natural heritage, by building a European lobby for Cultural Heritage and including an award scheme in its initiatives. The member organizations count 250 partners among heritage associations and foundations and 150 associated organizations including governmental bodies, local authorities and corporations as well as 1500 individual members. From the diplomatic and institutional point of view, Europa Nostra is the *trait d'union* among the European Union, the Council of Europe and UNESCO ("Europa Nostra," n.d.).

[8] This Trust is part of the Aga Khan Development Network (AKDN) founded by the prince Aga Khan, with the aim of promoting social and economic developments in developing countries (Aga Khan Trust for Culture, n.d.-a).

[9] ISESCO is an international organization which aim and mission can be compared to that one of UNESCO with a focus on the Islamic world. It counts fifty-two Member States and three Observer States (ISESCO, n.d.-a).

[10] The Global Heritage Fund is a nonprofit public benefit organization with the mission to protect, preserve and sustain the most significant and endangered cultural heritage sites in the developing world. The organization is based in Palo Alto, California and raises money throughout the United States for conservation projects in developing countries. The organization works with other non-profit organizations in many countries to fund cultural heritage conservation projects (Global HeritageFund, n.d.-a).

[11] The Fund is a private non-profit organization founded in 1965 to contrast the increasing loss of cultural heritage after the Second World War. Currently, it continues its mission, providing financial and technical support, to develop conservation programs worldwide (World Monuments Fund, n.d.-b).

On the basis of the argument developed in the previous paragraphs, it is then interesting to analyze priorities, aims, and goals of the main international, not political organization – that differ in status, source of income and social context – to understand the current orientations of conservation initiatives.

The table below illustrates how different international stakeholders, acting in the cultural heritage field, share general aims, missions, and modalities of project financing while differing in terms of contributions to cultural built heritage conservation.

Among the aims of these organizations it is possible to identify two main common aspects:

1) Dissemination of the social and intangible meanings of built heritage;

2) Conservation and dissemination of technical features and scientific aspects of built structures, including local skills and knowledge, in order to make communities more resilient.

Table 1 Aims, missions, and modalities of projects financed by the main international stakeholders in the cultural heritage field. Source: Author.

ORGANIZATION NAME	GEOGRAPHIC AREA	SOURCE OF INCOME TYPOLOGY	AIM & MISSION	CONTRIBUTION TO CULTURAL HERITAGE CONSERVATION	MAIN CONSERVATION ASPECTS
ISESCO[12]	Africa Middle East	-Donations and subsidies allocated by Muslim organizations and banks. -Grants by international organizations (such as the European Union, the Council of Europe and the International Development Agency, etc.). -Grants by legal entities, businessmen and benefactors. -West Africa Ambassadors' Fund (WAAF).	-Coordinate initiatives in the field of education, science and culture, protecting Islamic identity and aspirations preserving religious values and instill ethical concepts. -Integrate Muslims in the general political, economic, social and cultural context of the host societies.	-Supervise and support the policy of sensitization adopted by Islamic associations and cultural centers outside the Islamic world. -Awareness raising of the Islamic heritage amongst Muslims so as to protect, safeguard, preserve and rehabilitate it. -Elaborate standardized criteria for the codification and classification of cultural assets.	Social Cultural
UNESCO[13] (World Heritage Centre)	Worldwide	-Compulsory contributions from countries (States Parties). -Donations, including Funds-in-Trust, are donations given by countries to support specific projects. -Voluntary contributions. -Profits derived from sales of World Heritage publications, or funds-in-trust that are donated by countries for specific purposes.	-Encourage the identification, protection and preservation of cultural heritage sites around the world considered to be of outstanding value to the humanity. -Provide awareness-building activities and emergency assistance for World Heritage sites in immediate danger. -Encourage participation of the local population in the preservation of cultural and natural heritage.	-Technical assistance and professional training to safeguard heritage sites. -Encourage international cooperation in the conservation of our world's cultural heritage.	Social Cultural
Getty Conservation Institute[14]	Based in North America, working worldwide	-Internal incomes -Donations	-Advance conservation practice in the visual arts broadly interpreted to include objects, collections, architecture, and sites.	-Scientific research, education and training, model field projects, and the broad dissemination of the results of both its own work and the work of others in the field. -Development of novel approaches, policies, and best practices.	Cultural Scientific Social

World Monuments Fund[15]	Based in North America, working worldwide	-Donations (coming from Individuals, Corporations, Governments and Foundations). -Financial support of corporate and foundation partners.	-Identify and preserve imperiled cultural heritage sites. -Through fieldwork, advocacy, education and training, support conservation of heritage sites worldwide.	-Direct financial and technical support for the conservation of heritage sites. -Training of local actors in conserving heritage sites. -Dissemination of heritage values.	Cultural Social Scientific
Aga Khan Trust for Culture (AKTC)[16]	It works in the Middle East, Eastern, Western Africa, North America, Oceania, Central and South Asia and Europe.	-Donations -Institutional partners[17] (local, state and national governments)	-It focuses on the physical, social, cultural and economic revitalization of communities in the Muslim world.	-The programs mainly focus on the practice of architecture in the Muslim world undertaking specific intervention focused on the economic revitalization of historic sites (Joint Programming Initiative for Cultural Heritage and Global Change, 2014).	Social Cultural Scientific Economic
Global Heritage Fund[18]	Based in North America but working in South America, Asia and North Africa	-Donations' Fundraising -Public Support and Revenue Contributions -Net assets released from restrictions	-Sustainable preservation of the most significant and endangered cultural heritage sites in developing regions of the world. Conserve heritage all over the world, providing emergency assistance to damaged sites.	-Empower local actors through conservation science, partnerships, and community development, to appreciate, protect and manage cultural heritage. -Provide a holistic approach to conservation.	Social Cultural Scientific
Europa Nostra[19]	Europe	-Donations (from private organizations, enterprises and foundations as well as public and international institutions and organizations).	-Safeguarding of Europe's cultural and natural heritage contrasting current threats. -Supporting cultural heritage achievements and enhance human resources employed or related to cultural heritage	-Development of quality standards -Networking in the cultural heritage field.	Cultural Social
Council of Europe[20]	Europe	European Commission	-Promote diversity and dialogue through access to heritage thus fostering a sense of identity, collective memory and mutual understanding within and between communities.	-Cultural policies in term of promotion of cultural diversity and intercultural dialogue as well as in terms of safeguarding of tangible and intangible heritage. -Systematic exchange of	Social Cultural
			-Contribute to territorial cohesion, life style and relationships through the notion of heritage and landscape as community resources in order to promote territorial development.	information, reviews of policies, development of thinking perspectives in the cultural heritage sector.	

The synopsis presented in the above table shows that the conservation of the sole aesthetic dimensions of heritage is not a priority. Evidence of this attitude can then be found in the growing programs aimed at the conservation of modern heritage and industrial sites promoting the technical and social dimensions of built structures, conceived as a place of production and collective work. The proposed nomination of Ivrea to the World Heritage List (WHL) as an outstanding example of industrial city of the XX century (MiBACT, n.d.), and previously inscribed UNESCO sites, like Crespi D'Adda[21] or the Zollverein Coal Mine Industrial Complex in Essen[22], or the *Conserving Modern Architecture Initiative* launched by the Getty Conservation Institute, are just some examples.

From the table, it is possible to conclude that the main international actors engaged in heritage conservation focus on conserving and disseminating the social meanings and scientific values of heritage, in order to make communities and territories more resilient.

In terms of social meanings promoting built heritage conservation, it is worth to mention the practice of 'conservation assistance' (Stubbs & Makas, 2011), p. 37, in the establishment and consolidation of international diplomatic relations. This trend is particularly consolidated in Europe, finding in Italy one of the main 'conservator assistant'[23] due to its *" […] long-standing international perspective on architectural conservation […] (due to) […] the participation of the country's leading figures at the*

[21] It is an outstanding example of the so called 'enlightened' industrialists that tried to provide to workers better conditions, by ensuring a pleasant and comforting working environment according to the principles of autarchy. Founded by Cristoforo Benigno Crespi, it is a tangible evidence of one of the first attempts to give employees a high standard of living "with housing in multi-family residences (each with its own garden) and community services that were well ahead of the times" (UNESCO, n.d.-b).
[22] The site represents a remarkable evidence of the industrial development, over the past 150 years, of the area corresponding to the current North Rhine-Westphalia State in the Federal Republic of Germany. It presents infrastructures of a historical coal-mining site as well as residential buildings and offices connected to the industrial production (UNESCO, n.d.-f).
[23] Indeed, aware of the potential of its conservation talent, the Italian government stimulate the cooperation of the Ministry of Cultural Heritage (Ministero dei beni e delle attività culturali e del turismo - MiBACT) and the Ministry of Foreign Affairs and International Cooperation (Ministero degli Affari Esteri e della Cooperazione Internazionale - MAECI) to exploit this national intangible intellectual capital in international cooperation and diplomatic policies (Stubbs & Makas, 2011).

seminal international conferences that resulted in the Athens Charter of 1931 and the Venice Charter of 1964" (Stubbs & Makas, 2011), p. 35.

The analysis of the main international stakeholders in heritage conservation has been useful to inquire, in general terms, the economic and 'diplomatic' feasibility of the approach that is outlined in Part II and Part III of this thesis.

The relevance of the social meanings and technical aspects of heritage conservation, instead, is deepened in the following paragraphs.

1.1.1 Participation, social aspects and heritage diplomacy in conservation

Conservation is embedded in social and political aspects. Hence, it is worth to develop some considerations on the politics of heritage conservation. Heritage diplomacy (Tim Winter, 2016) influences the aims, modalities and choices in heritage conservation. Incidences can be found in the past in the restoration of the tomb of Cyrus[24] by Alexander the Great, as a tribute to the Persian emperor after the raid and destruction of Persepolis in the IV century B.C. (UNESCO, n.d.-d).

Similar cases include monuments and works of art that have survived destruction because of new values assigned to them by the communities that undertook their restoration, thus re-contextualizing their forms within new functions or new meanings[25].

[24] The tomb is located in Pasargadae, in the current Islamic Republic of Iran. Pasargadae was founded by Cyrus II the Great as capital of the Achaemenid Empire in the VI century B.C. (UNESCO, n.d.-d). The capital of the empire was then moved to Persepolis. In the IV century B.C. Alexander the Great restored the mausoleum of Cyrus. The structure has been conserved until today because it was believed to be the tomb of the King Salomon's mother (Qabr-e Madar-e Sulaiman) (Castelli Gattinara, 2009).

[25] This is the case of the bronze Equestrian Statue of Marcus Aurelius, preserved in the late Roman empire period and in the Middle Ages - when most such statues, considered as pagan idols, were melted down to recycle their bronze - because it was mistakenly thought as portraying Constantine, the first Christian Emperor. Notable examples, again in terms of religious values, range from the preservation of the Pantheon, a Roman temple converted into a church in Rome, to the one of the Hagia Sophia (Saint Sophia) basilica in Istanbul, converted into an imperial mosque by Sultan Mehmet II after the fall of Constantinople in 1453.

As noted by Luca Zevi, medieval Europe was marked by the practice of resorting to creative uses of the remains of classical antiquity, as witnessed in Rome by the transformation of the Theatre of Marcellus into the *Palazzo de' Savelli*, the arrangement of the Mausoleum of Hadrian as a fortress, the *Castel Sant'Angelo*, and the use of the area of the *frigidarium* of the Baths of Diocletian for the Basilica of Saint Mary of the Angels and the Martyrs (Zevi, 2011), p. 17.

Figure 1 The tomb of Cyrus, Pasargadae, Iran (Islamic Republic of). Image source: UNESCO web site (UNESCO, n.d.-d).

Later examples of restoration went beyond the mere functional usage of old structures and were the expressions of political statements[26]. The politics of heritage is a common feature of any conservation project, and it has increasingly been playing a role beyond

[26] In this perspective, the case of the double function, at the same time didactic and symbolic, of the restoration of the Arch of Titus is noteworthy. The sculptural apparatus within the Arch depicts the Roman conquer of Jerusalem by Emperor Titus. The conservation works on the Arch, accomplished in 1831 by Raffaele Stern and Giuseppe Valadier, under Pope Pius VII, served as a warning to the Hebrews in Rome that the ideals of brotherhood, equality and freedom of the Enlightenment had failed following the Restoration (Giannattasio, 2013). This is a good example of the politics of heritage that imply, for any technical intervention, a political statement about the present that makes use of the past, in situations characterized by contestation and conflict.

national boundaries. Over the last two centuries, heritage diplomacy has marked the emergence and establishment of cultural nationalism, international relations and, eventually, globalization. According to Astrid Swenson, heritage diplomacy can be found not only at the national but also at the international level. The period between 1789 (French revolution) and the First World War was marked by 'informal' international approaches to heritage protection and conservation, firstly developed as European efforts to contrast the looting of artworks and objects by the Napoleonic armies (Swenson, 2016) in an Enlightenment conviction of heritage objects as commons as reported by Quatremère de Quincy in his *Letter to Miranda*[27] (Swenson, 2016). When in the first decade of the XIX century Lord Elgin[28] removed about half of the remaining sculptures from the fallen ruins and from the Parthenon itself in Athens, a common conscience toward a masterpiece of the classical culture rose again.

After the Congress of Vienna in 1815, formal diplomatic services were employed to set up a European preservation system for national heritage (Swenson, 2016).

After the huge destructions of the First World War, different initiatives arose including the creation of the *Red cross for monuments* and in 1922 the *International Committee on Intellectual Collaboration (ICIC)* of the League of Nations (Swenson, 2016).

[27] In response to the military pillage of masterpieces from the 1790 to the 1800 a firm denouncement arrived from the pamphlet "*Letters to Miranda"* by the French Quatremère de Quincy, architectural theoretician, art critic, and political conservative (Miller & Gilks, 2012).
[28] British ambassador to the Ottoman Empire, between 1801 and 1805 he negotiated with the Ottoman authorities the authorization for the removal of the fallen ruins of the Parthenon and transported the sculptures to the United Kingdom.

Figure 2 Caricature of Napoleon Bonaparte stealing Antiquities from the conquered countries, by Dr. Syntax Pub 1814 (Google Art Project, 1814).

To contrast and prevent the looting and destruction of cultural heritage in Europe during the Second World War, another action consisted in the establishment of the so-called *Monuments*, *Fine Arts, and Archives (MFAA)* programme as part of the Civil Affairs and Military Government Sections of the Allied armies, also known as *Monument men*[29] (Morrison, 2014).

After the Second World War and the creation of the United Nations, the formalization of these policies (Swenson, 2016) reached a peak with the establishment of the United

[29] It consisted in a team of American and British soldiers, art curators, scholars, architects, librarians and archivists charged with the identification and protection of European Cultural Sites from Allied bombing - in a first phase - and with the recovering of raided and pillaged art works by the Nazi in a second phase (Archives of American Art, 2014).

Nations Educational, Scientific, and Cultural Organization (UNESCO) in 1945 (UNESCO, n.d.-c) and the constitution of its Advisory Bodies[30].

This brief overview illustrates how different social motivations have been the drivers of conservation actions and of the connected choices. Even today this tendency is still valid. Evidence can be found in the European context in the *Societal challenge* of the European program *Horizon 2020*, and more precisely in the action *Europe in a changing world - inclusive, innovative and reflective Societies.* As the name suggests, the initiatives consist in sensitizing people about the perception of a world in constant change and empowering them to be able to understand their current context through an awareness of their past in terms of social, cultural and scientific legacy. Hence, the understanding of the relationship between tangible and intangible heritage becomes even more significant in order to preserve meanings and values of cultural built heritage (European Commission, n.d.).

1.1.2 The conservation of the innovative features in traditional architecture: know-how, skills, material knowledge and technical solutions

The institutionalization of technical know-how – that today would be defined as part of the intangible aspects of built heritage – traces its first example back to the Middle Ages. The reason of this can be found in the Christian religion that brought to medieval culture a new conception of manual work not intended anymore as a servile activity but as a

[30] The three international intergovernmental organizations are the International Union for Conservation of Nature (IUCN), the International Council on Monuments and Sites (ICOMOS) and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM). Their role, established in the UNESCO convention consist in advising the UNESCO Committee in its deliberations (UNESCO, n.d.-a).

creative expression of a free man. Evidence of this trend is available in the walls of Giotto Bell Tower in Florence, decorated with sculptures describing the nexus between work and time (the tower bells stroke the hours and stressed the most important events), *"a relation pervading all human activities"*[31] (Fondazione San Paolo, 2011).

Figure 3 Hexagonal marble tiles in the first order of Giotto Bell Tower in the Church of Santa Maria del Fiore complex in Florence. The left one presents the work of the Architect personified by Euclid drawing (Euclid. Formella Dal Campanile Di Giotto. Marmo. Museo dell'Opera Del Duomo. Firenze, 2016). On the right is Tubalcain metaphoric depiction of the 'arte del costruire' (building art) or 'arte del fabbro' (craftsmanship) (Alinari Archives, n.d.). Both tiles are part of the decorative apparatus of the 21 hexagonal tiles designed by Giotto and carved by Andrea Pisano between the 1334 and 1336 (Tomei & Viggiani, 2009).

Currently, the affirmation of the importance of Cultural Heritage intangible values, including craftsmanship and technical knowledge is among the goals of the World

[31] Other examples are provided by artistic works glorifying the working activity, such as the portals of the Modena or Chartres cathedrals, or the fountain of Perugia designed by Nicola Pisano and his son Giovanni containing, in its decorative apparatus, a series of allegoric sculptures depicting different local working activities. Medieval men were aware that their work, intended as participation in the creativity of God, conveys its sense to time, transforming it into history and civilization (Fondazione San Paolo, 2011).

Heritage List (WHL) (reinforced by the adoption of the 2003 UNESCO Convention[34]) as well as a stated objective of many governments that aim at developing a sense of national and local identity as well as resilient communities.

An increasing number of events and projects currently aims to promote and protect handicraft tradition[35].

This trend is evidence of a growing attention towards a complex set of knowledge skills and capabilities inherited from the past[36].They are threatened by obsolescence in a society where, thanks to the extensive use of technologies, information spreads fast, globally and often superficially with the consequent homologation and simplification of

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34 The Article 2 the Convention for the Safeguarding of the Intangible Cultural Heritage, 2003, defines as intangible cultural heritage:

- oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- performing arts;
- social practices, rituals and festive events;
- knowledge and practices concerning nature and the universe;
- traditional craftsmanship (UNESCO, n.d.-e).

35 Among others, Carrozzino, Scucces, Leonardi, Evangelista, and Bergamasco, outline the threats faced nowadays by traditional knowledge and handicraft: *"[…] handicraft process tends to remain isolated in its own workshop entrusting its survival to the passage of knowledge from artisan to artisan. This important artistic process which concentrates the ability of masters and the history of the territory, […] is indeed a complete cultural asset, (that) runs the risk to be lost in a very few decades"* (Carrozzino et al., 2011).

36 In the architectural field, the reasons for this trend are also related to the environmental sustainability features of historic buildings in terms of technological solutions and constructive systems. Indeed, prior to industrialization, the surrounding climate always forced civilizations to live within their means. The first civilizations were fully integrated into their environments and their different economies and industries arose by what was inherent to the land (Wright 2005). Evidence of this is present in the four regions that first developed civilization, such as China's Yangtze River Valley, Mesopotamia's Fertile Crescent, Egypt's Nile River Valley, and India's Indus River Valley. (Wright 2005), p.33. Concerning architecture, the use of passive and adaptive design strategies was a *trait d'union* in every region. Along the centuries, passive and adaptive design along with creative solutions to exploit environmental elements continued to play a key role in architectural design that consciously considered the response of its materials to the environment. By seeking a symbiotic relationship with its environment, historic buildings' design constantly sought creative solutions to strike a balance with occupants' needs, local climate as well as socio-cultural and economic context. Evidences are provided by heterogeneous structural as well as decorative and functional solutions of historic structures, product and tangible evidence of local know-how and working skills. An outstanding example is the Ospedale Maggiore (the Ca' Granda) in Milan, designed and partially built by Antonio Averlino (1400-1469), also known as Filarete. The architectural complex, whose first built structures date back to the second half of the XV century, presents interesting solutions in term of location, water management, structural design and functional distribution, providing an interesting case of adaptation of a historic building to its urban and geomorphological context.

As consequence of the endorsement of Pope Pius II (1405-1464) and of the philanthropic and public wealth policies of the duke Francesco Sforza and Bianca Maria Visconti, the foundation of a big hospital was established by a ducal decree in 1456 (Vaglienti, 2014), p. 4.

In terms of location, the hospital was located close to the now buried *'Naviglio'* (one of the water ways in ancient Milan), between *porta Romana* and *porta Tosa.* The site was selected in order to provide natural water supply to guarantee a constant cleaning and removal of the sewage of the hospital.

Concerning structural solutions, the interior walls presented one of the first examples of canalization for rubbish, medicaments and garbage removal in order to guarantee the best hygienic conditions. Innovative solutions included also an underground sewage system connected to the flowing water of the *Naviglio* for a constant cleaning and removal of the waste, so as to avoid patients' exposure to disease risks.

From the functional point of view, the complex layout consisted into two crosses (one for men and one for women), obtaining from each square four inner courts, each one having a different function (such as the woodshed, the ice house, the baths and the pharmacy) (Vaglienti, 2014). According to the original project by Filarete, two larger blocks were connected by a large rectangular courtyard. This planning disposal was designed to differentiate and organize the flows of people, making mobility within the hospital efficient. Then, another interesting solution in terms of functional distribution consisted in the design of 'private wardrobe' digs in the walls in front of each bed of the main corridors of the crossbars.

processes in all the fields of our life (Carrozzino, Scucces, Leonardi, Evangelista, & Bergamasco, 2011).

In the debate concerning the intangible aspects associated with built heritage, many experts and scholars in different disciplines analyzed and reflected on the role of craftsmanship, intended as the whole of intangible knowledge, in contemporary society (Sennett, 2008).

Feilden stressed that the lack of recognition of skills needed for conservation and shortage of craftsmen and materials are two of the main problems in built heritage conservation[37].

Already in the 80's, he noted that "*the organization of modern building industry is not related to maintenance"* (Feilden, 1985a). Feilden stressed this issue focusing on developed countries, where specialists related to the field of architecture are becoming increasingly unaware of maintenance techniques, in favor of new design skills required for developments and new constructions (Feilden, 1985a). This trend is causing the loss of skills and capabilities necessary for the understanding of historic buildings.

Feilden's approach does not imply a nostalgic vision of the past as something immutable. Rather, it underlines the importance of harmonious transformations in the architectural and conservation field, where sustainable techniques and constructive systems can be emulated from the past and innovated through the employment of new materials or revisited construction systems[38]. More recently, similar concepts were then recalled by many scholars such as Manuela Mattone, who underlined the relevance of the

[37] Other critical aspects in conservation of built heritage indicated by Bernard M. Feilden are the lack of an integrated approach by governments difficulties in quantifying conservation's benefits and the necessity of proper consciousness and education initiative (Feilden, 1985b).

[38] Nevertheless, the recovery of past know-how, and 'traditional' methods and systems in architecture do not pretend to be the best solution; they rather provide possible solutions potentially useful in the conservation of shape, materials, potential unity (Price, Talley, Melucco Vaccaro, 1996), colour, values, significance and sustainable features of built heritage.

technological culture associated with landscapes, architectures and its key role in the preservation of the tangible and intangible assets (Mattone, 2016).

1.2 Re-conceptualizing the Cultural Built Heritage: the dynamic relationship among its tangible and intangible dimensions

Values and meanings of Cultural Heritage are subject of many reflections, assumptions and theories that imply different approaches to conservation practice.

Randall Mason[39] describes the concept of value in its double nature: as *"morals, principles, or […] ideas that serve to guide an action*" and as the "*qualities and characteristic of an object*" (De La Torre, 2002), p.7. Frank Matero stresses the pivotal role of value in built heritage conservation dynamics underlining that *"[…] who determines the value and how it plays out through 'appropriate' methods of use, presentation, intervention, and ownership has become one of the major issues […]"* (Matero, 2003), p. vii.

More recently, the report 'Cultural Heritage Counts for Europe' underscores that *"within the framework of cultural heritage, the value of heritage refers to what given sites mean to people […]"* (Sanetra-Szeliga, 2015), p.53.

The unique features of Cultural Built Heritage and the irreplaceability of its social, cultural and economic values, are commonly shared notions. As noticed by Van Balen

[39] Randall F. Mason is an Associate Professor of City & Regional Planning at the University of Pennsylvania School of Design, Philadelphia, United States of America. He is also Chair at the Graduate Program in Historic Preservation at the same university. His research expertise focuses on historic preservation planning, urban conservation, history, and cultural landscape studies. Mason's research interests include theory and methods of preservation planning, cultural policy, the economics of preservation, historic site management, the history and design of memorials, and the history of historic preservation. He is also the director of the Center for Research on Preservation and Society. The Center undertakes applied research projects on site management and on social, economic and political aspects of historic preservation (University of Pennsylvania School of Design, n.d.).

K.[40] and Vandesande A.[41] already in 1975, the idea of heritage as a *"capital of irreplaceable cultural, social and economic value was already present in the European Charter of the Architectural Heritage, adopted by the Council of Europe"* (Van Balen, 2016). The report *Cultural Heritage Count for Europe*, published in 2015, provides an overview of the typologies of heritage values. Table 2 shows the theories of some of the main authors that provided significant contributions to the definition of the typologies of heritage values.

Table 2 Typologies of heritage values proposed by different authors in the XX and XXI century. Adapted from (Sanetra-Szeliga, 2015), p. 56-57.

AUTHORS	PROPOSED TYPOLOGY OF HERITAGE VALUES/IMPACTS					
Riegl, 1903	Age	Historical	Commemorative	Use	Newness	
Lipe, 1984	Economic	Aesthetic	Associative-symbolic	Scientific	Social (including: spiritual, political, national and cultural)	
Frey, 1997	Monetary	Option	Existence	Bequest	Prestige	Educational
English Heritage, 1997	Economic	Educational and academic	Resource	Cultural	Recreational	Aesthetic
Mason, 2002	**Economic values:** ▪ Use values ▪ Non-use values: existence, option, bequest		**Socio-cultural:** ▪ historical ▪ cultural/symbolic ▪ social ▪ spiritual/religious ▪ aesthetic			
McCarthy et al, 2004	Instrumental effects	Social effects	Individual effects	Intrinsic effects		

[40] Koen Van Balen is a full professor of the Faculty of Engineering Science at the KU Leuven, in Leuven, Belgium. He is also the head of the Heritage @ KU Leuven and Director of the Raymond Lemaire International Centre for Conservation. Van Balen's research expertise are related to conservation techniques for ancient constructions, structural analysis and repair of ancient structures, heritage research for conservation and sustainable construction technology, building lime and its influence on masonry behaviour, carbonation and durability of lime and of hydrated or hydraulic lime based mortar (KU Leuven, n.d.).

[41] Aziliz Vandesande was a Doctoral Researcher at the Raymond Lemaire International Centre for Conservation (RLICC), at the KU Leuven. Her expertise is on the preventive conservation strategy for the built heritage stock (Raymond Lemaire International Centre for Conservation, n.d.).

McLoughlin et al, 2006a	**Economic:** ▪ direct ▪ indirect ▪ induced	**Social:** ▪ cultural identity ▪ inclusion/ access ▪ education	**Individual:** ▪ direct use ▪ indirect use ▪ non use	**Environmental:** ▪ aesthetics ▪ pollution ▪ congestion
Yung and Chan, July 2012	**Economical:** ▪ economic viability ▪ job creation ▪ tourism ▪ cost efficiency ▪ compliance with statutory regulations	**Social and cultural:** ▪ sense of place and identity ▪ continuity of social life ▪ social cohesion and inclusiveness	**Environmental and physical:** ▪ environmental performance ▪ retain historical setting ▪ and patterns ▪ infrastructure ▪ townscape	**Political:** ▪ community participation ▪ supportive policies ▪ transparency and accountability
Gielen, et al, 2014	Economic	Cognitive	Health	Experience

This chart could be integrated by including authors such as Cesare Brandi, who theorized the pivot role of the aesthetic and historic dimensions (*istanza estetica* and *istanza storica*) in any conservation action, and others like Camillo Boito, Gustavo Giovannoni, Saverio Muratori, Marco Dezzi Bardeschi, Paolo Marconi and Walter Santagata just to mention some authors within the Italian debate on cultural heritage conservation.

Nevertheless, the different points of view reported are relevant for the research in order to understand how tangible and intangible dimensions affect values, meanings and therefore the concepts of Cultural Built Heritage sites. Indeed, the current debate stresses that meanings, unique features of Cultural Built Heritage - in terms of technical solutions, socio-historical values, and scientific knowledge embodied in it – derive from the close interconnection of tangible and intangible aspects.

The intangible features of tangible heritage is not a new issue in the conservation field. Many authors and international documents debated on this issue, even if they adopted different approaches and provided multiple interpretations.

For instance, in XIX century John Ruskin, in his *Seven Lamp of Architecture* underlined the *"[…] question of the spirit and joy of creation, which was a condition for the quality of workmanship.*" (Jokiletho, 2002), p. 175. Ruskin's critique of any kind of intervention that could alter the unicity of the authentic values of the structures molded by artists and craftsmen can then be seen as a recognition of the importance of the intangible knowledge and skills that guided them in the realization of historic structures and of their set of values and meanings.

A follower and admirer of Ruskin, the Count Alvise Piero Zorzi, underlined the difference between restoration and conservation. He underscored that "*Restoration presupposes innovations according to needs; conservation excludes them completely […] conservation aims at the safeguarding from decay of what, for its antiquity and for historic reasons, has a special merit superior to art, symmetry, architectural orders, and good taste*." (Jokiletho, 2002), p. 199. In this statement, it is possible to notice the relevance of the intangible dimension of conservation that, compared to restoration, does not have to merely recover a building but also to preserve and disseminate its values, stratifications, history and meanings.

According to Giovanni Carbonara, Cesare Brandi's critique, aware of the extension of cultural heritage concept, recognizes the need of conservation supported by what he defines as *"documentazioni storico-testimoniali"* (historical-evidence documentation) (Carbonara, 2005), p. 340.

Besides, Cesare Brandi's critique reflects on the relationship between conservation practice and the recognition of the value of a masterpiece. As reported by Giovanni Carbonara referring to Brandi's thought, the masterpiece - or in the case of the built heritage a building, a monument, a structure or an architectural complex - influences the conservation choices: "any behaviour towards the work of art, included the intervention of restoration, depends on the recognition, or lack thereof, of the work of art as such" ("*qualsiasi comportamento verso l'opera d'arte, ivi compreso l'intervento di restauro, dipende dall'avvenuto riconoscimento o no dell'opera d'arte come opera d'arte*") (Carbonara, 2005), p. 341. This approach to conservation is therefore guided by a selective process, defined by Giovanni Carbonara as value judgment ("*giudizio di valore"*) (Carbonara, 2005), p. 340.

More recently, international Charters, Conventions, Declarations and Recommendations claimed the relevance of the intangible aspects associated with conservation practice and the meanings of conservation itself. Hence, it is worth to note that such international instruments consider the intangible aspects associated with built heritage by addressing their relevance in terms of value judgment, in order to identify their related impacts.

Table 3 provides a synopsis of the international instruments that deal with the intangible aspects and values of a heritage site, ranging from the Venice Charter of 1964 to the UNESCO Recommendations on the Historic Urban Landscape and the Valletta Principles of 2011. The table evidences the dimensions and aspects recognized by the different instruments in relation to the date in which they were adopted. Then, considerations about the aspects outlined in each document are reported, stressing the connection between values, meanings of heritage safeguard and conservation actions.

Table 3 The table reports Italian and international documents dealing with the conservation and safeguard of the intangible elements and values associated with built heritage in order to legitimize and make meaningful any conservation action. Source: Author.

DOCUMENT NAME	DOCUMENT TYPE	DATE	ELEMENTS OF INTANGIBLE HERITAGE VALUES	CONSIDERATIONS	SOURCE
Venice Charter	Charter	1964	Introduction) *Imbued with a message from the past, the historic monuments of generations of people remain to the present day as* ***living witnesses of their age-old traditions***	To the built heritage is associated a spiritual value. In addition to tangible values of historic buildings, a sentimental and cultural value is recognized and associated to them.	[illegible]
Convention Concerning the Protection of the World Cultural and Natural Heritage	Convention	1972	Art. 11.1) *Every State Party to this Convention shall, in so far as possible, submit to the World Heritage Committee an* ***inventory of property*** *forming part of the cultural and natural heritage, situated in its territory and suitable for inclusion in the list provided for in paragraph 2 of this Article. This inventory, which shall not be considered exhaustive,* ***shall include documentation about the location of the property in question and its significance.***	The Convention only concerns about a generic 'interest' on the cultural heritage, without specifying causes and nature of this interest.	[illegible]
Amsterdam Charter	Charter	1975	Art. 3) *The* ***architectural heritage*** *is a capital of* ***irreplaceable spiritual, cultural, social and economic value.***	Social, economic, cultural and spiritual values of built heritage are recognized.	[illegible]

Amsterdam Declaration	Declaration	1975	*Conservation calls for artists and highly-qualified* ***craftsmen*** *whose talents and know-how have to be kept alive and passed on. [...] This should help to* ***create the required pool of qualified planners, architects, technicians, and craftsmen to prepare conservation programmes*** *[…]*	It is underlined the relevance of local know-how and experts in the application of traditional knowledge and skills for conservation and maintenance actions.	[illegible]
Granada - Convention for the Protection of the Architectural Heritage of Europe	Convention	1985	Art. 17) *The Parties undertake to exchange information on their conservation policies concerning such matters as: the possibilities afforded by new technologies for* ***identifying and recording the architectural heritage and combating the deterioration of materials as well as in the fields of scientific research, restoration work and methods of managing and promoting the heritage*** *[...].*	Member States are committed to contrast the loss of commons and of threatened traditional and local professions associated with craftsmanship. The aim also consists in exchanging information on conservation practices and policies, also taking advantage of the new technologies.	[illegible]
Carta di Noto Prospettive per la Conservazione e il Recupero del Centro Storico	Charter	1996	Art. 4.b) ***Training and qualification of Art Masters in the architectural conservation field.*** *Considering the transformation or the vanishing of craftmens activities and of the associated techniques in the construction field and considering at the same time that good results in conservation are strongly influenced by the possibility of finding qualified workers with a thorough understanding of these techniques, the necessity and the urgency to train these workers and to retrain those already operating become evident*[illegible]. *(Translation by the Author).*	It is recommended the training of professionals able to work in the field of built heritage conservation.	[illegible]
Washington Charter	Charter	1987	Art. 2) *Qualities to be preserved include the historic character of the town or urban area and all those* ***material and spiritual elements that express this character.***	General principles are stated. Historic, spiritual along with tangible values are indicated as the aspects to be preserved.	[illegible]
Carta C.N.R. Conservazione e Restauro degli Oggetti d'Arte e di Cultura/Charter of the National Research Council for the Conservation of artistic objects	Charter	1987	Attachment B) *Instructions to deal with the conservation, maintenance, and restoration of the architectural heritage. Despite the recovery of traditional techniques, it is recommendable, it is not sufficient because it is necessary to be trained in their use. The substantial use of new techniques in the construction field and more generally also in the conservation field caused a loss of traditional know-how considered obsolete and improper.* ***A revitalization of that know-how it is possible only if carefully understood and combined with proper ad hoc training activities in Professional Schools and Universities***[illegible].	The Charter proposes the conservation of artistic objects through traditional technical solutions recognizing how these need to be supported by technological advances also to contrast the loss of traditional knowledge and skills. The Charter underlines how this approach could help to recover and safeguard traditional skills and reputable technical know how in the conservation practice.	[illegible]

Nara Document on Authenticity	Document	1994	Art. 5) *The* ***diversity of cultures*** *and heritage in our world is an irreplaceable source of* ***spiritual and intellectual richness*** *for all humankind.* Art. 13) *Aspects of the sources may include* ***form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling****, and other internal and external factors.*	It is underlined the difference between tangible and intangible values associated with built heritage. In a speculation emerges how these values can guarantee cultural diversity and the need to stress how these values are connected to the safeguard of cultural diversity and to the respect of each peculiar local context.	[illegible]
Declaration of Sant'Antonio	Declaration	1996	Art. 1) *The* ***authenticity*** *of our cultural resources* ***lies in the identification, evaluation and interpretation*** *of their true* ***values as perceived by*** *our* ***ancestors*** *in the past* ***and*** *by* ***ourselves*** *now as an evolving and diverse community.* *The comprehensive cultural value of our heritage can be understood only through an objective study of history, the material elements inherent in the tangible heritage, and a deep* ***understanding*** *of the* ***intangible*** *traditions associated with the tangible patrimony.* Art. 3) *In the case of cultural landscapes, the importance of material fabric must be weighed along with the* ***immaterial distinctive character*** *and components of the site.* *[...] there are heritage sites built of durable materials but that are subject to damage caused by periodic natural catastrophes, such as earthquakes, [...] In these cases, we also assert the* ***validity of using traditional techniques for their repair,*** *especially when those techniques are still in use in the region, or when more sophisticated approaches would be economically prohibitive.*	It stresses the importance of cultural identity as the core of the community and national life (this concept is addressed in reference to the America cultural diversity). The dynamicity of heritage values is also stressed by the Declaration outlining how authenticity is a compromise between the past and current values associated with built heritage. The relevance of intangible aspect to understand heritage cultural value is then clearly expressed in the Article 1 of the Declaration. These intangible aspects are defined as traditions. The Declaration also outlines the value of traditional building materials and techniques and their key role in the built heritage resilience. In a speculation, this can also be seen as a recognition of the value of local know-how.	[illegible]
Burra Charter	Charter	1999	1.1) *Place means a geographically defined area. It may include elements, objects, spaces and views. Place may have tangible and* ***intangible dimensions****.* 1.2) *Cultural significance means* ***aesthetic, historic, scientific, social or spiritual value for past****, present or future generations.* 1.12) *Setting means the immediate and extended environment of a place that is part of or contributes to its* ***cultural significance and distinctive character****.* 1.15) *Associations mean the connections that exist between* ***people and a place****.* 1.16) *Meanings denote what a place signifies, indicates, evokes or expresses to people.*	The Charter modifies the approach to conservation introducing the concept of intangible heritage stressing its cultural relevance. Intangible aspects include aesthetic and spiritual, dimensions.	[illegible]

			24.2) Significant meanings, including ***spiritual values****, of a place should be respected. Opportunities for the continuation or revival of these meanings should be investigated and implemented.*		
The Riga Charter on Authenticity and Historical Reconstruction	Charter	2000	Art.1) *The value of cultural heritage is as evidence, tangible or* ***intangible, of past human activity****.* Art. 4) *Authenticity is a measure of the degree to which the attributes of cultural heritage (including form and design, materials and substance, use and function,* ***traditions and techniques****, location and setting, and* ***spirit and feeling****, and other factors) credibly and accurately bear witness to their significance.*	In the Riga Charted is recognized the intangible values of cultural heritage as well as its tangible features. The document considers the intangible values more than the tangible ones, thus justifying reconstruction actions that would alter the tangible authenticity of a monument.	[illegible]
Charter of Krakow Principles for conservation and restoration of built heritage	Charter	2000	Art. 8) *Conservation in the urban context deals with ensembles [...] including* ***intangible values****.* Art. 9) *Landscapes as cultural heritage [...] integrating material and* ***intangible values****.* Art. 12) *The plurality of heritage* ***values and diversity*** *[...] participation of individuals and institutions in the decision-making process*	Focusing on built heritage, the concepts of the Burra Charter, the document stresses the relevance of morphological, functional and structural aspects in any conservation action. These aspects, including also the intangible ones, are intended to be witness to the changin relationship between society and environment.	[illegible]
Convention on the Value of Cultural Heritage for Society (Faro Convention)	Convention	2005	Art. 2) *Cultural heritage is a group of resources inherited from the past which people identify;* Art. 9) *a) promote respect for the integrity of the cultural heritage by ensuring that decisions about change include an understanding of the cultural values involved; b) define and promote principles for sustainable management, and to encourage maintenance ;c) promote the use of materials, techniques and skills based on tradition, and explore their potential for contemporary applications;* Art 13) *Encourage continuous professional training and the exchange of* ***knowledge and skills****;*	Intangible Cultural Heritage is considered as a retain and a resource for the society and its cultural memory. The Convention also encourages the exchange of these intangible values, such as knowledge and skills.	[illegible]
QUÉBEC DECLARATION On The Preservation Of The Spirit Of Place	Declaration	2008	Art. 1) *Recognizing that the spirit of place is made up of tangible as well as* ***intangible elements****, which all significantly contribute to making place and to giving it spirit, we declare that intangible cultural heritage gives a richer and more complete meaning to heritage as a whole and it must be taken into account in all legislation concerning cultural heritage, and in all conservation and restoration projects [...].* Art. 6) *Because in most countries of the world today the spirit of place, in particular its* ***intangible components****, do* ***not*** *currently* ***benefit from formal educational programs*** *or* ***legal protection****, we* ***recommend*** *the setting up of forums and consultations with experts from different backgrounds and resource persons from local communities,* ***and the development of training programs and legal policies*** *in order to better* ***safeguard and promote the spirit of place.***	The Declaration introduces the concept of the "spirit of place" claiming that it is made of tangible as well as intangible aspects. Focusing on the intangible aspects, the document stresses the need for educational programs, legal protection and policies. Further, opportunities provided by digital technologies are also considered and recommended in the preservation and promotion of intangible as well as tangible dimensions of heritage sites.	[illegible]

			Art. 7) *Considering that modern* ***digital technologies*** *[…] (that) can be used efficiently and effectively at a low cost to develop multimedia inventories that* ***integrate tangible and intangible elements of heritage****, their widespread use in order to better preserve, disseminate and promote heritage places and their spirit (is recommended)[…].*		
Recommendations on the Historic Urban Landscape	Recommendations	2011	Introduction - 3) *Urban heritage, including its tangible and* ***intangible components constitutes a key resource in enhancing the livability of urban areas, and fosters economic development and social cohesion in a changing global environment.*** I. Definition - 9) *[Historic Urban Landscape] wider context includes notably the site's topography, geomorphology, hydrology and natural features, its built environment, both historic and contemporary […]. It also* ***includes social and cultural practices*** *and values, economic processes and the* ***intangible dimensions*** *of heritage as related to diversity and identity.*	The Recommendations consider the multiple dimensions of the Historic Urban Landscape, including the intangible dimensions of heritage in these ones. These are intended as a key resource to increase urban life quality, economic development and social cohesion. The role of intangible dimensions is also stressed in relation to their pivotal role to guarantee cultural diversity and identity of the urban environment (with the associated repercussions in economic and social terms).	[illegible]
Valletta Principles	Principles	2011	Art 2.) *Historic towns and urban areas, as* ***living organisms****, are subject to continual change. These changes affect all the elements of the town (natural, human, tangible and intangible). Change, when appropriately managed, can be an opportunity to improve the quality of historic towns and urban areas […].* Art. 4.) *A management plan is based on the* ***knowledge, conservation and enhancement of tangible and intangible resources****. […] it must: determine the cultural values; identify stakeholders and their values; identify potential conflicts; determine conservation targets; determine legal, financial, administrative and technical methods and tools; understand strengths, weaknesses, opportunities and threats; define suitable strategies, deadlines for the work, and specific actions. The production of such a management plan should be a participatory process.*	The Principles evidence an increased awareness of the value of a place intended as integration among cultural and economic contexts, considering the constant change that characterizes living organisms such as historic towns and urban areas. Intangible resources are identified as one of the components to orient and manage this change in terms of policies, strategies of participatory planning and technical methods. They can guarantee an effective management of tangible and intangible resources preserving and promoting their knowledge for effective conservation and enhancement actions.	[illegible]

The analysis proposed in the table, helps to understand the role of the intangible aspects of built heritage in the value recognition process.

Laura Jane Smith states that heritage is not a 'thing' with crystallized and static meanings and values, rather it is an "*inherently political and discordant*" practice that performs the cultural 'work' of the present (Smith, 2006), p.11. As such, heritage can be conceived of as a social and cultural construct. These thoughts are defined in the concept of 'heritagization' (Poria, 2010), "*a social process whose final outcome is the presentation* *and interpretation of heritage (rather than the archiving or sustaining of heritage)*" (Poria, 2010), p. 218. Yaniv Poria underlines the relevance of the interpretation processes for cultural heritage and how tangible and intangible aspects as well as digital and IT supported solutions play a key role in this interpretation process.

Hence, modalities of people and institutions, loaded with value judgments, appear to be a fundamental issue in the heritage field.

Consequently, this study explores innovative ways to support the value judgments and the documentation in the cultural built heritage field through a creative combination of digital documentation workflows.

What is the final aim of the research?

The aim of the research consists in analyzing the dynamic relationship between tangible and intangible heritage because it strongly affects the values of a site with a consequent repercussion on the impacts of these values.

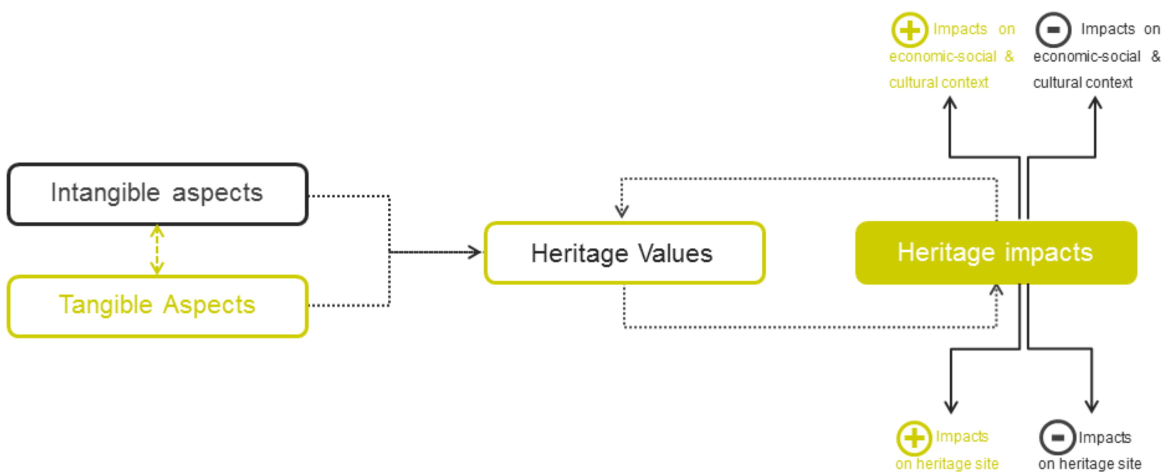

Figure 4 Aim of the research: the conceptualization of how tangible and intangible aspects affect heritage values and consequently bring about both positive and negative impacts on it, while heritage itself may, in turn, have positive or negative impacts on the surrounding social, economic and cultural context. Source: Author.

The report *Cultural Heritage Counts for Europe* defines the mutual connection among values and impacts. It states that "*values can affect impacts which in turn can lead to the elevation of the values, since an increase of heritage impact will evolve into a higher valuation of heritage. […] heritage is valued as a cultural asset, therefore people go and visit it, and this generates economic impact. This again can lead to a higher valuation of the good.*" (Sanetra-Szeliga, 2015), p. 53. This statement clarifies the relevance of the research in terms of local development, justifying the theoretical assumptions of the study from a functional point of view.

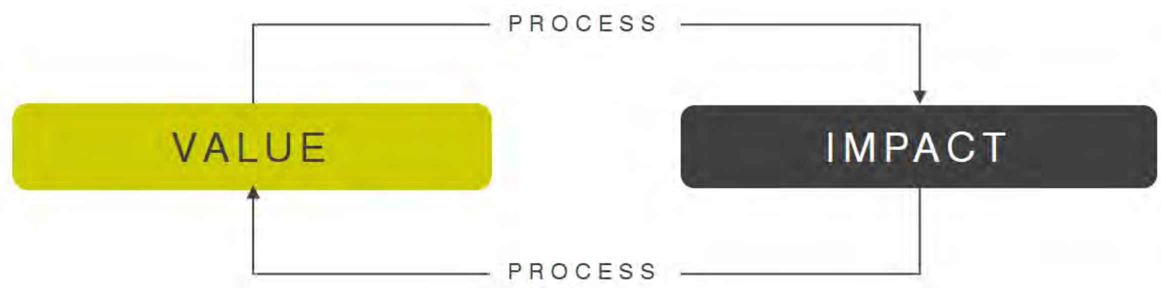

Figure 5 Relationship among Value and Impact as described in the report Cultural Heritage Counts for Europe (Sanetra-Szeliga, 2015), p. 53, readapted by the Author.

The same report tackles another topic of the research, justifying the importance of a bottom-up approach to information gathering, which takes into account the values and technical features associated with built heritage sites by different actors and stakeholders. The report notes that *"[…] although values and benefits are increasingly attributed to cultural heritage, they must be taken (by owners, local communities and authorities) rather than always derived only from the specific characteristic of heritage"* (Sanetra-Szeliga, 2015), p. 53.

1.3 Conceptual framework

In order to understand the relation between tangible and intangible heritage, it is firstly necessary to analyze the culture of conservation. To address this objective it is necessary to consider the close relationship between past and present by understanding their connection and consequentiality that find expression in the conservation processes. Indeed, "*the relation to the past is always an integral dimension of the form of being of the present, and restoration, dealing materially with the object, always exteriorizes this relationship in a manifest and indisputable manner, even in its least conscious aspects"* (Jokilehto, 1999), p. viii.

It is, therefore, important to stress, as noted by many experts and theoreticians, that conservation processes, evident manifestation of the past in the present, changed progressively. This change implied a gradual inclusion of wider objects (from single monuments to surrounding context and intangible aspects) and historical periods[44] (from classical architecture to modern one).

As Paul Philippot said, "*this extension of the domain of restoration and conservation is accompanied by a deepening of the critical concepts inherited from the classical tradition and the opening of a dialogue with other cultures*." (Jokilehto, 1999), p. viii.

According to this framework, the thesis deals with these aspects presenting the concept of conservation declined in extra-European contexts. More specifically, the role of the intangible values associated with built heritage is increasingly stressed in the current debate in the conservation field. Indeed, different cultural contexts develop their own

[44] This trend is analyzed in depth by Jukka Jokilehto reporting some consideration by Paul Philippot outlining that: *"[…] the European restoration panorama open itself progressively to diverse sectors originally neglected by classical tradition first to the Romanesque and Gothic Middle Ages, perceived especially in the national perspective, then, gradually, to the baroque world, and finally to the non- European cultures. In the second half of the twentieth century, interest spreads rapidly to historical ensembles, to vernacular or popular production, and eventually to territory where history and nature rejoin […]"*(Jokilehto, 1999), p.viii.

conservation approaches to the issues presently considered essential for any modern concept of conservation, such as the requirements of safeguarding the material authenticity and the intangible aspects related to the materiality of built heritage, its contexts and its uses.

This paragraph articulated into five subsections illustrates the conceptual framework at the basis of this research.

Starting from the semantic of different conservation terms, the associated meanings and concepts are presented. This premise introduces the concept of cultural diversity in heritage conservation. These considerations are aimed at justifying the role played by intangible aspects from the socio-cultural and technical point of view.

After that, challenges and threats brought by globalization phenomena are considered in relation to the decline of skilled professionals and keepers of local knowledge in the built heritage field. These considerations provide the context for the development of the research ideas justifying the focus on the conservation and documentation of both the intangible aspects embedded in historic structures and those rooted in the craftsmen (i.e. their tacit knowledge) needed for their maintenance.

The relationship among architecture, craftsmanship and tacit knowledge in built heritage structures is then debated. In particular, the relevance of tacit knowledge as a *trait d'union* to preserve built structures is discussed.

Then, a reflection on the tools to document this tacit knowledge is developed in two phases.

The first one focuses on the potentials of 3D models to represent built structures. In this part, a historical analysis of the different kinds of 3D models (from the tangible to the virtual ones) and their associated function is presented.

In the second phase, the potential of digital techniques and web platforms to enable participatory processes as well as efficient data collecting and management strategies is discussed.

1.3.1 *Conservation, preservation, restoration, restauro:* different meanings for different practices?

Starting from the semantics of the different terms - *conservation, preservation, restoration, restauro, restauración, restauration* - several meanings can be found.

Conservation, preservation, restoration and restauro share the same Latin root: the words *instaurare* and *reficere,* which respectively mean establish (with innovative component) and 'to make it again' (Enciclopedia Treccani, n.d.). Hence, the semantics of the term expresses in an effective way the meaning of re-inventing embedded in these concepts (Dezzi Bardeschi & Gioeni, 2004).

Jukka Jokilehto in his book 'History of Architectural Conservation' proposes the idea of an *"overall European culture"* of restoration (Jokilehto, 1999), p.vii. More recently, English Heritage reports that "*Current policies and good practice about what should be conserved and how that should be done represent a snapshot in time, rather than unchangeable truths."* (English Heritage, 2013), p.5. This assumption becomes more evident if we develop some reflections starting from the semantics of the different terms related to cultural heritage conservation concept along the time.

The different meanings of the term "restauration" and "conservation" date back to the XIX century.

The English term “restoration” assumed a negative meaning and was replaced by the word “conservation” as a consequence of the firm critique and denounce by John Ruskin. He deplored any sort of restoration that employed the destruction and/or alteration of the historical authenticity of a built structure. Indeed, Jukka Jokiletho Ruskin intended historic buildings *“[…] as a unique creation by an artisan or artist in a specific historic context. Such a genuine was based on man’s perception of beauty in nature, where it existed as a reflection of God. Age in itself contributed to beauty; the marks of age could thus be seen as an essential element in an object, that could only be considered ‘mature’ in its beauty after several centuries.”* (Jokiletho, 2002), p. 174-175.

Hence, even if Ruskin did not write a theory of conservation, he defined significance and values of historic built heritage, *“[…] providing a foundation for modern conservation philosophies.”*(Jokiletho, 2002), p. 175.

It is remarkable to notice that the terms related to heritage conservation change depending on the period of time as well as on the cultural context in which they are used.

According to Jorge Otero Pailos, different etymologies have different meanings[45]. For example, the term “preservation” is strictly connected to natural heritage[46]. This word has been particularly used, in the United States and more broadly in North America, referring to the safeguarding of parks and natural sites.

[45] Skype interview with Professor Jorge Otero Pailos, Associate Professor, Graduate School of Architecture, Planning and Preservation, Columbia University, The interview was held on October 14, 2014 at the Azrieli School of Architecture and Urbanism, Carleton University.

[46] Natural heritage includes: natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty. Article 2, Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972 (UNESCO, 1972).

In any case, even if different terms provide different meanings and interpretations of the "*act on heritage"*[47], they do not suggest a treatment or a particular group of professionals. Jukka Jokiletho stresses that modern conservation is *"founded in the new historical consciousness and in the resulting perception of cultural diversity."* (Jokiletho, 2002), p. 174.

Jorge Otero Pailos argued that preservation processes are important for heritage engagement. The act of preservation has to touch the people's mind. It deals with how people perceive a heritage object and suggests that the object is not only a physical thing, as it epitomizes a complex system of cultural relations. In order to deal with such relations, it is necessary to start from the semantics of the different terms defining the concept of heritage conservation. In fact, different words emphasize the cultural differences and consequently the different ways of acting on heritage sites with different features, values and meanings.

In fact, the concept of conservation is shaped within different cultures and societies as a political statement about the present, despite it may take the form of a reconstruction of the past[48]. See for example the case of the Old Bridge of Mostar[49] in Bosnia and Herzegovina, target of an attack void of any tactical justification (the bridge was destroyed precisely for its symbolic value of reaching across ethnic and religious divides), and whose intangible meanings of peace drove reconstruction – with the original stones recovered from the river in which they had fallen - after its destruction

[47] Jorge Otero Pailos interviewed on the 10th of December, 2014.
[48] The concept of heritage itself is multicultural by definition, and it is patchy in its interactions.
[49] The bridge is located in the historic town of Mostar, in Bosnia and Herzegovina, that developed in the 15th and 16th centuries as an Ottoman frontier town. After annexing to the Austro-Hungarian Empire (1908), military, cultural, and Christian religious buildings were established, these were mainly on the right bank of the river, where a new quarter was developed according to a strict 'Rondo' plan. Between 1992 and 1995 the town was badly damaged during the war. Most of the historic town and the Old Bridge, designed by the renowned architect Sinan, were destroyed. Recently, the Old Bridge was rebuilt and many of the buildings in the Old Town have been restored or rebuilt in order to re-establish the multicultural values of the city as a driver for peace. Source: http://whc.unesco.org/en/list/946 Consulted on December 14, 2014.

during the 1990s conflict (conservation = reconstruction). Another example is the reconstruction of the Castle of Gemona, in North - East Italy, that was destroyed by the 1976 earthquake and subsequently reconstructed by combining *anastylosis* with anti-seismic criteria (conservation = creative restoration).

Intangible aspects play a pivotal role within conservation processes. Hence, how can a holistic approach to conservation, intended as a physical and conceptual process, lead to a more inclusive intervention based on the respect of different context-based perspectives and interpretations of the cultural dimensions of heritage conservation/preservation/ restoration?

According to Jorge Otero Pailos, it is necessary to train professional figures[50], even at Ph.D. level, to be able to deal with the social and political issues of conservation processes as well as the practical and technical knowledge related to conservation acts. This aim is particularly challenging in the current world characterized by a globalized system of relations and knowledge that threatens cultural diversity. Since this diversity is a driver of local development, it is essential for guaranteeing inclusive cultural memory and heritage engagement.

In light of the considerations about different conservation theories and concepts, and with the awareness of the open issues in the heritage conservation field, what approach should be adopted for built heritage conservation? Which common principles and guidelines can be followed?

[50] According to Jorge Otero Pailos, there is a huge amount of existing buildings to be preserved. In the United States, for example, one third of the total amount of money invested in the architecture sector turns around existing buildings. However, there is currently no specialized training for specialized professional figures that are usually taken from other different fields.

How to judge in different cultural contexts the 'restoration fever' denounced in 1861 by Wilhelm Lubke after the restoration of the Frauenkirche[51]?

In order to address these complex issues, the first step consists in a comprehensive documentation that could allow and orient different conservation choices by respecting at the same time the local culture.

This documentation has to take into account not only the formal aspects but also the material aspects of a building and the *hic et nunc* (Dezzi Bardeschi, Gioeni, 2004) intended as the whole of changes and layers of a structure, witness of to its history and its cultural, economic and social context.

In line with Dezzi Bardeschi, the research aims at a better knowledge of the past legacy embedded in the built heritage for an improvement of actions and strategies on built heritage sites.

1.3.2 Setting up the problem: the importance of the local knowledge for built heritage conservation

One of the key issues this research will address concerns the problem of how to contrast the loss of skills and know-how related to architectural constructive techniques and building materials.

According to Feilden, the lack of recognition of skills needed for conservation and shortage of craftsmen and materials are two of the main problems in built heritage

[51] The restoration of Frauenkirche in Munich was strongly promoted by the archbishop of Munich. The purpose of the restoration was to bring the church back to its original shape, considered as an outstanding example of beauty according to the aesthetic taste of the time. Nevertheless, when the restoration works were concluded, many critiques arose including by such intellectuals and writers as Wilhelm Lubke, who stressed the importance of historical stratifications and their connection with the life of the local community, pointing out that "these buildings were not erected for the sake of an abstract ideal of beauty, but for a living consciousness of God" (Jokiletho, 2002), p. 194.

conservation[52]. Already in the 80's, he noted that "*the organisation of modern building industry is not related to maintenance"* (Feilden, 1985). Feilden stressed the evidence of this issue focusing on developed countries, where specialists related to the architectural field are becoming increasingly unaware of maintenance techniques, in favor of design requirements for new developments and constructions. This trend is causing the loss of skills and capabilities necessary for the understanding of historic buildings.

As it will be debated more in-depth in the next paragraph[53], such trend is usually slightly slowdown in developing countries. Indeed, in the so-called developing economies[54], socio-economic reasons make building maintenance, employing traditional materials and techniques, a common practice. Among the possible explanations, a key role is surely played by the slow assimilation of industrial production processes and by difficulties in importing globalized products (Feilden, 1985). As a matter of fact, as Feilden reports, in the pre-industrial period maintenance was normal building routine, since construction techniques were the same as the repairing ones.

Feilden's position does not imply a nostalgic vision of the past as something immutable. Rather, it underlines the importance of harmonious transformations in the architectural field, since sustainable techniques and constructive systems can be emulated from the past and innovated through the employment of new materials or revisited construction systems.

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[52] Other critical aspects in conservation of built heritage indicated by Bernard M. Feilden are the lack of an integrated approach by governments, difficulties in quantifying conservation's benefits, and the necessity of proper consciousness and education initiatives (Feilden, 1985), pp. 197-221.

[53] See section *1.3.3 Globalization and built heritage conservation in industrialized and developing countries: the decline of skilled craftsmen*.

[54] According to the World Economic Situation and Prospects (WESP), countries can be classified into three broad categories: developed economies, economies in transition and developing countries. Source: (World Economic Situation and Prospects (WESP), 2012).

Overall, the main research challenge consists in addressing how digitalization can support the understanding and the inclusion of these intangible aspects in built heritage conservation. As Cameron and Kenderdine observed, cultural heritage conservation and promotion benefit from digital technologies (Cameron & Kenderdine, 2007). Indeed, IT-supported documentation offers an opportunity to document, visualize and access different cultural objects at different scales in order to support their preservation. Nevertheless, despite the current development in the techniques and tools of digitalization, a key challenge addressed by the research is how to move on from documenting shape and geometry to a more comprehensive documentation that includes issues ranging from material assembly to technical solutions of heritage structures.

In line with these issues some questions arise:

1) How to deal with the limited knowledge and documentation on the traditional construction technologies and materials in heritage conservation? What is the potential role of the increasing range of IT-supported solutions for heritage documentation?

2) How to document the intangible knowledge and skills that produced the unique features of a given built heritage? How to recover this knowledge to increase efficiency, durability and compatibility of conservation projects stressing the value of craftsmanship in a mechanical qualitative society?

Concerning the first cluster of questions, IT techniques and systems are strongly affecting documentation projects in the Cultural Heritage field in terms of modalities and quality of the outcomes. Indeed, documentation is becoming increasingly time efficient and, in most of the cases, cost effective. The latter is a consequence of the fast diffusion in the market of Commercial Off-the-Shelf (COST) components and tools, the increasing availability of open source software and more generally the decreasing cost of tools and data processing software due to market competition as well as to the increasing availability of a range of tools and software supply.

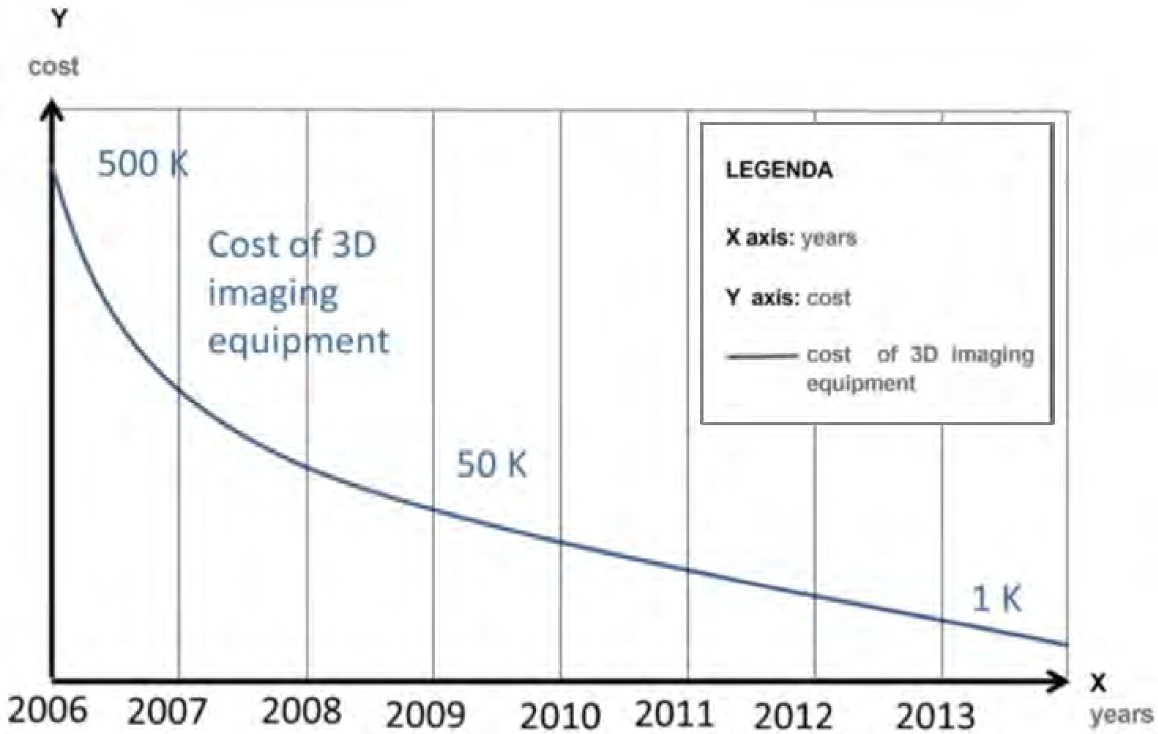

Figure 5 Cost and availability of 3D image systems. This diagram provides an example of the decreasing cost of digital documentation tool, in the last few years, with a focus on the 3D imaging equipment. Image adapted from Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts", (Mona, 2015).

Despite the constant development of IT solutions, these still present some limitations to be faced in the documentation within cultural built heritage field. Indeed, these tools are only able to capture surface information of the recorded structures, including color, shape, geometry and conditions. Nevertheless, this acquired information is not able to answer some necessary relevant questions for a full understanding of a built structure.

Hence, to move from a documentation of shape and geometry to a more comprehensive one including the documentation of material assembly and technical solutions of heritage structures, additional documentation strategies need to be developed. Consequently, additional issues arise. These include:

- *Which is the form of the inner structure of a recorded building?*
- *How are the inside elements - for example, the bricks of a cross vault or of a bearing wall - assembled and how to document them?*
- *What is the shape and configuration of employed materials (for example regular parallelepiped bricks or fragments of bricks/stones/etc.)? Which materials are used?*

These issues derive from the awareness of the architectural complexity of built structure, in line with Simon Unwin, who noticed that *"Architecture is not just as easy as knowing the basic elements. A large portion of its subtlety lies in how they are put together"* (Unwin, 2009).

Hence, the above-cited questions play a key role for a full understanding of the structures to document and are relevant to orient and support informed conservation actions as well as monitoring strategies.

In relation to the second cluster of questions, the outlined issues open up to wider concerns addressed by this study. These include the above-mentioned aim of the research consisting in contrasting the loss of skills and know-how related to architectural constructive techniques and building materials in heritage sites. For this aim, a comprehensive documentation of both the interior elements (intended as inner parts) as well as exterior features (intended as surfaces) of a building is fundamental. An organic and comprehensive documentation can indeed allow for informative conservation actions as well as effective monitoring and promotion strategies.

The digitalization of documentation, from the data acquisition to the final outcomes, can strongly support these processes by providing time and cost effective methodology as well as accurate and detailed information of heritage sites to be employed for long term management and planning. Digital documentation potentialities can also be used to document intangible aspects related to built heritage features, in terms of technical factors (i.e. adopted building solutions, knowledge and skills employed) and social aspects (i.e. significant building elements for a community).

However, despite the opportunities of digital documentation, it is necessary to consider additional aspects for its proper uses. These include information source and data gathering strategies, data longevity, data compatibility and the required time and costs for training and for the use of software applications and hardware tools.

Another opportunity introduced by digitalization processes in cultural heritage documentation consists in the possibility of crowdsourcing information or, more generally, information gathering through bottom-up logics. Interoperability among web digital platforms, databases and social networks opens up incredible opportunities and challenges in the Cultural Heritage field, allowing for dialogue, information-sharing and mutual collaboration among conservation specialists and the general public[55]. In relation to heritage engagement and social inclusion, the thesis stresses the concept of heritage ‘prosumer’[56] (Bertacchini, Feraco, Pantano, Reitano, Tavernise, 2008). The research approach aims at enhancing users as both information providers and final users[57]. Final outputs of users’ contributions to conservation processes can include, for instance, the

[55] All of these issues are based on the assumption that public inclusion and involvement are fundamental for any actions on heritage sites, justifying the conservation concept itself.

[56] This term indicates the role of heritage ‘users’ both as consumers and producers of heritage information.

[57] Once information is supplied, it is elaborated by heritage specialists providing tangible feedbacks - in terms of conservation choices and actions - to the inputs provided by different users (prosumers).

conservation of particular elements of a building or the eventual reconstruction of some of its components to which the local community associates particular meanings.

Dealing with inclusiveness in conservation processes, one of the main objectives is the understanding of the potential role of digital tools and web platforms. Henceforth, the key role of bottom-up strategies and digital tools is analyzed. In particular, the research investigates whether and how participation can contribute to built heritage conservation in a constructive way, by orienting its choices and providing valuable sources to be employed in the project development phase. Considering these opportunities, the research assesses common documentation practice, analyzing the most recent developments in recording techniques as a consequence of the adoption of IT solutions. These solutions include for example the developments of laser scanning, digital photography, aerial and terrestrial photogrammetry, IR camera techniques as well as the recent expansion of BIM systems, social media and web platforms.

In testing different techniques and tools, particular attention is paid to understanding if participation can considerably contribute to built heritage conservation. Possible modalities for participation in conservation are explored. From a technical point of view, a key research question is whether quality of knowledge can coexist with free and equal exchange in a community, thus reconciling quality and open access.

Finally, some of the main obstacles in the achievement of shared quality objectives in conservation projects are associated with the challenges in recognizing the cultural values that exist and characterize a built heritage site and its resident communities. This is evidenced by analyzing the case study of the living heritage site of Bagan. It presents further difficulties that consist in interpolating and organizing data within an adequate global project, for positive impacts for both the communities who live on a given site and other stakeholders who see it as a destination for organized cultural or learning tourism.

The questions of the research do not focus only on the "how" to include intangible aspects in the 'grasping' process of a historic structure, but also on the reasons why this should be carried out.

1.3.3 Globalization and built heritage conservation in industrialized and developing countries: the decline of skilled craftsmen

The consequences connected to the globalization and industrialization concepts were already perceived in the theoretical debate of the XIX century.

An example can be found in John Ruskin's theories promoting the importance of safeguarding the traditional craftsmanship in the face of massive industrialization processes that, at his time, were affecting also the architecture and construction field. Jukka Jokiletho outlines how Ruskin *"[…] feared that industrialization would alienate man from enjoying his work, and the result would thus remain empty and lifeless, lacking the life and 'sacrifice'".* (Jokiletho, 2002), p. 180. The relevance of craftsmen's work in architecture, in opposition to the industrialization and mechanization of the society,s was underscored by Colvin[58], who underlined the beauty of old workmanship in architecture, and stressed its superiority to the new models of beauty in terms of technical aspects and sociocultural meanings (Jokiletho, 2002), p. 183.

[58] Sir Sidney Colvin (1845-1927), was the first director of the Fitzwilliam Museum in Cambridge University; British Museum Keeper of Prints and Drawings. As a boy, he knew John Ruskin, whose work he emulated. He entered Trinity College, Cambridge where he was follwoign appointed as fellow. He entered the circle of Dante Gabrielle Rosetti from 1868 to 1872. In 1873, he was elected Slade professor of fine art at Cambridge. Archaeology and especially sculpture captured Colvin's interest (Dictionary of Art Historians, n.d.).

In the same period the recognition of the importance of craftsmen's intangible skills and knowledge was confirmed in 1861, when William Morris, with Dante Gabriel Rossetti and Philip Webb, among others, decided to set up the *Morris, Marshall, Faulkner & Co*. to provide fine arts with specialized workmen in painting, carving, furniture and metals. The purpose of this firm consisted in promoting a revival of the medieval artist-craftsmen, as idealized by Ruskin, by actively involving craftsmen in conservation processes (Jokiletho, 2002), p. 184.

From a more theoretical point of view, as Jukka Jokilehto reports, William Morris *"[…] extended the concept of art beyond the traditional three great arts, architecture, sculpture and painting, to what he called the 'lesser arts', the artistically creative design of all objects used by man".* (Jokiletho, 2002), p. 185.

More recently, due to the mechanization of the society (Ellul, 1967), the slow decline of skilled craftsman has been evidenced by Bernard Feilden[59]. He noted that "*the organization of modern building industry is not related to maintenance"* (Feilden, 1985a). This consideration becomes evident, in the current context, particularly in developed countries, where specialists related to the field of architecture are becoming increasingly unaware of maintenance techniques, in favor of new design skills required for developments and new constructions (Feilden, 1985a).

The Sant'Antonio ICOMOS Declaration is also aware of this issue. Stressing the value of heritage sites in relation to their cultural identity, the Declaration addresses the problem of cultural homogenization focused on the American context. The document makes aware

[59] Sir Bernard Feilden was a conservation architect and UNESCO consultant. Director of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) in 1977, since 1968 fellow of the Royal Institute of British Architects and from 1972 until 1977 he sat on the institute's council. He received several awards including the Aga Khan Award for Architecture, he was appointed OBE in 1969, CBE in 1976 and knighted as a Knight Bachelor in 1985 (The Telegraph, 2008).

of how within the globalization framework this phenomenon promotes commercial development and short-term benefits to the detriment of local values (ICOMOS, n.d.).

In developing countries, even if this trend is slightly slowed down, it still is an issue that needs to be faced not only for conservation purposes but also for harmonious development ones. The case of Bagan, Myanmar, presented in this research, is significant of this trend. Indeed, on the field surveys and direct observations evidenced how local crafts (i.e. craftsmen, brick makers, masons, plaster making and decorators, blacksmiths, carpenters, etc.) are rapidly disappearing because of new employment offer provided by firms in the tourist sector. Therefore, craftsmen - keepers of experience and tacit knowledge useful for the maintenance and conservation of Bagan heritage – are moving to other more profitable professions such as car or bus driver, tourist guide, workmen for new constructions (including hotels and other services for tourists).

1.3.4 Architecture, handicraft and tacit knowledge

In order to deal with architecture and the tacit knowledge that produced it, it is worth to introduce the concept of unity between 'head' and 'hand'. This concept is rooted in the Enlightenment theories and in the Ruskin theories related to the defense of manual work and of its dignity.

This relationship between craftsmanship – hand – and architecture – head – can find evidence in a consolidated tradition (from the medieval workshop to the strict association among craftsmanship, decoration, and design in the Barocco architecture, to the Art and Crafts movement, etc.).

More recently, Richard Sennet analyzed the association between tacit knowledge and handicraft studying the relationship between ‘head’ and ‘hand’ in the making process of built objects. The same approach can be extended also to the architectural level by considering handicraft as related not only to object and decorative parts but also to structural parts and constructive techniques. Sennet’s book, ‘The Craftsman’, stresses that craftsmen’s work commitment presents two forms: decision and obligation. The latter is organized by rhythm as craftsmen learn to perform their duty through continuous attempts. This can be found also in religious rituals that *”need to be repeated to become persuasive”* (Sennett, 2008), p. 177. The same rhythmical “*character”* (Sennett, 2008), p. 177, can be found in the production and maintenance of built heritage components: from the brick production and assembly in situ to the process of making plaster decorations.

Hence, how to preserve and document rhythm and rituals useful and fundamental to make meaningful the conservation of religious heritage?

Firstly, it is necessary to underline that 'prehension'[60] anticipates the meaning of an object such as a building (Sennet, 2008) and how it affects actions on it. For example, when looking at a church it is possible to anticipate that it is a place of worship and devotion, it is possible to imagine its construction period, the building techniques used, etc.

Prehension should be considered in the first phases of any conservation action because:

1. this mental prefiguration precedes every step of the making process and related consequences.

[60] According to Richard Sennet, Raymond Tallis structures the prehension into four dimensions: 1) Anticipation: for example, a man looking at a church is already prefiguring its inside and overall shape; 2) Contact: when we can touch an object understanding its materiality; 3) Language cognition: naming what one holds; 4) Reflections on what one has done (Sennett, 2008), p.155.

2. the prehension aspects should be considered and retained by any action on heritage site since it constitutes the identity and spirit of a place. Consequently, different conservation steps will have implications related to the prehension phase.

Therefore, the research proposes possible approaches to externalize the prehesion through ethnographic methods and digital workflows. This would orient the documentation providing a better understanding of the factors that characterize, for instance, the architecture of historic structures i.e. functional choices, spatiality, natural light design and management or decorative apparatus.

1.3.5. Architectural knowledge representation: the opportunities of 3D models[61]

The relevance of 3D models, either tangible or virtual, was not unknown in the past. Models as useful tools within architecture were used for centuries. While information about their use before Hellenistic civilization is limited, evidence suggests that the ancient Greek society used models in architectural practice (Piga, 1996). This trend continued until the Renaissance.

Greek epigraphic sources show the use of models in the Hellenic world[62]. For instance, Aristotle (384 - 322 a.C.), in the *Constitution of the Athenians* (Lozza, 1991)[63] noted that the Fifty's Council judged proposed projects of public buildings. These buildings had to be built according to models made of clay or wood. Architects were obliged to develop

[61] This part does extensive reference to a paper published at the XIII international Forum Le Vie dei Mercanti, "HERITAGE and TECHNOLOGY Mind Knowledge Experience", held in Aversa and Capri, June11-13, 2015. The title of the Conference Proceedings publication is "*3D modelling in Architecture: from tangible to virtual model*".
[62] Nevertheless, information about these models is poor and difficult to recover because usually quoted in contexts outside the architectural one.
[63] It is a short text formed by two parts concerning the history of the Athenian state - in the first part – and its constitution at the time of Aristotele - in the second part.

models in order to gain public approval and funding for their developments. These models were necessary to obtain the client's approval. Nevertheless, it is not yet clear if these models were used also during the building's construction phase. The use of clay and wooden models in the Greek world has been discussed in two passages of the *De Architectura* (Schofield, 2009) by Marco Pollione Vitruvio (80 - 15 B.C.). In the preface of the second book, Vitruvio recalled that the architect Dinocrates of Rodi[64] showed models to Alexander the Great in the attempt to get a contract.

Then, in the last but one chapter of the book X Vitruvio writes about Callia displaying his model of a technological solution, for the defensive walls of a city, in front of the authorities.[65]

It is interesting to stress that this trend is still modern. Indeed, even if the virtual models have replaced the wooden ones, they share a common function. Both are important to provide an immediate understanding of the project also to non-architects. According to Carlo Amati (Morolli, 1988), the use of models was common among architects to show their ideas to the clients and to give a real sense of their concepts.

Based on Greek tradition the architectural models were given less credit than theoretical project ideas, despite their main role in the acceptance process of a project. On the other hand, they were considered secondary to the intellectual development phase of a project (Guarducci & Coarelli, 1980). This lack of recognition has been demonstrated by the inclusion of the model within the production costs and thereby retracting its value as an individual entity (Piga, 1996). Evidence of the use of models in the ancient times can be

[64] Dinocrates was a Greek architect who lived under Alexander the Great in the IV century B.C. (Britannica.com, n.d.).
[65] Dinocrates presented to Alexander the Great his project for a huge fortified city on the Athos Mountain and a cistern for the water collecting and management. Callia presented a technological solution for the fortified wall, able to neutralize possible enemies' attack and sieges.

found in the Bible. In, *Chronicle I* it is described that the temple of Salomon in the X century BC was built on the basis of a model, defined by the Jewish term "Tabnit"[66].

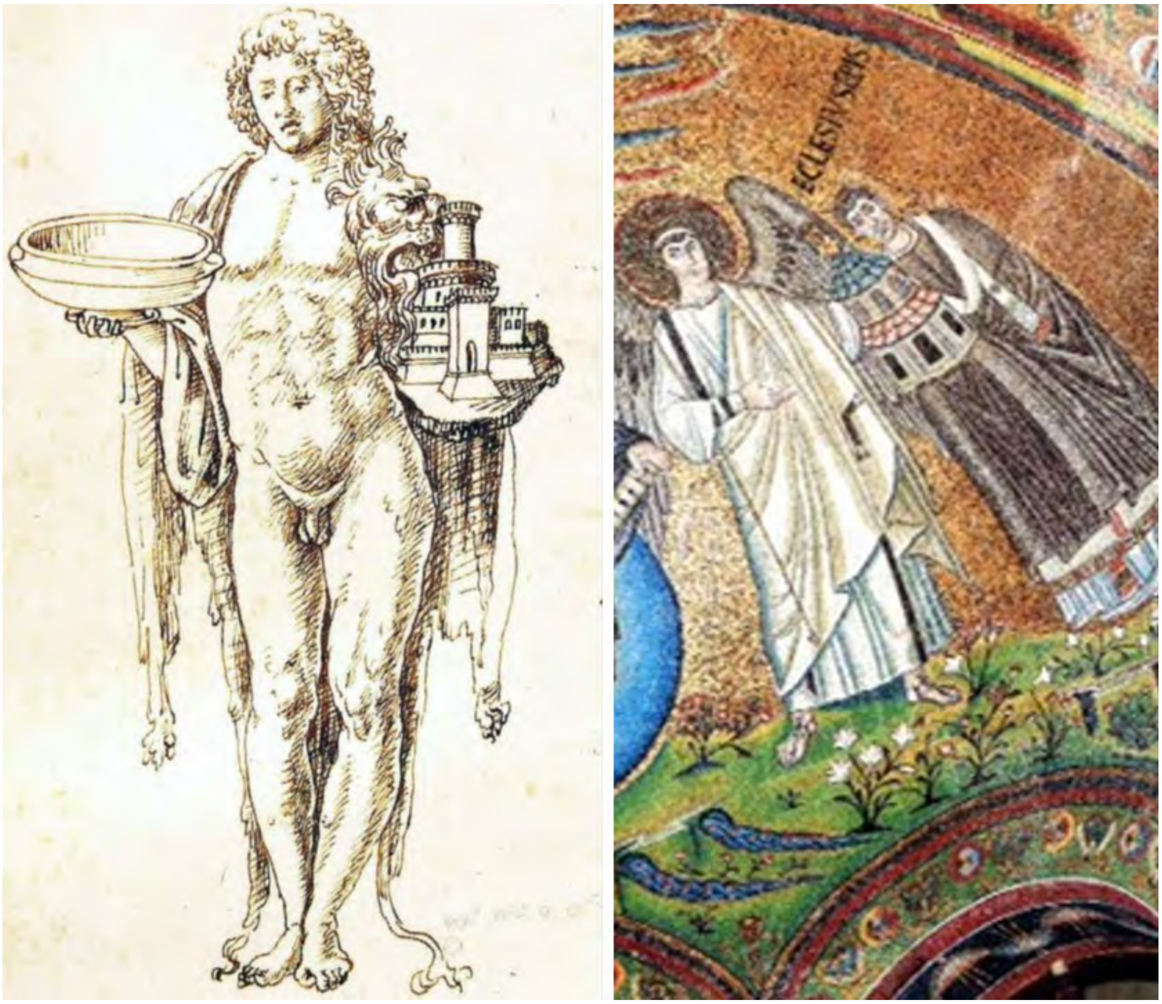

Figure 6 The image on the left depicts Dinocrates holding in his left hand the model of the project to re-shape Mount Athos. In his right hand, he holds his design of a cistern for collecting water for the city on the Mount Athos. Drawing, XV century, by Francesco di Giorgio Martini, in Cod. Magliabechiano II.I.141, f. 27v Location Biblioteca Nazionale Centrale, Firenze (Atlante dell'arte italiana, n.d.). The image on the right presents the mosaic of the apsis of the Basilica of San Vitale, in Ravenna. Image source: Angiolini Martinelli Patrizia. La Basilica di San Vitale a Ravenna. Modena (Angiolini Martinelli, 1997).

[66] The decision of building a temple dates back to King David. Although David started all the preparation for the temple's construction, included the model for the construction, his son Salomone built the temple (Piga, 1996).

Until the XIV century, literary sources did not provide information on the use of models in architecture. Nevertheless, models are depicted in the coins of the late-empire as well as in pictures, frescoes, and mosaics of apsis of some Christian basilicas.

In the Middle Ages, there are many medieval depictions of models of buildings (constructed or to be constructed) offered to superior authorities such as emperors, popes or God. An example is the Scrovegni Chapel, where Giotto depicts Enrico Scrovegni offering his building to Maria. This can be interpreted as a proof that the use of models was common, although we do not find written documentation. During the XIV century, documentation of models in written sources appears once again. According to Richard A. Goldthwaite, a model was a kind of guarantee of the feasibility of the project as a tangible evidence, and it was also a tool to resist to pressures of those wanting to change the original design during its construction phase (Goldthwaite, 1980).

Moreover, in this period architectural models served as a sort of copyright for clients. In addition to this, models provided a method to engage clients in the full comprehension of the project, as they did not always understand the intricacies of architectural drawing, recognizing the importance of the projects and of the idea behind it. In addition to that, the evidence of the models played a key role to show a clear and scaled realization of the future project, without requiring the capability of abstraction for the clients as required by the drawing technicalities.

Figure 7 Enrico Scrovegni offering the Model of the Scrovegni Chapel to Maria, Giotto, 1303 - 1305. Image source: Forli news (Forli news, n.d.).

During the Renaissance period, the model gained a new dignity and the first theoretical settings for its development and its function were formulated. The architects of this period used models in a different and personal way, locating them in different manners within the design steps. Nevertheless, the models were elaborated to gain the clients' acceptance for their development in a 1:1 scale. In the Islamic world, the use of the models was fundamental to obtain an approval for the construction of a building (Gulru, 2005). An example is the use of the model by the architect Sinan[67] in Turkey, during the XVI century. For instance, there are written records of the model of Süleymaniye Mosque decorated with wood and ivory. It was so detailed in its construction that it was virtually identical to the original (Sinan, n.d.). The role of architects in the Islamic civilization was not limited to architectural drawings, but it was extended to the making of miniature models of buildings. This practice was common among Muslim rulers and was used in several circumstances. The use of prototypes became common practice in the Ottoman era. Wooden and silver models, such as the one of the Izet Pasha Mosque, became common. Records also mention models decorated by wax. For instance, the Ottoman Sultan Mohammed I only became convinced of constructing an Ottoman building after seeing a miniature model of it (Arabworldbooks, n.d.).

During the XIV and XV century, it is possible to find evidence of the use of models in architecture practice as for the Duomo of Florence, the Cathedral of Milano and the Basilica of Bologna.

[67] Sinan, called Mimar Sinan (Architect Sinan) and Mimar Koca Sinan (Great Architect Sinan), is the most celebrated of all Ottoman architects. Sinan was nicknamed "the Michelangelo of the Ottomans" because of his key role in the definition of the Ottoman architecture (Gulru, 2005).

 

Figure 8 The image on the left presents the wooden model of the Basilica of San Petronio, Bologna, 1514. Source: (Arte.it, n.d.). The wooden model on the right presents the completion for the San Lorenzo’s facade, in Florence, designed by Michelangelo Buonarroti, 1518. Wooden, 216 x 283 x 50 cm Casa Buonarroti, inv. 518. Image source: (Friends ofArt, n.d.).

During the XIV century, there is a huge written documentation about the use of models in architectural practice. In the Renaissance, architects used models as common tools in the design process. The sequence of this process is concept/idea – drawing – model. The model as physical visualization of the project was the tool used to deliver the architect ideas to the client. Indeed, the model was an unequivocal, immediate, tangible three-dimensional representation of the building to be achieved, easy understandable also by non-architect. Further, the model becomes also a tool to be used to build the final project.

Figure 9 Wooden model of the Duomo of Pavia,1497. Engraved in cypress, oak and walnut wood by Gian Pietro Fugazza based on the design by Giovanni Antonio Amadeo and Gian Giacomo Dolcebuono. Image source: (Panoramio, n.d.).

Leon Battista Alberti - writer, architect, humanist, philosopher, towering genius and *homo universalis* (Burk, 1974) - expressed the relevance of the use of models in architecture. In the *De Re Aedificatoria*[68] he gave the model a role of fundamental importance within the creative process of the architect: *"[...] I will always comment the time-honored custom, practiced by the best builders, of preparing not only drawings and sketches but also models of wood or any other material [...]" De re Aedificatoria*, Book II, 6 (Alberti, 1998), p. 34.

In the *De re Aedificatoria* Leon Battista Alberti expressed the cultural dignity of the models within the architectural practice. Indeed, he claimed the importance of models to obtain a perfect building execution: *"To avoid such pitfalls, therefore, I must urge you again and again [...] (to use) scale models, re-examine every part of your proposal [...] tile there is nothing, concealed or open [...] for which you have not thought out, resolved, and determined [...]" De re Aedificatoria*, Book 9, 8 (Alberti, 1998), p. 313.

[68] The Alberti's work is a humanist treatise devoted to architecture, very densely erudite. According to the trend of the recovery of the classics, driven by the rediscovery of the Vitruvian treatise by the Florentine humanist Poggio Bracciolini in 1414, "*the treatise has been written with the aim of organize the architecture discipline"*.(Alberti, 1998).

About ten years later after the publication of the *De re Aedificatoria*[69], Filarete wrote his treatise *On architecture* (Spencer, 1965). In his treatise, he dealt also with the opportunities of using models. The treatise defined a model as the final output of a project, «*disegno piccolo rilevato di legname*» (Filarete, 1972), which is responsible for the whole design process. For Antonio Averlino, known as Filarete, the model lead to a less hermeneutic and theoretical dimension, providing a bi-univocal interaction with the drawing, fixing its ratios. In the book VII of the treatise, he dealt with the combined use of wooden models and drawings and how to overlap both in the execution phase. The key role of the model in architecture design as well as in the construction and building phase, during the Renaissance, was proved by Filippo Brunelleschi. Thanks to Vasari, it is possible to know the function of models for the structural analysis in the constructive technique choices to be adopted as well as in the design phase.

[69] The first five books were apparently written between 1443 and 1445. The five others were written between 1447 and 1452, if Poliziano's brief letter can be believed. Leon Battista Alberti apparently intended to publish his work, dedicated to Lorenzo de Medici. In spite of this, the first version was presented to Pope Nicolas V in 1452. Alberti gave a copy of his treatise to Pope Nicholas V because the pope was rebuilding Rome. (Rykwert et al., 1998).

Figure 10 Wooden model of the Lantern of the Cathedral of Florence, by Filippo Brunelleschi. Museo dll'Opera di Santa Maria del Fiore, Florence. The model may have been made by Brunelleschi or it may be one of the models made for him by Ciaccheri in 1436 ("Wooden model of the Lantern of the Cathedral of Florence," n.d.).

The importance of a model is then stressed in a passage of Vasari which points out the secrecy of the model during the project step (Manetti, De Robertis, & Tanturli, 1976). Moreover, according to the historian Piero Sanpaolesi, the impossibility to find a precise date of the completion of the wood model of the cathedral of Florence, is an evidence of its development *"contemporary with the construction*" (Scolari, 2012), p. 187. Massimo Scolari reports that models, as in the ancient Greece, were used to compete for a project*: "The jury […] selected Brunelleschi's design as being the most robust and at the same time, the lightest; moreover, it permitted better lighting and formed efficacious protection against elements".* (Scolari, 2012), p. 187.

Figure 11 The wooden model of the dome of the cathedral of Santa Maria del Fiore, XV century (measuring 100 X 90 cm central part, 55 X 63 X 35 cm side parts), is kept in the Museo dell'Opera di Santa Maria del Fiore. It includes parts of the apse and the block formed by the dome and drum, with a portion of the piers and arches underneath. Source: Il balllatoio della cupola di Santa Matria del Fiore. In Antichita' viva (Marchin, 1977), (insidethevatican.com, n.d.). The image on the right presents the interior of the wooden model for the Basilica of San Peter, by Antonio da Sangallo il Giovane, XVI century ("Wooden model for the Basilica of San Peter," n.d.).

Some years later, Antonio da Sangallo[70] and Michelangelo Buonarroti, used the model not only for structural assessment and design purposes but also as a reference tool within the building site activities. Their models prepared for the construction of the Basilica of San Peter in Rome[71] were used as main construction tools. These scaled models were used by the workmen in the building site, to the construction in a 1:1 scale. In addition, the models were also tangible demonstrations of the good or bad work of the architect. Michelangelo, for example, used the model of the roof to show the accuracy of his project and the mistakes of the workmen during the execution phase, to defend his own work (Pacciani, 1987). Therefore, it is possible to claim that the architects of the Renaissance used models as effective reference tools for construction and design.

3D Digital Models

Current practice is once again embracing the use of 3D modeling, although virtual and digital forms replaced the tangible form of historical models.

Tangible and virtual 3D models used by architects have changed in type, scope, and function. They play different roles within the design processes and in the project management of the built environment.

[70] The model of the project by Antonio da Sangallo elaborated by Antonio d'Abaco was completed between 1539 and 1546.

[71] In 1505, the pope Giulio II charged Bramante of the reconstruction of the Basilica of San Peter, who presented a project of reconstruction of the Basilica. Not totally convinced, the Pope asked sought also the opinion of Giuliano da Sangallo, who developed in 1506 the definitive project, which included some of Bramante's ideas. When in 1516 Giuliano da Sangallo died, his nephew Antonio replaced him in the works on the Basilica of San Peter. In 1519 a new project was approved by Pope Leone X who succeeded Giulio II. Only in 1534 Paolo II Farnese charged Antonio da Sangallo to re-elaborate the project and to build a detailed wooden model. The model was made in 1:30 scale and it is the biggest model ever built in the Renaissance. The model is elaborated in order to have a tangible guarantee of the project. Moreover, it was used as communication tool between the architect and the workers. Its elaboration required more than seven years and it was developed in parallel with the construction works of the Basilica.

Figure 12 Symbolic representation of the transformation of the use of models, from the tangible to the virtual ones, within the design processes along history. Image source: author's elaboration. Image source: Author.

The historical consideration of the model's practice is useful to understand the impact of the computer-aided design in the 1980s that has radically transformed their generative process. 3D modelling is a procedure of graphic representation of an object in three dimensions in a virtual space. It is based on algorithms, by employing dedicated software that uses, as a starting point, data coming from 3D surveys or from other sources of information.

Currently, the techniques of 3D modelling can be divided into manual modelling with 3D computer graphics; procedural modelling and modelling based on real measures (with data coming from 3D scanning).

The manual modelling with 3D computer graphics consists in the creation of three-dimensional models based on imagination or imitation, instead of surveys or real data measurements. This technique is principally used for the representation of scenes and figures, both still and moving, through complex surfaces, based on math formulas and algorithms designed with specific software (Sketch-up, 3DStudioMax, Maya, etc.,)[72].

The second technique is procedural modelling that generates 3D geometries using commands and functions of extrusion, on the basis of automatic or semi-automatic methods (for example through software like City Engine) including an analytical and a generative phase. The analytical phase entails the definition and the use of a vocabulary of shapes and rules classifiable for the designing phase and the indication of formal archetypes to assemble many geometrical elements based on similar algorithms. The generative phase entails the reproduction of complex architectural or urban structures (i.e. housing, palaces, temples, churches, fortifications, bridges, aqueducts, etc.).

[72] They are especially used in movies, television, architectural and engineering and in many scientific sectors.

Finally, the modelling based on real measures, obtained through a 2D and 3D survey, has the following purposes[73]:

- the metrical investigation aimed to the knowledge of the dimensions, shapes, and ratios of the resources in order to be able to elaborate comparative studies between monuments and contexts;
- investigation of the original constitutive materials and of those required for restoration;
- diagnostic studies before a particular intervention;
- assessment, analysis, and monitoring of different kinds of pathological degradation (chemical, physical, micro-climatic and accidental);
- simulation of specific physical phenomena on the building surface (or single parts of it) for the prediction of effects, for instance, the exposure to atmospheric agents, artificial light, deposits of dust and the prediction of the static behavior of buildings or urban contexts under particular stress conditions (i.e. catastrophic events);
- planning of routine and special maintenance;
- restoration projects, giving a visual database with a layered referencing of data coming from diagnostic surveys and from the different steps of the intervention and, consequently, chance to simulate integrative or reconstructive hypotheses (i.e. the determination of the methodologies to follow and the use of materials and products);
- creation of digital archives allowing the reunification of resources distant from each other and the possibility of consulting and studying masterpieces, monuments and urban complexes from remote positions;

[73] The purposes consider the application of 3D modelling based on real measures in the field of the Cultural Heritage field.

- communication and cultural dissemination, exploiting the potentialities of 3D visualization for information, not easily understandable by the direct contact with the monument and the context in which it is inserted (Mezzino, Rinaudo, 2015).

This overview on 3D modelling has been useful to understand how according to Branko Kolarevic 3D modelling "*capable of consistent continual and dynamic transformation*" are replacing the classical architectural drawing (Kolarevic, 2003).

In contemporary architectural design, digital media is increasingly being used as a tool to generate, visualize and control new and existing architecture (Mezzino et al., 2015).

The following sections analyze and test possible efficient uses of 3D modelling for a comprehensive management of built architecture (Chapter 5, 7 and 8).

1.3.6 Conservation and digitalization in the internet Era

Digital systems allow the development of a large amount of data on heritage sites including but not limited to photos, videos, 3D models, scans, multimedia files, etc., (Andaroodi & Kitamoto, 2014). These data are shared on the Internet on different portals (such as websites, social networks, webplatforms, etc.) that can be used to promote the sharing of additional information in a participatory logic. This information enriches the knowledge of heritage structures supporting their conservation, maintenance, and management.

Digital opportunities and challenges for cultural heritage are identified by several scholars such as Peter Stabel[74], which recognizes how *"Digital heritage is in danger of*

[74] Peter Stabel is a Professor of Medieval History at the History department of the University of Antwerp in Belgium. His research expertise is in urban history and economic culture in the Middle Ages and the Early Modern Period (Tamborrino, 2014).

becoming a real Pandora's Box: Hence it stimulates participation, digitization will unavoidably influence the content of heritage itself" (Stabel, 2014), p.29. Similarly, Donatella Calabi[75] noted that traditional research methods in the field of the humanities, combined with innovations in visualization technologies and tools, allow effective representation of the dynamic nature of heritage objects (Calabi, 2014).

In line with this concept, Caroline Bruzelius[76] stresses the role of the Digital Revolution in studies and applications in the humanities, noticing that this revolution is *"an inevitable and transformative part of the future"* (Bruzelius, 2014), p.107. She notices that digital technologies and web platforms are revolutionizing the representation of historic object in space and time at different scales (Bruzelius, 2014).

Web platforms, social networks and internet provide access to a vast amount of information and open up new documentation methodologies to collect and interpret it. While digital technologies and tools present several opportunities for data capturing and data processing in terms of accuracy, costs and time of the processes required.

[75] Donatella Calabi is a Professor of Urban History at the IUAV University of Venice, Italy. She is also visiting Professor in several academic institutions and former president of the European Association of Urban Historians (EAUH) and of the Italian Association of Urban History (AISU) (Tamborrino, 2014).

[76] Caroline Bruzelius is a Professor at the Duke University, Durham, United States. Her expertise is medieval architecture and urbanism. She is a member of the American Academy of Arts and Sciences, and a Fellow of the Society of Antiquaries, London, and the Medieval Academy of America. She was awarded with a Ph.D. at Yale University. In 2016 she received the leadership of the the Wired! Lab at Duke. In the Lab she is focusing on how to integrate digital technologies with Humanities teaching strategies and research approaches. From 1994-1998, she served as the Director of the American Academy in Rome (Tamborrino, 2014).

Figure 13 Example of Augmented Reality application in the Ara Pacis, Rome, Italy. Image source: Inglobe Technologies, "ARA as it was", a first of a kind Immersive Augmented Reality experience for Cultural Heritage, (Inglobe Technologies, n.d.-b).

In terms of visualization, digital technologies allow:

- to geo-reference historic information about the conditions of existing buildings and urban areas;
- to correlate information (i.e. archival resources in current as well as ancient maps);
- to visualize the change in buildings' shape as well as urban contexts through dynamic 3D models;

- to identify and study broad areas such as rural and urban landscapes or site borders (i.e. employing Remote sensing and satellite information);
- attractive visualizations and digital storytelling through multimedia, Virtual Reality (VR)[77] and Augmented Reality (AR)[78] applications. These applications can support built heritage conservation increasing understanding, awareness, and sensitivity towards built heritage, stimulating fundraising actions and community engagement.
- to document and reconstruct past transformations through historical and documentary evidence.

In terms of recording, digital workflows speed up recording activities in the data acquisition as well as in the data processing phase. Examples are provided by Laser scanning, Photogrammetry, Digital Photography, Reflectorless Electronic Distance Measurements (REDM), Global Position System (GPS) and Remote Sensing techniques. These digital techniques offer efficient solutions to record built structures in relatively short time (compared to manual recording techniques) with a 'good' accuracy depending on project requirements, type of technique, time and budget available as well as user skills.

Concerning the cost of these techniques, considering the constant pace of innovation, it will exponentially decrease making them more affordable also from the economic point of view (i.e. laser scanner, camera prices in the data acquisition as well as software license costs in the data processing phase).

[77] Digital innovation in the built heritage field focused the attention in the development of immersive environment as evidenced by the diffusion of Virtual Reality headsets, such as Google Cardboard, Oculus Rift, HTC Vive and Samsung Gear (Inglobe Technologies, n.d.-a), (Inglobe Technologies, n.d.-b).

[78] For instance, Augmented Reality applications on historic structures have been experimented by Zètema together with the municipality of Rome, in the Ara Pacis Augustae. The project "ARA as it was", consists in the first large scale augmented reality applied on the roman built heritage. The selected monument symbol of the Augustan peace in the Mediterranean areas after the wars of France (Gallia) and Spain embeds several values, from the tangible and historical, to the artistic, social and cultural ones. Built in the 9 B.C., the marble monument is an interesting example to test augmented reality application considering the abundance of values of Roman Empire architecture that it represents (Inglobe Technologies, n.d.-a), (Inglobe Technologies, n.d.-b) and (Roma Segreta.it, 2016).

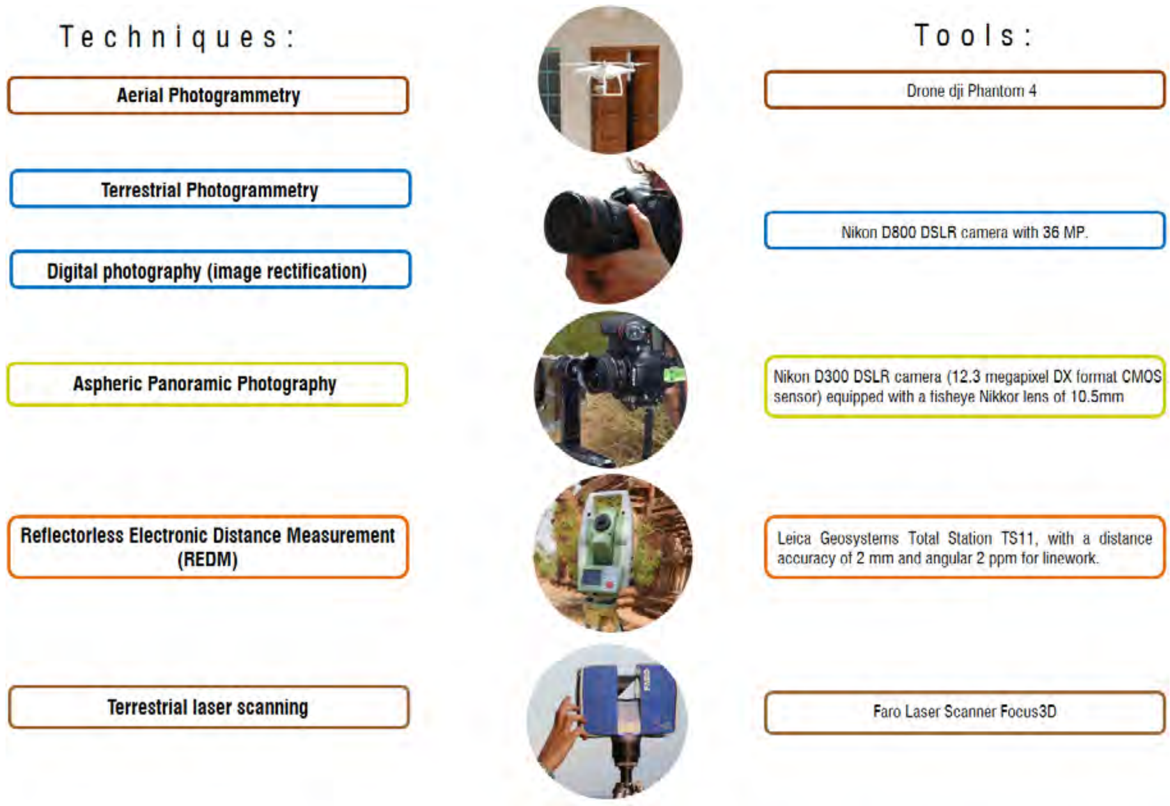

Figure 14 Example of digital recording techniques and associated tools. The tools specifications have been selected among that one used in this research. Image source: Author.

In terms of information management, digital database allows efficient and organic organization of different types of information associated with historic structures. Territorial Information Systems associate descriptive information to geometric features (such as areas, lines, and points) in georeferenced database. These systems, also known as Geographic Information Systems (GIS), allow supporting conservation actions offering efficient systems of information collecting, archiving, management, retrieving and analysis.

These functions support the inventory, evaluation, and preservation of historic sites (Droj, 2010).

Recent innovations in Territorial Information Systems, enlarged their application also at the architectural scale. The multiscale approach of GIS applications has been for instance tested by Cerutti, Donadio, Noardo and Spano'. Focusing on buildings facades identifying historical layers and pathologies spatial and semantic information were collected and archived. With these applications on different case studies, the potentials of GIS for stratigraphic survey at different scales (from territorial scale to building elevations) were experimented. These applications prove the potentialities of GIS to support interdisciplinary knowledge and planning phases (Cerutti, E.; Donadio, E.; Noardo, F.; Spanò, 2015).

Further researches focus on the development of open source GIS such as Arches, gvSIG project, Whitebox GAT, SAGA GIS (System for Automated Geoscientific Analyses), Open Street map, GRASS GIS (Geographic Resources Analysis Support System), ILWIS (Integrated Land and Water Information Management), MapWindow, GeoDa, uDig (User-friendly Desktop Internet GIS), Diva GIS, FalconView, OrbisGIS or QGIS (Geography, 2017).

Even if most of these open source GIS were not designed for the built heritage field, they can be easily adapted to it.

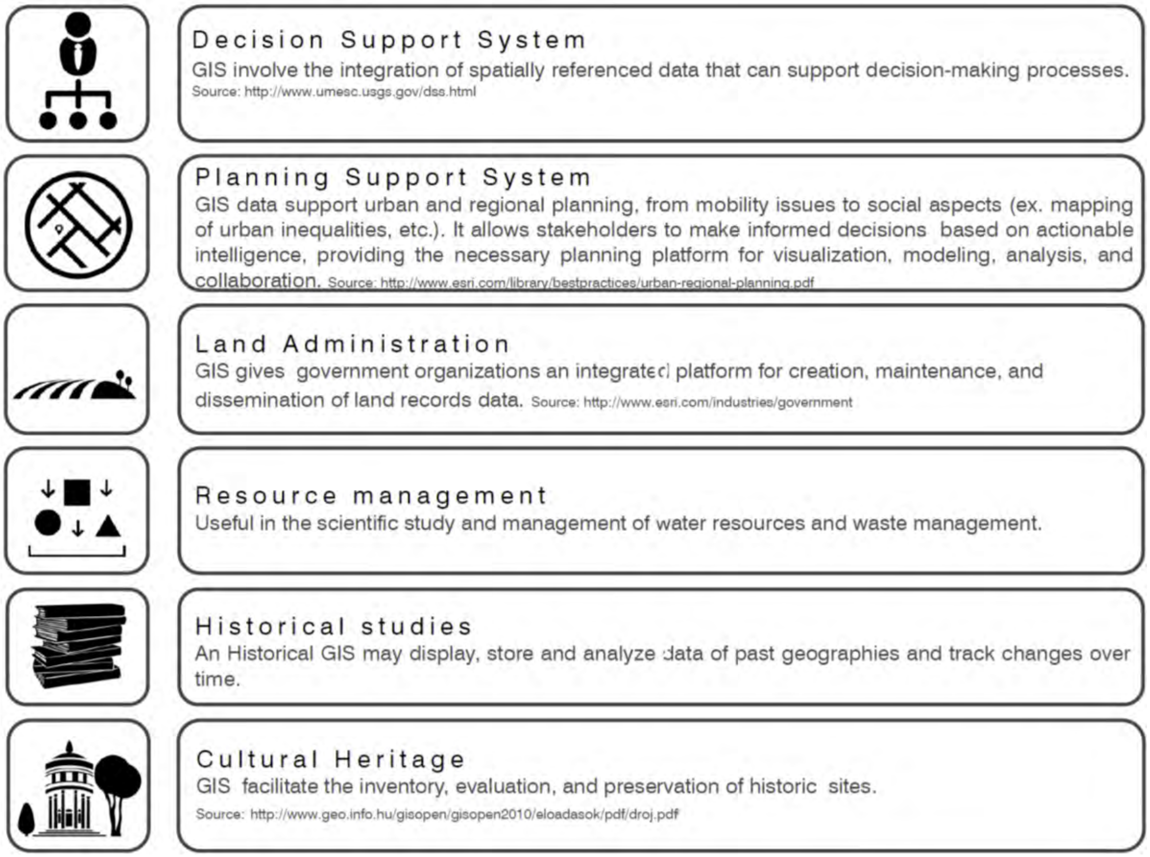

Figure 15 GIS application in the built heritage field. Image source: Author.

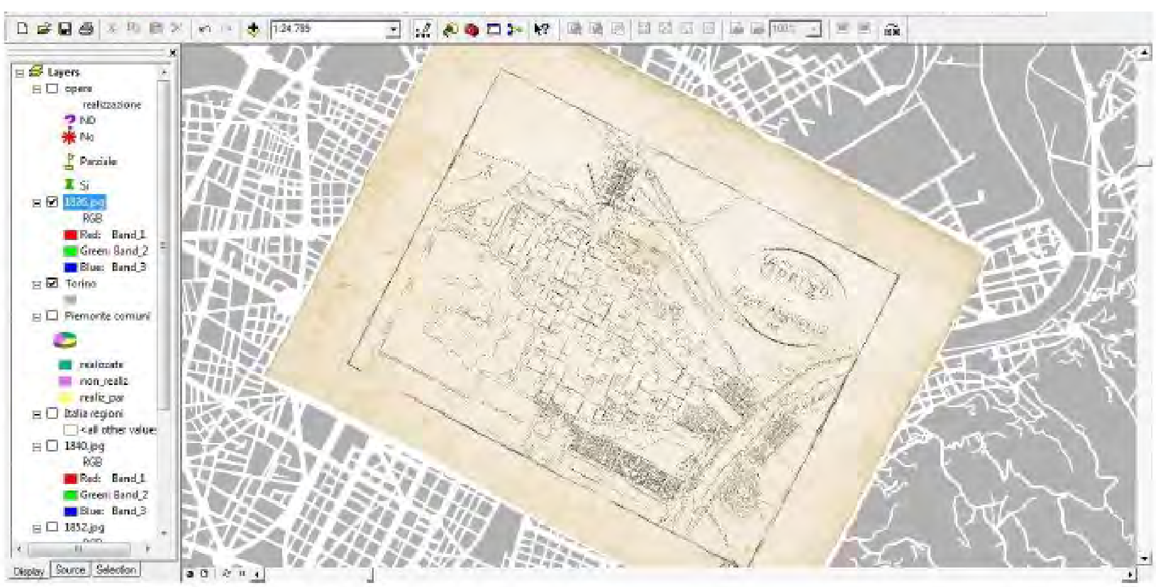

Figure 16 Example of historic information management in a GIS environment to store and structure geographic data and Attribute (descriptive information) on built heritage sites. Image source: Author.

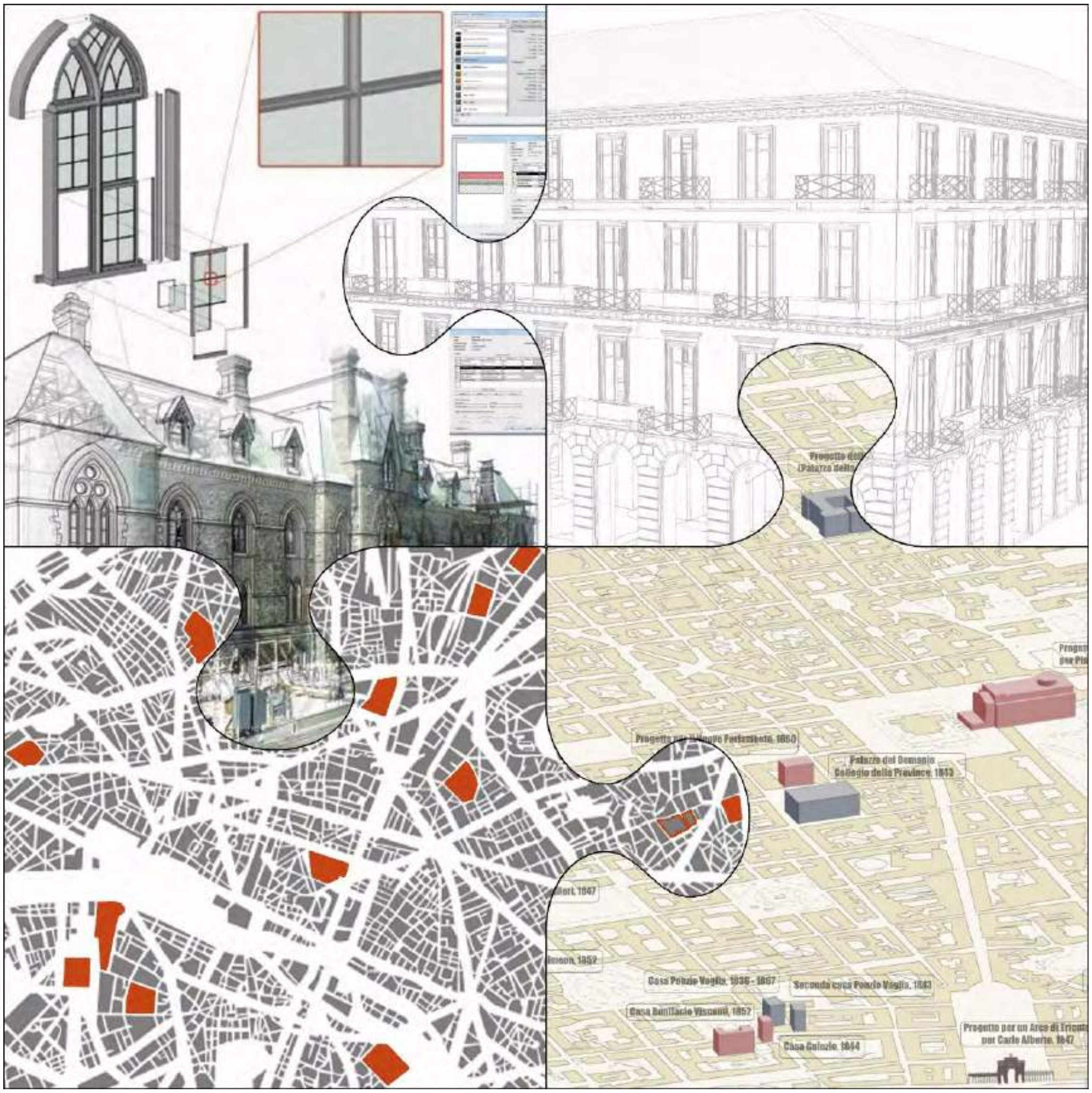

Figure 17 Image symbolizing the potentials of Spatial and Territorial Information Systems for built heritage conservation. Image source CIMS website (Carleton Immersive Media Studio (CIMS), n.d.)and I-Change website (I-Change, n.d.). Elaboration by the Author.

Apart for Territorial Information Systems, Spatial Information Systems are currently attracting the attention of academics and professionals that are experimenting different solutions also applied to built environments. Within this framework, research are mainly related to the potentials of BIM tools applied to historic structures as discussed in paragraphs *4.3 Digital 3D modelling for historic buildings: Building Information Modelling (BIM) potentials and applications* and *5.4 Challenges of BIM parametric modelling for built structures: LoD, model usability and effectiveness.*

Therefore, technological advances have several outputs in built heritage field, affecting its visualization, documentation and management workflows. The broad diffusion of these techniques and tools in built environments is evidenced by applications and initiatives promoted by both public and private stakeholders.

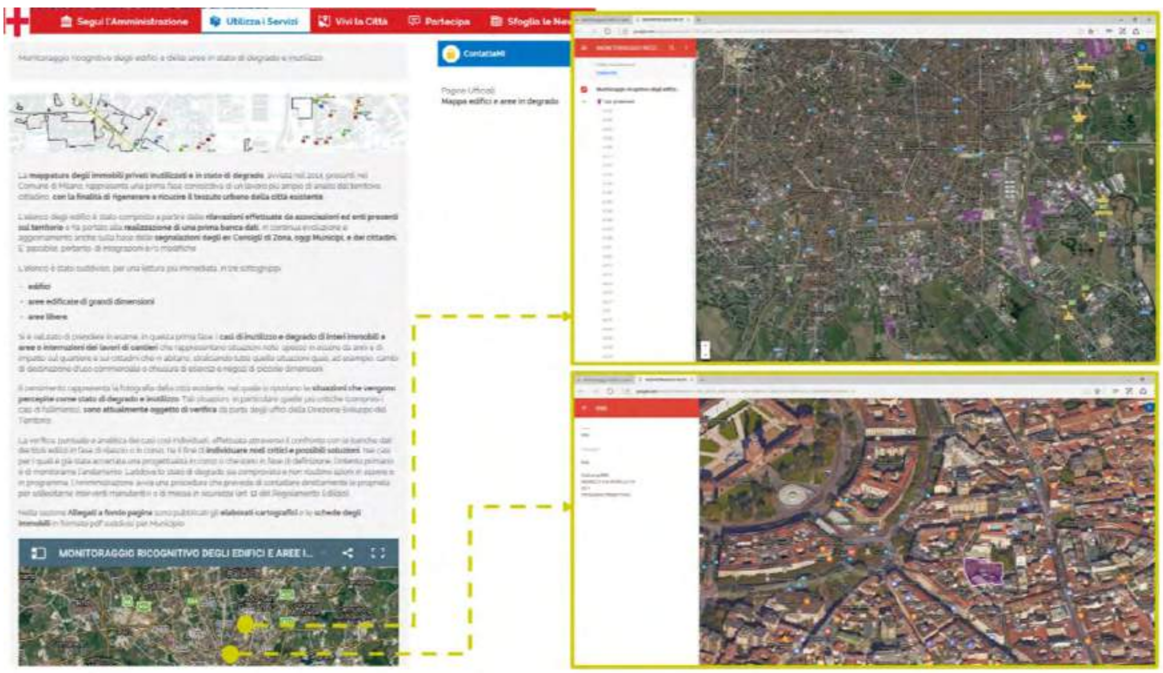

Figure 18 Online database of the Milan municipality allowing to visualize geo-referenced information of conditions and state of degrade of buildings and areas of the city mapped through top-down and bottom-up approaches (Comune di Milano, n.d.). Image adapted by the author.

For instance, the Comune di Milano (Municipality of the city of Milan) developed an online database to monitor the conditions of areas and buildings. The online database allows everybody to visualize geo-referenced information of the conditions of degrade of buildings and areas of the city and to update this inventory through the web service ‘ContattaMi’ (Comune di Milano, n.d.).

An example developed by private stakeholder for the public administration is the webGIS application LibraRisk. It consists in a bottom-up platform to prevent and manage catastrophic events that affect also historic sites. It relies on digital innovation to effectively communicate to the Civil Protection to citizens reporting alert or emergency conditions. This service can be extremely useful for the protection of historic centers in case of emergencies or exposition to danger (Librarisk srl, n.d.).

Another example is the European project INCEPTION. It applies 3D modelling to cultural heritage assets adopting *“an inclusive approach for dynamic 3D reconstruction”* (Inception, 2015) of objects and built environments. The inclusive aspect of this approach consists in the development of an open standard Semantic Web platform for the *“creation, visualization, and analysis of 3D (Heritage-)BIM models of cultural heritage over time”* (Di Giulio, n.d.). The objectives of the project are the development of cost-effective workflows for built sites recording and 3D reconstructions as well as the collaboration across different disciplines promoting the understanding of European cultural identity (Demoetnoantropologia, n.d.).

These initiatives and projects employ IT supported applications to stimulate participation in planning and heritage conservation. The selected projects and initiatives illustrate the global dimension of this trend, underlining how digital revolution pervades different socio-cultural contexts and different scales of application. The selected examples illustrate how digital and web technologies enable to communicate information accessible to a broad audience (local and non-local communities) through dynamic and semantic visualization strategies, open-access website and online databases.

Limits, challenges and further research in digital workflows to support knowledge representation and management of historic buildings and consequent conservation opportunities is discussing in depth in the following chapters.

2 Chapter: The Intangible dimensions of Cultural Built Heritage

In the past, only material structures (i.e. monuments, masterpieces, archaeological sites, architectural complexes, historical buildings, etc.) were considered as heritage. Recently, this concept enlarged its purpose to include the intangible heritage. Thus, also the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artifacts and cultural spaces - associated with a site started to be defined and protected as heritage.

Figure 1 March on Washington, August 28, 1963. Source: Powell J. E. Looking Into the Past (Powell, n.d.).

The concept of intangible cultural heritage includes everything that has defined, throughout history, the identity of people, their cultural diversity, and their personal creative potential. Moreover, intangible heritage embodies all kinds of events that characterize places, their history and consequently their inhabitants.

The affirmation of the importance of the intangible values of Cultural Heritage is also one of the current goals of the World Heritage List (WHL), reinforced by the adoption of the World Heritage Convention for the Safeguarding of the Intangible Cultural Heritage in 2003. The intangible heritage is featured by its specificity of being created by local communities and groups in strong relation with the local environment and its history. Indeed, Article 2 of the World Heritage Convention for the Safeguarding of the Intangible Cultural Heritage (2003), defines the intangible cultural heritage as:

"[...] the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their Cultural Heritage. This Intangible Cultural Heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity."

The same document defines, in Article 2, paragraph 2 the domains in which the Intangible Heritage can be manifested:

(a) oral traditions and expressions, including language as a vehicle of the Intangible Cultural Heritage;

(b) performing arts;

(c) social practices, rituals, and festive events;

(d) knowledge and practices concerning nature and the universe;

(e) traditional craftsmanship.

United Nations
Educational, Scientific and
Cultural Organization

Intangible
Cultural
Heritage

Figure 2 In 2008, the General Assembly of the State parties to the Convention for the Safeguarding of the Intangible Cultural Heritage selected this emblem as a symbol of the Intangible Cultural Heritage. The logo was designed by the Croatian artist Dragutin Dado Kovacevic. The emblem was chosen because it reflects the purposes and spirit of the Convention, which seeks the safeguarding of the living heritage, assurance of its respect and increased awareness of its importance. Source: Francoise Riviere, Birth of the Convention's emblem, the symbol of Intangible Cultural Heritage. The Intangible Heritage messenger (Riviere, 2008).

The Representative List of the Intangible Cultural Heritage of Humanity[1] is made up of those intangible heritage elements that help demonstrate the diversity of this heritage and raise awareness about its importance.

[1] In nomination files, the submitting State Parties are requested to demonstrate that an element proposed for inscription on the Representative List of the Intangible Cultural Heritage of Humanity satisfies all of the following criteria:

- R.1 The element constitutes Intangible Cultural Heritage as defined in Article 2 of the Convention.
- R.2 Inscription of the element will contribute to ensuring visibility and awareness of the significance of the Intangible Cultural Heritage and to encouraging dialogue, thus reflecting cultural diversity worldwide and testifying to human creativity.
- R.3 Safeguarding measures are elaborated that may protect and promote the element.
- R.4 The element has been nominated following the widest possible participation of the community, group or, if applicable, individuals concerned and with their free, prior and informed consent.
- R.5 The element is included in an inventory of the Intangible Cultural Heritage present in the territory(ies) of the submitting State(s) Party(ies), as defined in Article 11 and Article 12 of the Convention (UNESCO, n.d.-b).

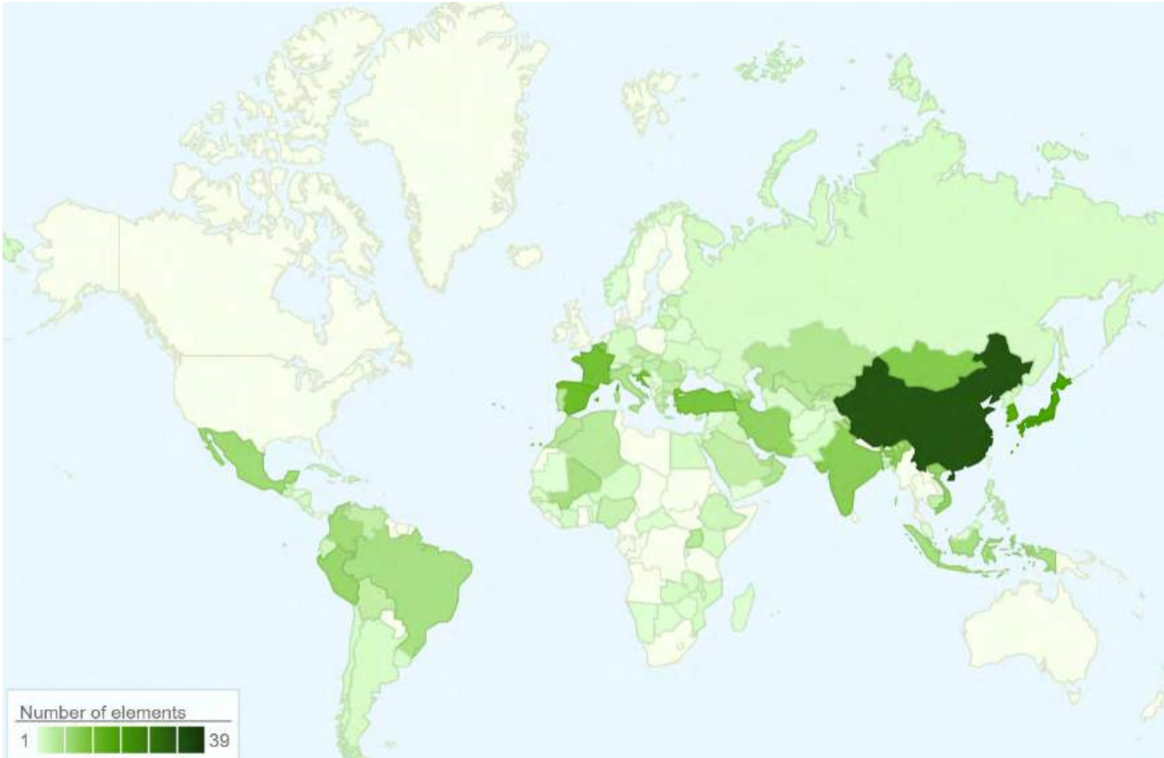

Figure 3 Map of the world's distribution of the intangible heritage site inscribed on the Representative List of the Intangible Cultural Heritage of Humanity. Source: Lists of Intangible Cultural Heritage and Register of best safeguarding practices (UNESCO, 2017).

In 2008, the Committee incorporated 90 elements (formerly proclaimed Masterpieces) into the Representative List. Between 2009 and 2013, it also inscribed 192 new elements on this List. From 2016, the list counts 429 inscribed elements (UNESCO, 2017).

Starting from the consciousness of the extensive past and contemporary theories and thoughts that associate intangible values to built structures, primary and secondary sources are analyzed. This analysis helps to track how intangible aspects affect and can potentially play a key role in conservation practice.

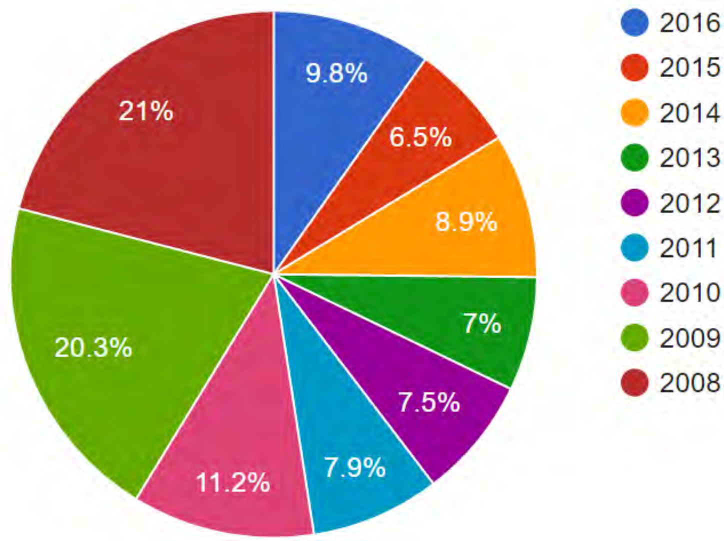

Figure 4 Percentages per year of inscribed sites in the Representative List of the Intangible Cultural Heritage of Humanity. Source: Lists of Intangible Cultural Heritage and Register of best safeguarding practices (UNESCO, n.d.-d).

In the debate about the relationship between tangible and intangible, Joel Taylor[2] differentiates between intangible value and intangible embodiment. He defines Intangible value as: *"association and qualities that people find important and intangible embodiment heritage without continuous physical embodiment […] that communicates value and discourse"* (Logan, Nic Craith, and Kocke, 2015), p. 81. This last definition is particularly relevant for this study because explains how tangible heritage embodies the meanings and values of its creators as well as those of its 'consumers' and 'users' at the same time. On this, William Logan, Máiréad Nic Craith, and Ullrich Kockel argued that ***"****Heritage involves a relationship between the creator of an object or a place or creative expression and the one who experiences it. It refers to the experience of that relationship****"*** (Logan et al., 2015)**,** p. 82.

[2] He is a researcher and lecturer in heritage. He worked as researched at the Norwegian Institute for Cultural Heritage Research (NIKU). He is currently project specialist at the Getty Conservation Institute (GCI).

On the debate on intangible values, several scholars underlined the importance of the intangible dimension associated to built environment and consequently its relevance within conservation processes. Joan Campos[3] stated that *"there is no built heritage without intangible dimension"* (Campos, 2003), Horst Bredekamp[4] wrote that the tangible heritage is the *"embodiment of intangible ideas and practices"* (Akagawa, 2016), p. 81. The British anthropologist Tim Ingold[5] noted that *"In the study of material culture, the overwhelming focus has been on finished objects and on what happens as they become caught up in the life histories and social interactions of the people who use, consume or treasure them. In the study of visual culture, the focus has been on the relations between object, images and their interpretations. What is lost in both on the fields of study, is the creativity of the productive processes that bring the artefacts themselves into being: on the one hand in the generative currents of the materials of which they are made; on the other in the sensory awareness of practitioners"* (Ingold, 2013), p.7.

Indeed, intangible factors intervene at different times and modalities in architecture conservation. Intangible influences and correlate four main aspects of historic built structures: form, fabric, use and symbol. In all these four aspects is embedded a contact with the past that is valuable for the present stewardship of a heritage building.

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[3] João Campos is a Portuguese Architect who got his MSc on Intercultural Relations. He is currently member of the Bureau of the CIVVIH / ICOMOS and of SCAT / ICOMOS. He is the advisor of the Municipal Board for the Historical Centre of Oporto, Porto (1998-2003). He is also working as consultant for the Calouste Gulbenkian Foundation, which has carried out various missions and projects in Benin, Brazil, Morocco, Uruguay, Kenya, Tanzania, Iran, India, Bangladesh, Holland, Malta, Thailand, Malaysia and Indonesia (Campos, 2003).

[4] He is a Professor of Art History at the Humboldt-Universität zu Berlin and spokesman of the Cluster of Excellence "Bildwissen Gestaltung. An interdisciplinary laboratory". His research focuses are Romanesque sculpture, Renaissance and Mannerism, political iconography, art and technology, new media (Institut für Kunst- und Bildgeschichte, n.d.).

[5] Ingold is Chair of Social Anthropology at the University of Aberdeen. He got his Ph.D. in Social Anthropology in 1976. Professor from1990 at the Max Gluckman Professor he then moved in 1999 to the University of Aberdeen, where he is currently teaching. His contributions range from environmental perception, language, technology and skilled practice, art and architecture, creativity, theories of evolution in anthropology, human-animal relations, and ecological approaches in anthropology. In his recent work, he links the themes of environmental perception and skilled practice, replacing traditional models of genetic and cultural transmission, founded upon the alliance of neo-Darwinian biology and cognitive science, with a relational approach focusing on the growth of embodied skills of perception and action within social and environmental contexts of human development. This has taken him to examining the use of lines in culture, and the relationship between anthropology, architecture, art and design (The University of Aberdeen, n.d.).

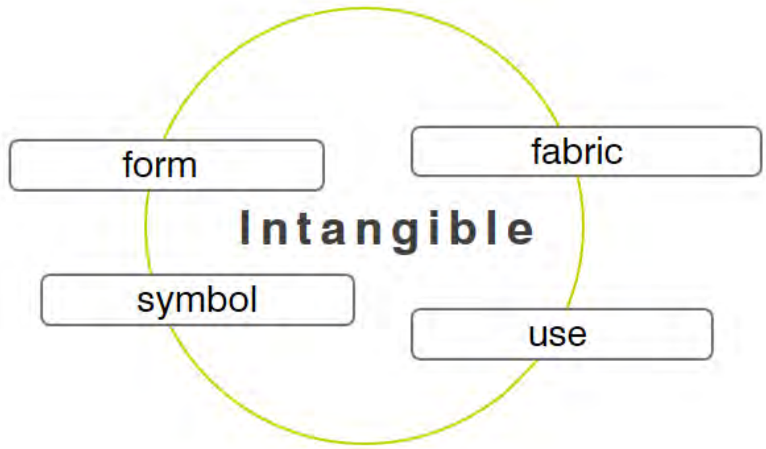

Figure 5 Correlation of the intangible with the four main aspects of historic built structures. Image source: Author

Figure 6 Examples of intangible heritage manifested as traditional craftsmanship (according to the UNESCO Convention UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage, 2003).Handicraft Lacquer production, Bagan Myanmar. Image source: Author.

Frank Matero also mentioned that *“Conservation directly engages the former (tangible) and when possible the latter (intangible) modalities, assuming both are recoverable”* (Matero, 2011).

Aware of the breadth of the intangible issue, this research considers the intangible heritage limited to *“Knowledge and practices concerning the nature and the universe”* and *“Traditional craftsmanship“*, according to the categories of intangible established by the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003). Conscious of the elusive nature of intangible dimensions, this study attempts to set up strategies for the documentation of intangible aspects associated with built heritage.

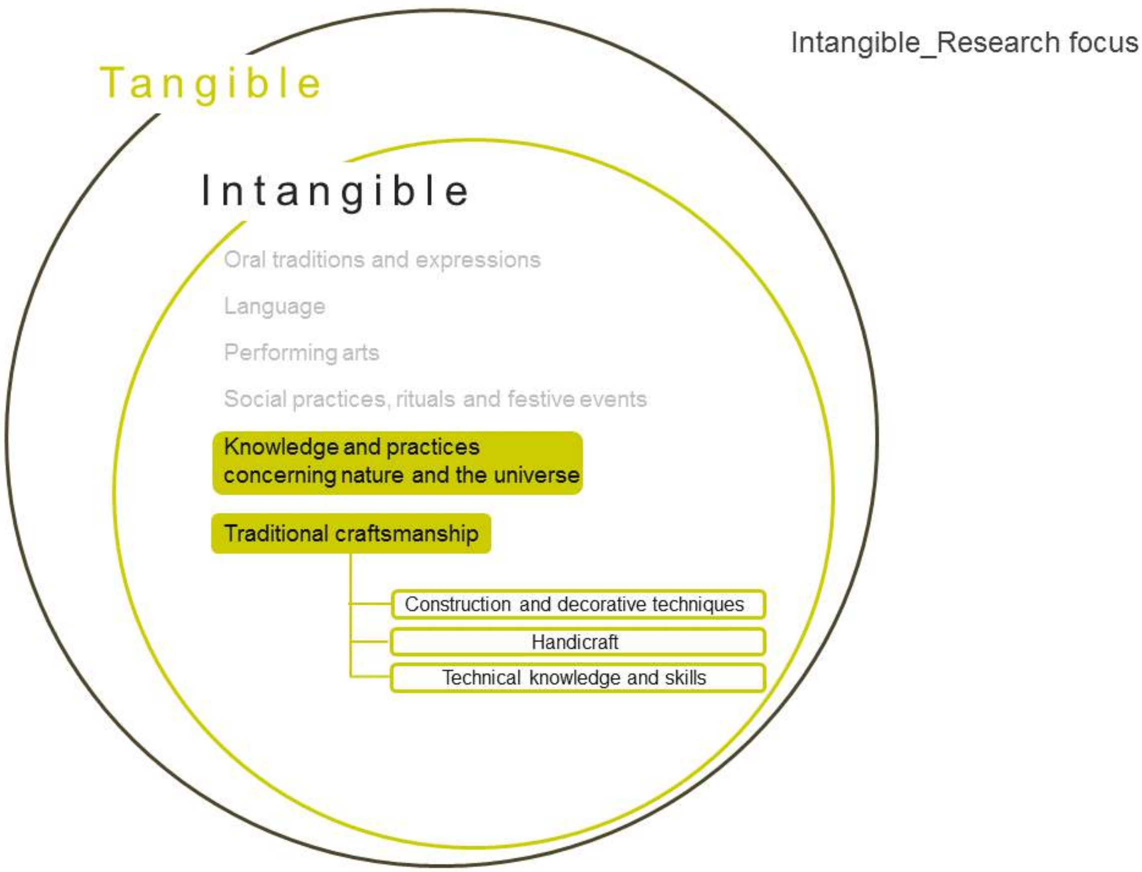

Figure 7 Research focus on the intangible domain. Image source: Author.

The following paragraphs address this issue, by considering how intangible aspects affect built heritage conservation from a technical as well as social and economic point of view. Indeed, intangible factors intervene at different times and modalities in architecture conservation. Intangible influences and correlates four main aspects of historic built structures: form, fabric, use and symbol. In all these four aspects is embedded a contact with the past that is valuable for the present stewardship of a heritage building.

2.1 The sense of place: intangible aspects in the Cultural Built Heritage conservation

The delay in recognizing the intangible dimension of heritage and the current lack of interest in it is probably a result of its immaterial features. These features make it incompatible with the interests of our society because they are difficult to quantify and devoid of immediate economic value.

Researching and adopting new methodologies, strategies and tools for its safeguarding and promotion must not be considered of secondary importance with respect to the 'classic' preservation and conservation of the tangible heritage. Moreover, in the general framework of an increasing globalization, the safeguard of intangible heritage is becoming a priority issue. Indeed, identity, cultural diversity and sustained growth are strictly connected to the intangible heritage.

Jukka Jokilehto outlined that already in the '80s, in its mid-term programme, UNESCO (25 C/4 1989:57) defined among the scope of heritage two important elements: giving "*each particular place its recognizable features*" (Jokilehto, 1999), p.1, and being "*the storehouse of human experience*" (Jokilehto, 1999), p.1.

Concrete-tangible entities and abstract-intangible components constitute form and content of heritage (Ilan Vit, 2014), p. 204. Therefore, this research proposes a reflection on how to combine them in the conservation practice.

Addressing this purpose, many researchers[6] have already underlined the importance of the conceptual work behind the construction of the historic urban landscape. For instance, Marcello Pignatelli outlines the unconscious and dreamlike image of the city, suggested by its historical elements (Pignatelli, 2007), p. 147. This concept was previously addressed in the 1970's by the Italian author Italo Calvino in his book the "*Invisible cities*"(Calvino, 1972). Through a description of different kinds of imaginary cities, the book expressed the importance of memory, identity, signs and many other intangible elements that create the lure of urban landscapes.

Focusing on Cultural Built Heritage, intangible aspects can be intended as knowledges, skills and know-how associated with building construction phases, materials assembly, building techniques to be employed, adaptive systems to the local weather conditions, spatial design, decorative elements with different functions (pedagogic, symbolic, functional, structural[7], etc.) building orientation and localization, etc.

Examples can be found worldwide. In the Middle East, marked by hot and dry temperatures, smart ventilation systems were developed. Examples are provided by the wind tower, used to ventilate the room below it. These kinds of towers are open on all sides

[6] The importance of immaterial values was recognized in the first years of the XX century and had already been anticipated by John Ruskin in the middle XIX century (and then recovered by Camillo Boito). Ruskin expressed the importance of intangible values linked to material objects (even if intended in a different meaning from the current one). This awareness led to an increasing attention towards society and its values and traditions, allowing thus the definition of the historical urban heritage. Indeed, this concept included all factors and elements characterizing urban contexts. As Vera Comoli said, *"the conflict between the historic and no-historic city does not exist […] it is important to find the historic structure of the city, not the structure of the historic city."*

[7] For instance, the pinnacles used in the Gothic cathedrals, which had the function to verticalize the loads.

and, by creating a descending and ascending air current, modify temperature and air density of the rooms below.

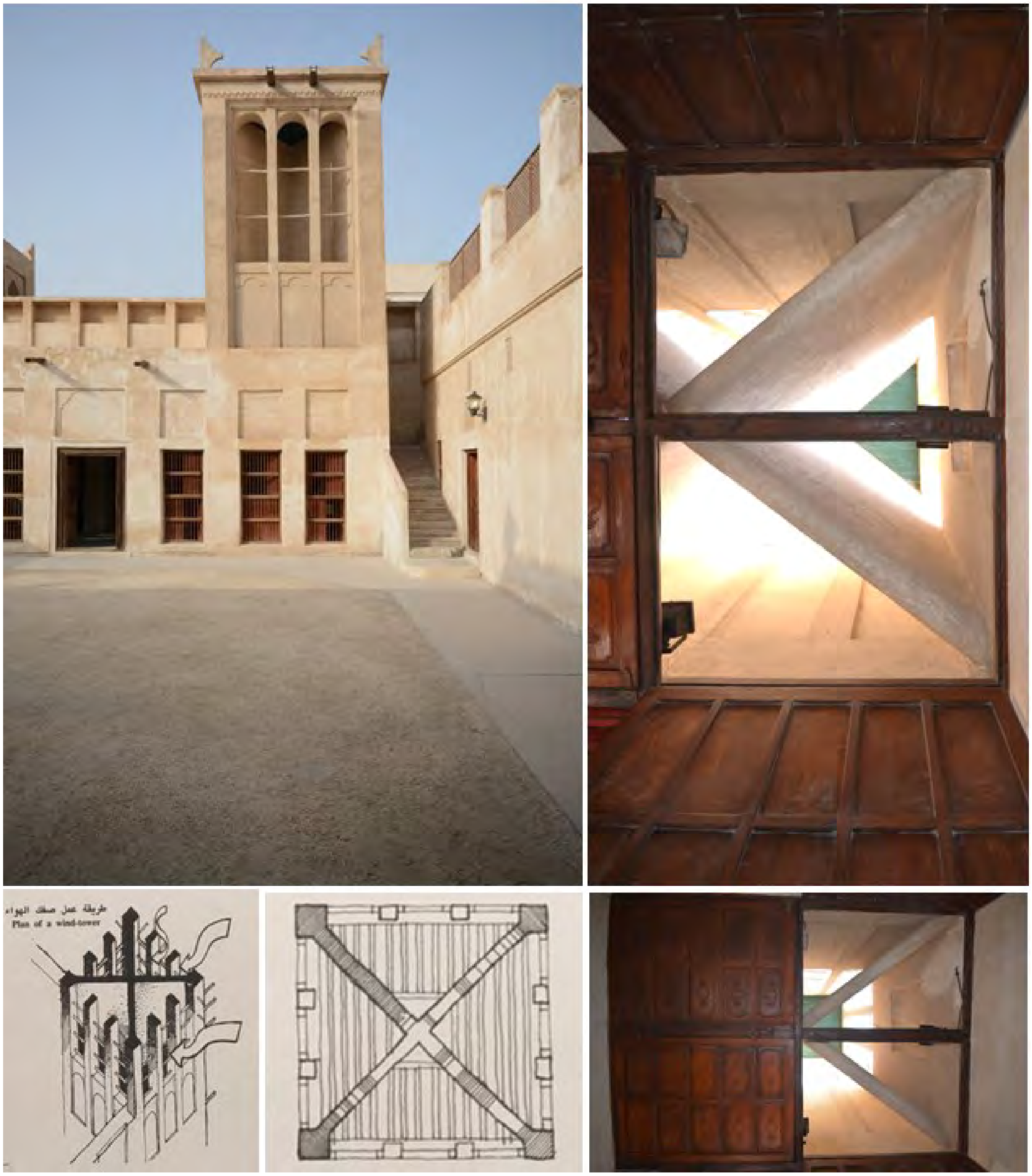

Figure 8 Wind tower, Shaikh Isa bin Ali House in Muharraq, Bahrain. This wind tower has a rectangular shape opened on the four sides. The openings allow the wind to funnel down into the house to the sitting-room (*Lea'good*) below. This wind tower or *badqeer*, has on the lower part shutters that

can be closed in the winter when the temperature is fresher. The *badqeer* was a traditional method of air-conditioning houses in Bahrain. Image source: Author.

Figure 9 Example of *badgir*, system. Shaikh Isa bin Ali House in Muharraq, Bahrain. Image source: Author.

Circulation of the air to the room is regulated by movable shutters (usually at the bottom of the tower). The images below depict the wind tower of the Shaikh Isa bin Ali House[8] in Muharraq, Bahrain. In the same context, another example of ventilation systems is the *badgir*, narrow openings in the wall that allow the wind to funnel down into a room refreshing it with natural ventilation.

Other examples can be found in the management of different materials to make building resistant despite adverse weather conditions. For instance, in Myanmar, wooden elements

[8] This house dates back to the early XIX century and has been the residence of the Bahrain ruler from 1869 to 1932. After that, it was passed down to the family and finally abandoned in 1973 when the dwellers moved to another city, Riffa. Even if in the late '70s due to its advanced state of decay it was going to be demolished (1976) to build a public square, the director for museum and archeology, Shaikha Haya bint Ali Al-Khalifa, at that time under the ministry of education, decided to take the property of the building to later conserve it. Currently, the Bahrain Authority for Culture and Antiquities (BACA) is taking care of its conservation and maintenance.

are combined with stones to decrease the moisture effects, perhaps protecting the extremities of the wooden teak pillars with stone element, improving the resistance of these structures to the heavy rain during the monsoon season.

Figure 10 Wooden elements combined with stones to decrease the moisture effects. Example of the construction solutions developed to preserve the monastery structure from the heavy rain during the

monsoon season. Bagaya monastery, Inwa, Mandalay Region, Mandalay. Image source and elaboration: Author.

2.2 Meaning vs Meaninglessness: the conservation of the intangible cultural heritage

The tangible and intangible dimensions of heritage are intertwined and cannot be arbitrarily separated. Many intangible elements of tangible goods are crucial for their definition, perception, and categorization as heritage, as indicated by the extensive social science literature on the so-called processes of 'heritagization', that is "*a social process whose final outcome is the presentation and interpretation of heritage (rather than the archiving or sustaining of heritage)*"[9].

Intangible heritage can be considered at the core of all cultures and an engine of creativity and innovation. It derives from the integration of cultural exchange, tangible heritage, history and material culture. The conservation of masterpieces, archeological sites and historic buildings is not sufficient. It is irrelevant if not combined with the promotion and transmission of the intangible factors that have generated them and contributed to their dynamic (re-)interpretation within conflicting identity politics. The recovery of these factors can also generate know-how in the future.

Ms. Irina Bokova, the Director-General of UNESCO[10] emphasized the topical nature of tangible and intangible cultural heritage, as key components in development policies. On

[9] (Poria, 2010), p.218. On the concept of 'heritagization' see Laurajane Smith, *The Uses of Heritage*, (Smith, 2006). For her, heritage is not a 'thing' with crystalized and static meanings and values; it is rather an "inherently political and discordant" practice (page 11) that performs the cultural 'work' of the present.

[10] On November 12, 2013, the General Conference of Unesco, which brings together 195 Member Countries and nine Associate Members, confirmed the vote of the Executive Board, reappointing Irina Bokova as Unesco's Director-General for a term of four years. Source: Culture(s) with vivendi. http://cultureswithvivendi.com/en/de-facto/irina-bokova-director-general-of-unesco/ Consulted o on the 16th July, 2014.

28 June 2014, Ms. Irina Bokova - opening the First Meeting of the Council of Ministers of Culture of South-East Europe "Enhancing Culture for Sustainable Development"[11] – stressed the importance of the strong linkages between culture and sustainable development, demanding that the countries play a decisive role in promoting the power of culture in the post-2015 sustainable development agenda.

"Culture brings sustainability of development by making it meaningful to people, by deepening ownership and participation, by making sure it is of the people, for the people, and by the people".

Ms. Irina Bokova, 28 June 2014, First Meeting of the Council of Ministers of Culture of South-East Europe "Enhancing Culture for Sustainable Development".

The main international document dealing with this issue, the Intangible Heritage Convention, aims to promote respect of cultural diversities, encouraging creativity and local identity.

In order to reach these goals, it states, in Article 12, the importance of inventories and their constant update for a proper documentation database. Furthermore, the Convention states the importance of policies aimed at promoting the function of the intangible heritage within society, outlining the importance of the integration of intangible values in planning programmes. It also stresses the importance of proper tools and methodologies for an effective safeguarding of the Intangible Cultural Heritage in order to improve its accessibility.

[11] The conference held in Ohrid was the first meeting of the new unified ministerial cooperation platform on culture and development in South-East Europe. It was organized within the overall framework of UNESCO's global initiative "Culture: A Bridge to Development", which aims to develop innovative solutions for the safeguarding of culture in all its forms, as a tool for social, economic and human development. The meeting adopted a new "Regional strategy for cultural cooperation in South-East Europe", which sets forth the priorities and modalities of action for future cooperation efforts (UNESCO, n.d.-c).

unsustainable at all the points of view (cultural, economic and ethnoanthropological).

Heritage conservation has the responsibility to consider both the tangible and intangible aspects of the built heritage. As Bianca Gioia Marino wrote if we study the material dimension of architecture, we observe the evident links with the sensible sphere, in other words with the intangible values related to architecture (Gioia, 2012).

William Morris (founder of the S.P.A.B., the Society for the Protection of Ancient Buildings[12]) observed in the materiality of the architecture the association with other meanings and values, such as the evocative power of the ancient structures. Even if the awareness of the intangible values, as interpreted by the UNESCO Convention of 2003, is

[12] The S.P.A.B. was a manifesto written by William Morris (and others) in 1877. In order to give an answer to the debates on the conservation issues in the 19th century, the manifesto stated the importance of the conservation of the buildings and monuments authenticity, through the preservation of all its stratifications/layering (SPAB, 2009).

still far away, it is interesting to notice the sensibility and the awareness of something that goes over the only tangible dimension of the ancient structures.

The permanence and the rediscovery of unreal elements in the tangible objects combine the studies of such philosophers as Ernst Bloch[13] and Martin Heidegger[14], who argued that things are able to absorb intangible relations which can become the essence of the thing itself.

Similarly, in the *Teoria generale della critica,* Cesare Brandi, asserts that it is important not to limit the field of investigation only to the material dimension, thus broadening it to the consideration of other aspects[15].

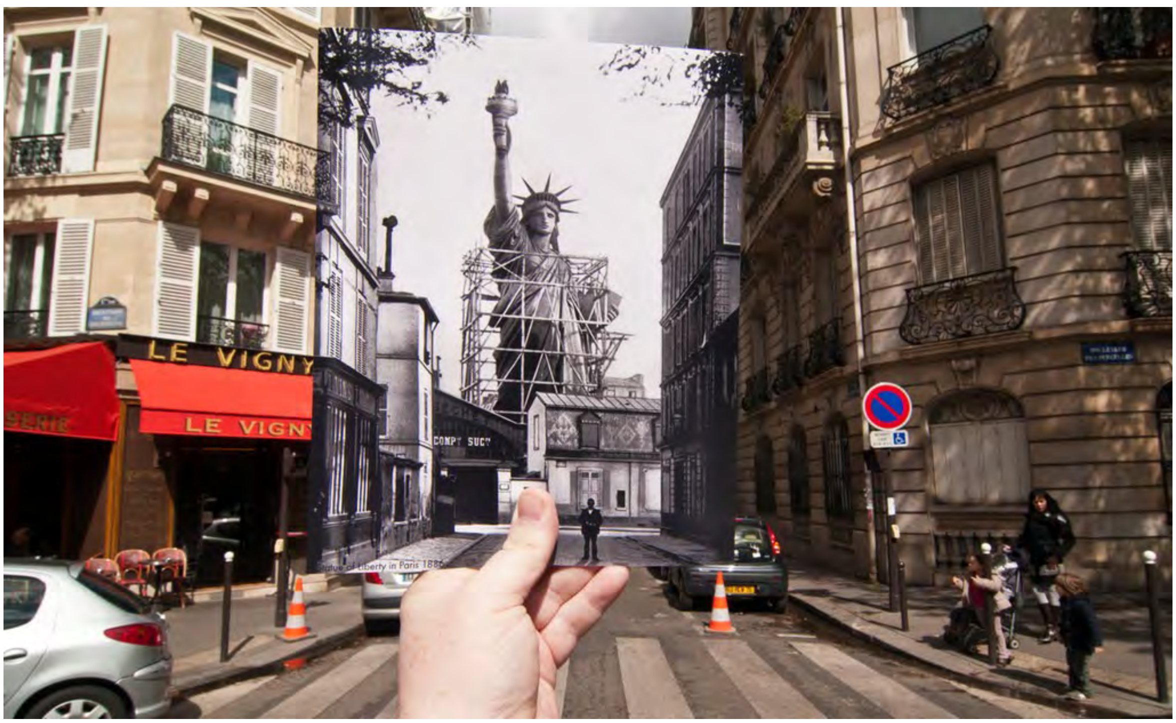

Figure 12 Statue of Liberty under construction, 1875 Paris France. Source: Powell J. E. Looking Into the Past (Powell, n.d.)

[13] Ernst Bloch (Ludwigshafen 1885 - Tubinga 1977) was a German Marxist philosopher who asserted the importance of link the utopia to the potentialities of the nature and the material/substance. (Treccani.it, n.d.-a).
[14] Martin Heidegger (Messkirch, Baden, 1889 - ivi 1976) was a German philosopher who asserted the importance of the art as tool to reach the truth (Treccani.it, n.d.-b).
[15] *"Another erroneous conceptualization of matter in a work of art limits it to the material consistency that constitutes the work itself"* (Gioia, 2012).

To actualize all these considerations and find out the connections with the proposed research project, discussions were carried out with experts in the Cultural Intangible Heritage field with different cultural backgrounds and competencies.

The first conversation was with Mrs. Luciana Mariotti, an Italian ethno-anthropologist active in the field of cultural heritage preservation[16].

According with her experience she evidenced that recently, the inscription procedures in the List of Intangible Cultural Heritage have changed a lot. Indeed, until 2011 there were no limits to the number of the elements presented for the registration in the Representative List of the Intangible Cultural Heritage of Humanity. This is for example demonstrated by the copious number of inscribed elements of China[17] and Japan[18].

From 2011, the Bali Committee[19] established the limit of one candidacy every year for each State. For example, since 2011, Italy proposed and registered in the List of Intangible Cultural Heritage the following candidacies:

- Traditional violin craftsmanship in Cremona, 2012;
- Celebrations of big shoulder-borne processional structures, 2013;
- The plantation of the grapevine of Alberello and the 'passito' of Pantelleria, proposed for 2014;
- The Perdonanza celebration of the Aquila, proposed for 2015.

[16] From 2006 to 2012, she was the responsible for the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage within the Italian Ministry of Cultural Heritage and Tourism.

[17] Currently with 39 inscribed elements in the Intangible Cultural Heritage List. Source: Lists of Intangible Cultural Heritage and Register of best safeguarding practices (UNESCO, 2017).

[18] With 22 inscribed elements in the Representative List of the Intangible Cultural Heritage of Humanity. Source: Lists of Intangible Cultural Heritage and Register of best safeguarding practices (UNESCO, 2017).

[19] The 6th session of the Intergovernmental Committee for the Safeguarding of Intangible Cultural Heritage, held in Bali (Indonesia) from 22 to 29 November 2011.

During the talk, Mrs. Mariotti evidenced that in the Italian case the main weaknesses in the conservation, management, and promotion of the Intangible heritage are related to the lack of a proper knowledge of the Convention for the Safeguarding of the Intangible Cultural Heritage of 2003 and in general the phenomena of the “campanilismo”[20] (parochialism). The parochialism, intended as the lack of communication and knowledge sharing, goes against knowledge dissemination and inclusive culture principles required for the candidacy. Integration between the intangible ‘elements’ (such as oral traditions, performing arts, social practices, rituals, festive events, knowledge, and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts) and the surrounding territory, verifying eventual similar elements/phenomena, is fundamental.

Debating of the potentials of technological support Mrs. Mariotti described that generally in Italy the potentials of new technologies for Cultural Heritage is still not fully exploited. Instead, in North America the ‘digital revolution’ for Cultural Heritage is a priority issue. The anthropologist George E. Marcus, for example, analyzed in depth the transition of anthropological research from a human relation to a digital one. Mrs. Mariotti also agreed on the potentials of digital workflows proposed by the present thesis in the development of inventories.

Supporting the idea of the present thesis, Mrs. Mariotti, found very interesting the idea of an integrated documentation of the demo-ethno-anthropological dimensions of Cultural Heritage associated with built environment. A comprehensive project thus developed could promote the knowledge of the Heritage in all its aspects and features. Moreover, this

[20] The ‘campanilismo’ is a consequence of the fascist regime of the 1930’s that, despite having been past almost ninety years, is sometimes still embedded in cultural approaches.

approach would satisfy the principles of the Convention for the Safeguarding of the Intangible Cultural Heritage (2003), regarding the integrated approach to the Intangible Heritage. An integrated system for the documentation and the management of the intangible values related to the built heritage would increase the quality of the candidacies (both those presented and to be presented). Additionally, the proposed approach would be relevant for the presentation of a candidacy to the UNESCO Representative List of the Intangible Cultural Heritage of Humanity.

According with these considerations, the proposed idea of the thesis appears relevant also according with the UNESCO requirements for best practices for safeguarding and managing intangible and tangible heritage. Further, an integrated approach could be a useful tool for promotion purposes, providing the dissemination of the values and meanings of the Intangible Heritage. If well oriented, digital tools might raise the awareness of the new generations towards Cultural Heritage. Currently, Article 14[21] of the Convention for the Safeguarding of the Intangible Cultural Heritage (2003) underlines the importance of schools in the transmission of the candidacies without specifying means and tools. On this regard, Mrs. Mariotti believed that the proposed approach could be considered as an "appropriate means" for the State Party to endeavor the recognition, respect, and enhancement of the Intangible Cultural Heritage. Further, the Italian Ministry of Cultural Heritage, Cultural Activities, and Tourism (MiBACT) is preparing the Guidelines for an integrated approach to the tangible and intangible heritage. Within this framework, the proposed methodology could be taken into account as a good initiative to support the

[21] Article 14 - Education, awareness-raising and capacity-building.

safeguarding and the promotion of the Intangible Cultural Heritage at the national and local level.

The second conversation is with Mr. Giovanni Scepi, UNESCO's regional officer at the Intangible Cultural Heritage section. After a short presentation of the proposed research's topics, the telephonic call concerned some general considerations on how the proposed research could give a practical response to the World Heritage Convention for the Safeguarding of the Intangible Cultural Heritage principles. Then, the attention focused on how the Wiki-BIM approach could give a specific and effective response to the general recommendations of Article 12 – Inventories of the Convention. Finally, we commented the management policy of the Intangible Cultural Heritage and the possible integration with the tangible heritage ones.

Focusing on the Article 12[22] of the Convention, Mr. Scepi stressed its relevance for the proposed research project providing theoretical as well as technical and specific feedback to the UNESCO general directives. Indeed, the proposed integrated approach of a graphic and semantic documentation system could be an effective solution that the National governments could adopt.

Mr. Scepi believed that the project proposal would potentially implement the 2003 Convention measures. The term measure, in this case, refers to an appropriate technical tool that could be undertaken by the institutions mandated with the conservation and

[22] Article 12 – Inventories 1. To ensure identification with a view to safeguarding, each State Party shall draw up, in a manner geared to its own situation, one or more inventories of the intangible cultural heritage present in its territory. These inventories shall be regularly updated. 2. When each State Party periodically submits its report to the Committee, in accordance with Article 29, it shall provide relevant information on such inventories. http://www.unesco.org/culture/ich/en/convention.

management of the Cultural (tangible and intangible) Heritage at the national and local level and civil society including communities and groups.

Further, the proposed system could be included as best practice in the Management plan for the intangible cultural heritage. Since the management of the Intangible Heritage is different from the management of the tangible one, the approach proposed by the List of Intangible Cultural Heritage is slightly different from the one of the World Heritage List.

For the Intangible Heritage elements, the management is articulated into two different parts:

- The List of Intangible Cultural Heritage in Need of Urgent Safeguarding;
- The Register of Best Safeguarding Practices.

According to this articulation Mr. Scepi see the potential application of the project proposal in the Register of Best Safeguarding Practices[23]. As stated in Article 18 of the Convention *"the Intergovernmental Committee periodically selects, among proposals submitted by States Parties, programmes, projects and activities for the safeguarding of Intangible Cultural Heritage considered to best reflect the principles and objectives of the Convention. Once selected, the Committee promotes these initiatives as good safeguarding practices and accompanies their implementation for wider dissemination"* (UNESCO, n.d.-a). Therefore, a practical actualization and demonstration of the effectiveness of the proposed approach could lead to the registration as good practice within the Register of Best Safeguarding Practices.

[23] The Register allows States Parties, communities and other stakeholders to share successful safeguarding experiences and examples of how to deal with challenges faced in the transmission of their living heritage. *The Register of Best Safeguarding Practices* should be useful as lessons and models that can be adapted to other circumstances, including those in developing countries (UNESCO, n.d.-e).

Additionally, Mr. Scepi believed that the idea to test the effectiveness of the system into a geographically, temporally and architecturally different context from the more 'traditional' North American and European ones would satisfy the need to provide evidence of a widespread efficacy (required by the Article 18). He supported the preconditions of the present project proposal as a good innovative solution to increase and facilitate the involvement of the communities, groups and non-governmental organizations (NGOs). Concerning other ongoing similar safeguarding proposals Mr. Scepi underlined that China pioneered in integrating the safeguarding of Intangible Cultural Heritage into planning programmes. In 2006, the Chinese Government included the safeguarding of Intangible Cultural Heritage into 'The Development Programme of Culture in the Eleventh Five-Year Plan (2006-2010)'. Currently, 'The Development Programme in the Twelfth Five-Year Plan (2011-2015)' includes once again the safeguarding of Intangible Cultural Heritage (UNESCO, 2011). While the approach proposed by the present research addresses an integrated management of the tangible-intangible heritage - from the documentation and safeguarding phase to the planning one – the Chinese government is integrating the safeguarding policies of the Intangible Heritage into development and planning programmes, promoting the social function of Intangible Heritage values.

On a final note, Mr. Scepi advised that other interesting initiatives that could be integrated with the research approach are documented in the periodic report database[24]. Indeed, as stated in the Article 29 of the Convention the "*States Parties shall submit to the Committee reports on the legislative, regulatory and other measures taken for the safeguarding of the Intangible Cultural Heritage in their territories*". For example, about the Inventories, the

[24] Such periodic reports are requested every six years from the ratification date of the Convention.

Chinese periodical report of 2011 describes how the responsible entity – the Ministry of Culture – started the creation of a National List of Intangible Cultural Heritage of China (UNESCO, 2011). The List involves ten different categories: folk literature, traditional music, traditional dance, traditional opera, Quyi, traditional sport, entertainment and acrobatics, traditional fine arts, traditional handicraft, traditional medicine and folk custom. According to these considerations Mr. Scepi believed that it could be interesting to test how the proposal could be an effective method of inventory and inventory - updating. Another interesting issue would consist in the investigation into how the proposed approach could improve the community involvement in the identification and definition of the Intangible Heritage elements to be included in the Inventory.

The conversations outlined the relevance of the research proposal to make built heritage conservation processes meaningful through the safeguard and dissemination of the embodied intangible values.

The example of the Chinese government, that is integrating the safeguarding policies of the Intangible Heritage into development and planning programmes, promoting the social function of Intangible Heritage values, can be interpreted as evidence of the pivotal role of intangible aspects associated with built structure.

In a way, the importance of intangible values can be compared to the importance of biodiversity for the natural heritage, as stated in the Universal Declaration on Cultural Diversity UNESCO (2001): *"The common heritage of humanity […] is necessary for humankind as biodiversity is for nature"*.

The same declaration states the importance of the intangible values as "*[…] the key to sustainable human development"* for their capability of being an engine of creativity, progress, and sustainable development.

"Creation draws on the roots of cultural tradition, but flourishes in contact with other cultures. For this reason, heritage in all its forms must be preserved, enhanced and handed on to future generations as a record of human experience and aspirations, so as to foster creativity in all its diversity and to inspire genuine dialogue among cultures".

Article 7 - Cultural Heritage as the wellspring of creativity, Universal Declaration on Cultural Diversity UNESCO, 2001.

Therefore, intangible heritage can be considered as an engine of creativity and innovation. It derives from the integration of cultural exchange, tangible heritage, history and material culture. The conservation of masterpieces, archeological sites and historical buildings is not sufficient. It is irrelevant if not combined with the promotion and transmission of the intangible factors that have generated them. The recovery of these factors will also generate conservation-related *know how* in the future.

In addition, the safeguarding of the intangible systems of consolidated and layered knowledge involves the transmission of local skills specific to local areas. Focusing on these unique and irreplaceable competencies, will make the next generation's situation less precarious, and it will perhaps contribute to strengthening the resilience of communities in case of natural hazards or human driven crises (included the economic ones).

2.3 Safeguarding traditional craftsmanship for the conservation of Cultural Built Heritage

The safeguarding of the intangible heritage associated with existing structures is not something new in the built heritage field.

In his book *The Craftsman*, Richard Sennett[25] carries out an in-depth historical inquiry regarding the meaning of the word 'craftsmanship' (Solodukhin, 2009). His analysis, explaining the social, economic and ethical changes of this notion from the past until present-day, is relevant for understanding the dynamics between craftsmanship, local know-how, built heritage and their interplay in the conservation processes.

In his analysis, Sennet finds out that the importance of craftsmanship was already recognized in the VIII century B.C., within the Hellenic culture, when Homer, in his Hymn to Hephaestus, wrote that *"[…] now that they (the men) have learned crafts […] easily they live a peaceful life in their own houses the whole year round*" (Sennett, 2008), p.22. This consideration is particularly interesting if we think about the connection between craftsmanship, local knowledge and the related theoretical debate in the heritage conservation field.

Then, in the XIX century, John Ruskin, Count Alvise Piero Zorzi and Alfonso Rubbiani[26], developed different approaches aimed at recognizing and safeguarding knowledge and skills that guided workmanship in the realization of historical structures and of their set of values and meanings

[25] Richard Sennet is a professor at the New York University and London School of Economics . He is a sociologist with a focus on urban environments. He wrote several books analyzing the connection among cities, labor and culture (Sennett, 2017).

[26] Alfonso Rubbiani, for instance, founded in 1898 the Comitato per Bologna Storica ed Artistica, inspired by the Arts and Crafts founded by William Morris (Jokiletho, 2002).

After several years, the relevance of these issues emerged again in the ‘50s and ‘60s, during the reconstruction that followed the Second World War. Experimentation posed the urgent problem of codifying behavior, not only on the individual interventions on the built heritage but also on the historical settlements, landscape, and environment, integrating the traces of material culture with the immaterial aspects that characterize the identity of a site.

Evidence of the relevance of intangible heritage conservation can also be found in its historical practice. In the debate concerning the intangible aspects associated with built heritage, scholars underline the importance of conceptual work and knowledge behind the built heritage. Experts and professionals involved in different disciplines associated with built heritage conservation reflected on the role of craftsmanship, intended as a whole of intangible knowledge and skills, in contemporary societies.

In this respect, it is interesting to recall some theoretical assumption by the philosopher and historian Hannah Arendt. She distinguished three forms of activity that are fundamental to the human condition:

- *Labor* which corresponds to the biological life of a man as an animal COMMUNITY;
- *Work* which corresponds to the artificial world of objects that human beings build upon the earth COMMUNITY;
- *Action* which corresponds to our plurality as distinct individuals INDIVIDUAL (Arendt, 1958), p.ix.

Richard Sennet, who stresses Hannah Arendt’s distinction between *Animal laborans* and *Homo Faber*, further comments on this distinction. The first one is associated with the human being akin to a “*beast of burden, a drudge condemned to routine […] (that) takes* *the work as an end itself"* (Sennett, 2008) p. 6. *Homo Faber* is instead the man who makes thing discussing and judging with other individuals on how and why to conduct a work. From this categorization, it is possible to infer that 'labor' men consume and do not use, with the resulting critical consequences of their activity, while 'work' men such as the craftsmen create and act in our society in a productive way, combining mind and hands.

Figure 13 Exemplification of the Homo Faber concept, Muharraq, Bahrain, workshop of Mr. Jamal Shaheen Image source: Author.

In support of this denotation, Hannah Arendt explains the passage from craftsmanship to mechanical fabrication, illustrating that *"the relativity of the market is connected with the instrumentality arising out of the world of the craftsman and the experience of fabrication. The former, indeed, develops without break and consistently from the latter"* (Arendt,

1958) p.166. In a speculation, these theories can be extended to the observation of the relevance of the working actions of craftsmen who, with their work, interact with the world in a continuous, harmonic and sustainable (from the economic, social and cultural point of view) way.

These considerations evidence the relevance of safeguarding intangible knowledge and skills of local craftsmanship involved in the conservation and building sector. Further, the connotation of sustainability of this process appears evident if compared with mechanized production, denounced by Hannah Arendt, which since the second decade of XIX century affected also the architectural field.

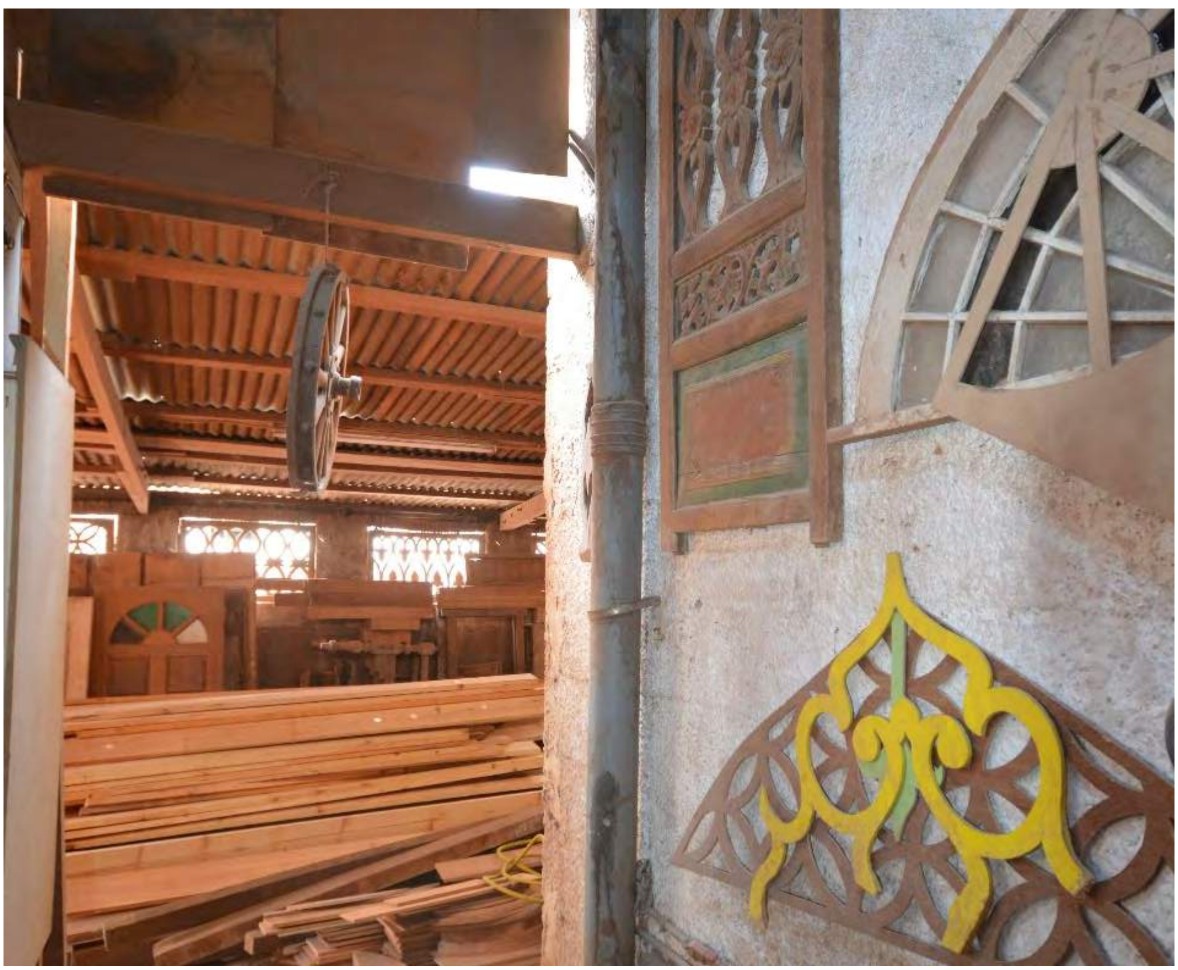

Figure 14 Example of a craftsman workshop. Muharraq, Bahrain, workshop of Mr. Jamal Shaheen. Source: Author.

In line with these premises, in the architectural field documentation has been identified as the first step for the safeguarding of traditional craftsmanship employed in the conservation of Cultural Built Heritage.

An outstanding example comes from Saverio Muratori's essay *Vita e storia della città*, which states that from the first half of the twentieth-century urban planning and urban design theory are not anymore rooted in history, with a consequent growth of a positivistic approach to the built environment (Cataldi, Maffei, & Vaccaro, 2002). This trend reduces planning and design to the status of mere technical devices, undermining the notions of architecture as a discipline and its human dimensions. Indeed, Muratori believes that systematic understandings of history's laws of urban reproduction are necessary to the further developments of architecture.

Muratori's methodology, originally applied to the urban scale, can be tested at the architectural scale. This becomes evident in addressing the missing relationships between consolidated historical constructive techniques and materials, progressively abandoned for the diffusion of steel and reinforced concrete[27] structures since the mid of the XIX century.

Facing these issues, Saverio Muratori saw possible solutions in the *"[...] capacity of human beings to establish, on a global scale, a balanced relationship with their territories"* (Cataldi et al., 2002), p. 5. Muratori finds in history the main element to structure this 'balanced relationship' between built environment and the surrounding territory.

By reinterpreting Muratori's concept of operative history (see above, Chapter 1) and his idea of an *Atlante territoriale* and so-called *Tabelloni* - intended to be a sort of universal

[27] In 1892, Francois Hennebique patented the reinforced concrete. This system, designed to withstand the tensile forces against which ordinary concrete is weak, employing steel reinforcing bars that are embedded within the bottom face of the concrete slab had a huge diffusion in the building sector featuring following architectural developments (Fernandez, 2016).

logical classification of man-made structures, (Cataldi et al., 2002) - it is possible to turn it into a source of inspiration for documentation strategies of craftsmanship and know-how rooted in territorial contexts.

More recently, other sources of inspirations in setting up effective methodologies to document (and safeguard) intangible aspects associated with built heritage can be found in the theories of Maurizio Ferraris[28]. The Italian philosopher claims that documentation plays a key role in ontology. He argues that everything is based on memory and every behavior on imitation (*"[…] ogni ruolo […] poggia sulla memoria e ogni comportamento sulla imitazione*"), (Ferraris, 2009), p. XIV. Building on this assumption, it is impossible to conceive a society without memory and recordings (Ferraris, 2009). This philosophical statement evidences the core role of documentation and archiving, either digital or not, for our society. Therefore, focusing on intangible knowledge, the documentation on building processes as well as the identification of the keepers of knowledge and skills for the maintenance and conservation of built structures, become main challenges for preserving intangible heritage.

To clarify this concept it is worth to recall what Maurizio Ferraris defines as 'oggetti sociali' (social objects). These include, for example, money, universities, research projects as well as art and cultural heritage objects and sites.

These social objects are made of inscriptions and their ontology is made of recordings, documents, etc. For instance, the Dhammayangyi temple in Bagan derived from the will of

[28] Maurizio Ferraris is a Professor of Theoretical Philosophy at the University of Turin where he runs the Ontology Lab (LabOnt) and the Inter-University Centre for Theoretical and Applied Ontology (CTAO).

King Narathu (1176-1171) to build a tangible expression (inscription) of merit-making, 'documenting' his devotion to Buddha in the hope of wiping out the bad *karma* accumulated for the murder of his father, his brother and his bride.

Figure 15 Dhammayangyi temple, Bagan. Image source: Haititravels, (Haititravels, n.d.).

This is just an example that relates the existence of a social object to its documentation. This is more evident in the Cultural Heritage field if we think about the concept of memory that is, for its own nature, related to the recording and documentation, or quoting Ferraris, to the concept of 'documentality'.

The need for an organic and systematic documentation is an established conventional wisdom in the cultural heritage field. As a matter of fact, it has strongly influenced the conservation field throughout its history. Over the last two decades it culminated in the development of systems of digital documentation to be employed at the territorial and architectural scale, such as the Geographic Information Systems and Building Information Modelling.

In line with this trend, the aim of this research is to develop and test effective methodologies and tools to document and preserve intangible aspects associated with built structures, their construction and maintenance processes.

Addressing this goal, digitally supported systems of data archiving and collecting as well as information gathering strategies are explored.

Why preserve intangible values associated with built heritage?

In the framework of a growing awareness on sustainable development, climate change, and resilience, traditional knowledge in the Cultural Heritage field is gaining increasing relevance (ICCROM, 2016). This trend is confirmed by the fact that the UNESCO World Heritage System included, in its Operational Guidelines, the key role of traditional knowledge for Cultural Heritage management[29]. The ICCROM underlines the need of realizing an archive of knowledge systems, exploring their applicability and adaptability into our modern practices of heritage conservation and management.

The growing number of projects and initiatives related to the conservation and promotion of traditional knowledge illustrated in paragraph *3.2 How to document the intangible aspects of built heritage?* evidences the relevance of the topic.

[29] As reported by the Art. 110 of the UNESCO Operational Guidelines *"Management systems […] may incorporate traditional practices*." (UNESCO, 2016).

In the Italian context, the range of such initiatives includes painting, sculpture, archeology[30], architecture, landscape and urban design, generated and maintained across centuries thanks to the recovering and re-interpretation of traditional know-how and technical solutions.

This trend is evidenced by a growing attention paid to a complex of inherited knowledge and capabilities that would otherwise be lost.

Reflecting on the risk of losing this intangible heritage becomes relevant in a globalized society where, information spreads fast, globally and often superficially, with the consequent homologation and simplification of processes in all the fields including architecture. Sennet noticed that the passing of knowledge and skills through the generations was a sustainable way to maintain a diverse skill pool (Sennett, 2008), p .22. Along the same lines, Dall'Osto argued that *"When a workshop closes an entire library disappears, because the master's activity summarizes itself in a year-stratified experience, through a work that involves all the senses.*"(Dall'Osto, 2009).

Bernard Feilden stressed similarly the importance of skills and knowledge for the conservation, denouncing the increasing *"shortage of craftsmen"* (Feilden, 1985).

Finally, the reasons to preserve intangible values embedded in historical built structures can be found in the Italian cultural context. For instance, it is possible to find in Marco Dezzi Bardeschi's historicist ('*storicista'*) approach to built heritage conservation the understanding of the craftsmanship as the basis of beauty, functionality, and uniqueness of

[30] An example is the requalification of the Saxa Rubra site, now included into the urban borders of Rome. The project, developed by taking into account the infrastructures and ecosystems of the site, designed technical solutions recovering and reinterpreting historical uses and on-site materials of the area (Andreucci, 2014).

historical structures. Dezzi Bardeschi's approach implies the conservation of every single element and component of a building, enhancing the knowledge, the so-called '*genius loci*' that allowed its conception. It can also be interpreted as a recognition of the role of craftsmanship in heritage structures and in their usefulness for new designs.

Figure 16 Example of traditional craftsmanship related to the wood carving of structural as well as decorative and furnishing building elements. Muharraq, Bahrain, workshop of Mr. Jamal Shaheen. Source: Author.

3 Chapter: The documentation of the intangible aspects of built heritage

3.1 Why is it important to document the intangible dimensions associated with built heritage?

The need of documenting intangible aspects associated with built heritage dates back to the origins of architecture. Some recurring issues show the importance assigned to this theme in the history of the discipline.

The first one consists in the growing erosion of maintenance and repair capabilities: a current problem in built heritage conservation. Already in the first century B.C. Vitruvius, in his *De Architectura* stated the central role of maintenance in good building practice (Jokilehto, 1999), p.2. Centuries later, Feilden recalled the problem, evidencing that the lack of skills needed for conservation and the shortage of craftsmen and materials are two of the main problems in built heritage conservation[1]. The connection between the recovery of the intangible dimensions of built heritage and its maintenance is one of the reasons to preserve intangible knowledge and skills associated with built heritage.

Secondly, the key role played by traditional knowledge and skills in terms of innovation and community resilience makes intangible conservation relevant for local economies.

Thirdly, documentation of intangible variables would ensure the preservation of cultural diversity and local identity. Both these aspects are fundamental to the definition of any promotion and enhancement initiative.

[1] Other critical aspects in conservation of built heritage indicated by Bernard M. Feilden are the lack of an integrated approach by governments, difficulties in quantifying conservation's benefits, and the necessity of proper consciousness and education initiatives (Feilden, 1985), pp. 197-221.

In line with these issues, the documentation of intangible cultural heritage can support its safeguard, allowing the transfer of knowledge, skills, and meanings.

Furthermore, documentation plays a crucial role in any safeguarding measure. Indeed, the recording of diverse contexts and varied circumstances, featuring intangible elements, is necessary for the interpretation, transmission and continuous evolution of intangible cultural heritage. This concept is underlined by the UNESCO Convention for the Safeguard of the Intangible Cultural Heritage of 2003 that *"includes, in its definition of intangible cultural heritage, the instruments, objects, artifacts and cultural spaces associated with it"*(UNESCO, n.d.-a).

The same document reflects also on the reasons why, and for whom, it is necessary to conserve Intangible Cultural Heritage. Considering the living character of intangible heritage, which is naturally doomed to disappear (UNESCO, n.d.-a). It is possible to agree that certain intangible aspects can, along the time, no longer be considered relevant or meaningful for a community. In this regard, the UNESCO Convention stresses the role of the community in the identification and 'recognition' (UNESCO, n.d.-a) of intangible elements.

Therefore, the identification and recognition of significant craftsmanship and traditional intangible knowledge associated with historical structures should be developed involving both experts and local communities. The contribution of specialists is particularly relevant because relying on the consent of the local community only would not be enough for safeguarding the set of technical knowledge - related to structures, material choices, and combination, the design of the functional spaces, energy design[2] or systems and decorative apparatus - embedded in historical structures.

These considerations derive in part also from on field conservation experiences in which the author had the opportunity to be exposed within his Ph.D. studies.

These included the conservation of the Casa Cristo in Guadalajara, Mexico and of the Shaikh Isa bin Ali house and the Siyadi majlis in Muharraq, Bahrain.

These three sites, different in dimension, shape, function, architectural typology, design as well as historic, geographic, socio-economic and cultural context, have been particularly relevant for the development of the research theoretical assumptions.

These sites presented heterogeneous technical aspects and social values that oriented the documentation workflows.

In these cases, historical and socio-cultural values influenced and oriented the aims and goals of the documentation.

The first case consists in the Casa Cristo[3] in Guadalajara, Mexico. The documentation[4] of the house, declared National Historic Heritage Site (*Patrimonio Artístico de la Nación*),

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[2] These include, for instance, passive strategies usgin *"traditional design and techniques to improve energy performance"* (MTBA Mark Thompson Brandt Architect & Associates Inc., 2016), p. 31. These elements should be considered in the documentation project since they contribute to the value of heritage structures.

[3] The house was originally constructed for Gustavo Cristo. Later, it was acquired by the Colegio de Arquitectos del Estado de Jalisco in 1976 to serve as its offices. Currently, there is an ongoing project to transform it into a cultural centre since 2009 Source: Ficha - Pedro Moreno 1612 - Casa Cristo http://revisionesgdl.blogspot.ca/2012/02/ficha-pedro-moreno-1612-casa-cristo.html (16 February 2015).

[4] The author had the opportunity to work in a documentation project of this designated heritage building. The documentation activity to support the conservation of this house was developed within the framework of an International workshop on documentation of historic and cultural heritage developed jointly between Universidad de Guadalajara’s Centro Universitario de Arte, Arquitectura y Diseño (CUAAD) and Carleton University’s Architectural Conservation and Sustainability Program. The workshop took place in Guadalajara, in February 2015.

in 2004, by the Consejo Nacional para la Cultura y las Artes and the Instituto Nacional de Bellas Artes, was oriented by its significance and its embedded values.

The house built in 1927 for Gustavo R. Cristo, mayor of the city of Guadalajara, was commissioned to the renewed architect Luis Barragán[5] (Mezzino, Santana Quintero, Pei, & Reyes Rodriguez, 2015).

The design and building features of the house are known as Escuela Tapatía, which became a signature characteristics of architects like Luis Barragán, Rafael Urzúa and Pedro Castellanos (Del Arenal Pérez, 2010). This style reflects the substantial influences of Barragán's trip to Spain, particularly the architecture of Granada and Córdoba. Indeed, it is possible to notice these influences in the *moresco* style of Casa Cristo, such as the Moorish tower, the entry porch featured by parabolic arches, the silver-gilded door, the textured plaster finishes, the stained glass windows (made from coloured blown-glass bottle bases) and the unusual geometry of the back patio.

[5] Luis Barragán (1902-1988), Prizker Architecture Prize in 1980, has been recognized internationally as one of the leading architects of the 20th century . (The Editors of Encyclopædia Britannica, n.d.)
Luis Barragán was born in Guadalajara in 1902. After graduating as a civil engineer from the Escuela Libre de Ingenieros, he went to Europe in 1925. The journey was particularly significant for his cultural background. During his permanence in Europe, he went to the Exposition des Arts Décoratifs in Paris, where he had the chance to get in contact with some of the most important pioneers of the Modern Movement (such as Le Corbusier, Auguste Perret, etc.). In that occasion, he was also allured by the work of Ferdinand Bac, a writer, an architect and a landscape gardener. Moreover, Barragán was exposed with the Arabic architecture during his visit to Córdoba and Granada. Both discoveries of Bac's works and the Arab world, strictly linked to his Guadalajara cultural background, led Barragán to begin a process of translating formal elements into a personal architectural language. The handling of light and shadow, the extensive use of staircase motif, gardens and fountains became an integral part of his architecture. All these features can be found in the first phase of his works in Guadalajara, where he primarily built private residences for the growing upper middle class. (Del Arenal Pérez, 2010),

Figure 1 Casa Cristo by Luis Barragán in calle de Pedro Moreno, Guadalajra, Mexico. Image source: Author. (Mezzino et al., 2015).

Therefore, the documentation took into considerations these aspects also focusing on the connection between Barragán's architecture and the local craftsmanship. Such connotation can easily be observed in many elements, such as the stain glass windows (made in the neighboring town of Tonalá), the tiles, the mosaics, the *zarpeado* texture, the adobe walls and the cedar wood carpentries.

All of these features connote Casa Cristo as a regional architecture. Nevertheless, it has been strongly influenced also by the *Jardins enchantès* and *Les Colombiéres* by

Ferdinand Bac[6] that Barragán had the opportunity to see during is travel in Europe. As shown in the image below, it is possible to notice the similarities in the planning of garden and patios, as well as in the detail design of the house (such as the main entrance door).

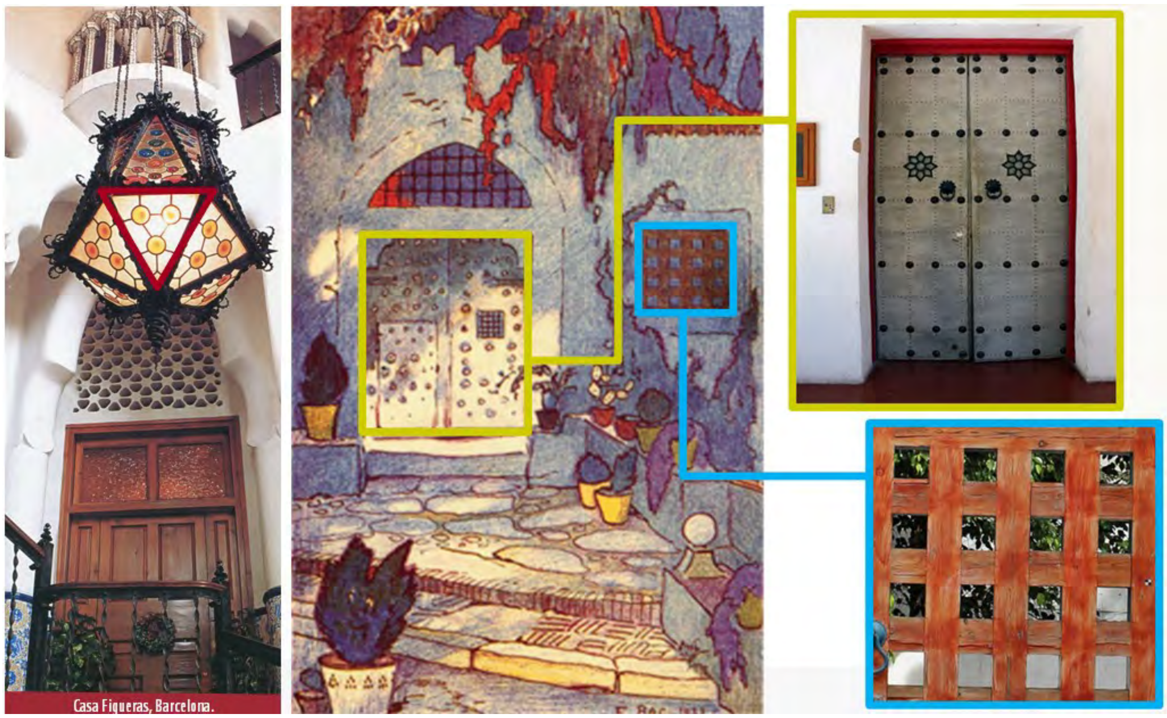

Figure 2 Example of the influences from the European architectural culture and from Ferdinand Bac's illustrations on Luis Barragán architecture of Casa Cristo. On the left *Casa Figueras* built by Antoni Gaudi' and on the right illustrations of the *Les Colombiéres* by Ferninand Bac. Image adapted and elaborated by the Author.

Other distinctive features of this house consist in the connections with the Arabic architecture, particularly the use of water in the design (that became one the recurring elements of Barragán's architectural production). Furthermore, the building is also a

[6] Ferdinand Bac was a 'naturalized' french artist,writer and landscape architect. Mr. Bac was born in Stuttgart in 1859 under the name of Ferdinand Sigismond Bach (Foremanaug, 2012).

distinctive expression of the colonial architectural language, as evidenced by the corner lamp and by the extensive use of the ceramic (Del Arenal Pérez, 2010).

Figure 3 Distinctive features of Casa Christo illustrating social values and craftsmanship associated with the house. Image source: Author.

The close connection between Barragán's architecture (tangible) and the local craftsmanship (intangible) is demonstrated through architectural details throughout the house, such as handcrafted stained glass windows and ceramic, produced by reputable 'know how' of the nearby villages of Tonalà and Tlaquepaque.

Despite their tangible nature, all the identified elements are representative of important meanings and values to understand Barragán's production as well as his historical-cultural and social context.

This information derived from direct sources (personal communications with local stakeholders and experts) as well as indirect ones (i.e. archival and historic documents).

This allowed to understand intangible values and aspects that oriented and guided the documentation of the house to gain a full awareness of the work of Luis Barragán. Therefore, the scope of the study was not limited to the building itself but extended to its territorial context, including the city of Guadalajara and the surrounding villages (Mezzino et al., 2015).

These intangible aspects aimed at documenting the house by broadening its understanding, not only to geometry and shape of the building but also to the values and significance of its architectural components. This would support possible conservation choices and ensure the preservation of the integrity and authenticity of the unique characteristics of this outstanding example of modern heritage (Mezzino et al., 2015).

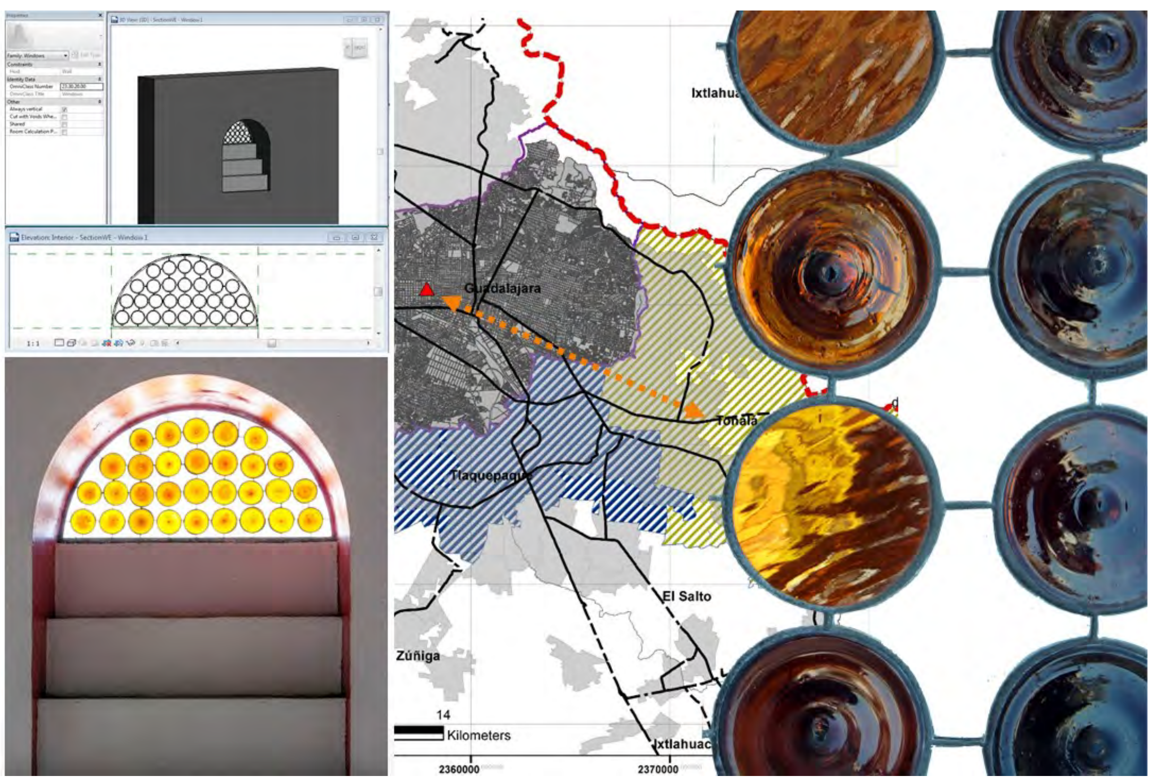

Figure 4 Image showing the analysis to document the close connection between Barragán's architecture and the local craftsmanship in the surrounding context of Guadalajara. This connection between tangible architectural features and intangible reputable *know-how* is demonstrated through

many building components such as the handcrafted stained glass windows in the nearby villages of Tonalà and Tlaquepaque. Image source: Author.

Another example is the documentation of the Siyadi majlis and the Shaikh Isa bin Ali house in Muharraq, Bahrain.

These two buildings are connected from the historic point of view since the Siyadi family arrived in Bahrain from Qatar with the Al Khalifa family (the current Bahrain royal family). This also explains the location of the *Siyadi* majlis, placed very close to the rulers' house - Shaikh Isa bin Ali house (Kingdom of Bahrain Ministry of Culture & Information, 2012)[7].

Both families established their wealth dealing with the pearls commerce. Evidences of this wealth are the huge and articulated residences that they built in Muharraq. These historic houses are a significant and unique tangible evidence of the intangible socio-economic and cultural context associated with the pearling economy.

The Siyadi majlis, built in the XIX century, is a second family house mainly used to receive and entertain guests. It is part of an architectural complex including other two buildings (the Siyadi house and the Siyadi Mosque) built for the Siyadi family, one of the leading pearl merchants families in Bahrain (Kingdom of Bahrain Ministry of Culture & Information, 2012).

The Shaikh Isa bin Ali house dates back to the early XIX century and has been the residence of the Bahrain ruler from 1869 to 1932 (Kingdom of Bahrain Ministry of

[7]The buildings are located in the Sh. Abdallah neighbourhood, in Muharraq urban area in Bahrain.

Culture & Information, 2012). After that, it was passed down to the Al-Khalifa family and was finally abandoned in 1973 because the dwellers moved to another city, Riffa[8].

Figure 5 Example of character defining element analysis. Carpentry floral mirror decorations in the Siyadi Majlis, Mashrabiya and decorated roof illustrating the wealth of the Siyadi family (some of the woodwork was imported from Shriraz, Iran (Kingdom of Bahrain Ministry of Culture & Information, 2012), p. 156. Image source: Author.

[8] Even if in the late '70s due to its advanced state of decay it was going to be demolished (1976) to build a public square, the director for museum and archaeology, Shaikha Haya bint Ali Al-Khalifa, at that time under the ministry of education, decided to take the property of the building to later conserve it. The project included several conservation stages. Currently, the Bahrain Authority for Culture and Antiquities (BACA) is taking care of its conservation and maintenance.

The documentation of these buildings to support informed conservation and maintenance actions as well as the dissemination of their values included also the identification of the character-defining elements of the buildings employing digital techniques, historical analysis as well as interviews with the main local stakeholders.

Figure 6 Character defining elements and adaptive architectural building solutions and materials employed in the Siyadi Majlis, Muharaq, Bahrain. Mashrabiya in one of the Maijlis tower to provide

indirect sunlight and assure natural ventilation. Traditional floor made of intertwined palms branches and leafs locally available. Image source: Author.

In both cases, particular attention in the documentation was given to the decorative apparatus (such as plaster decorative panels, refined timber panelled shutters or decorated external timber screens), spatial design and materials employed (i.e. the mangrove beams or the bamboo grids used for the ceilings), innovative building solutions adopted to adapt these structures to the local hot climate (such as ventilation strategies through wind tower, ventilation systems such as the badgir, etc.).

The outputs of this documentation aimed not only at recording shape, geometry and color of these tangible assets but also at stressing and understanding the adaptive strategies and constructive solutions adopted as well as the social values of these historic buildings associated with the Pearls cultivation and trade[9]. The Pearling is indeed a key element that shaped Bahrain economy and consequently the development of the built environment associated with this industry[10].

The historic structures of Muharraq area, in which the Siyadi majlis and the Shaikh Isa bin Ali house are located provide the tangible evidence of developments of the island associated with this traditional sea-use and its related economy[11]. The built heritage

[9] Pearls cultivation is deeply rooted in Bahrain history since the Neolithic under the Dilmun civilization. Pearls were cultivated and traded, during the Roman Empire, for instance, Bahrain had an organized pearling industry (Kingdom of Bahrain Ministry of Culture & Information, 2012). This trend expanded and consolidated in the medieval period reaching its apex between the XVIII and XIX century, when the global demand of pearls (mainly from Europe) grew exponentially strongly affecting Bahrain economic development and territorial developments in terms of infrastructure and services associated with the pearling market. In this framework Muharraq became the main pearl-diving settlement in Bahrain. Between the 1930s and the 1950s the pearling industry registered a huge decrease (Kingdom of Bahrain Ministry of Culture & Information, 2012).

[10] Pearls cultivation and trade is an outstanding example of a traditional sea-use which shaped the local economy and cultural identity[10] (Kingdom of Bahrain Ministry of Culture & Information, 2012).

[11] These include residential and commercial buildings, tangible examples of the historical cultural and socio-economic context associated with the pearling society. These historic structures, developed within the pearling socio and economic phenomena, also embed intangible values including but not limited to social hierarchies, legal systems, songs, stories, poetry, festivals, and dances (Kingdom of Bahrain Ministry of Culture & Information, 2012).

associated with the pearling economy is also representative of the traditional uses and functions of these buildings and related specific building techniques and design.

These examples are representative of the role of intangible in orienting heritage documentation in terms of what, how, who and when document.

3.1.1 The costs of ignorance: the dichotomy between conservation and sustainability

The term conservation was defined in 1998[12] as *"the action to secure the survival or preservation of objects of acknowledged value for the future*" (British Standards Institution, 1998).

Sustainable development is instead intended as the *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*[13].

Nowadays, the word conservation is associated with the concept of '*permanent'* while the word sustainability is associated with the concept of *'change'*.

CONSERVATION vs SUSTAINABILITY?

Permanent Change

In this perspective, the two concepts are seen as opposing one another, whereby policy choices would lean either towards the latter or the former. A more recent trend looks at the interplay between such notions, no longer conceived of as mutually exclusive. If we

[12] As James Simpson wrote *"the intention in BS 7913 in 1998 was to produce a system of definitions fit for the 21st century, one which would facilitate intelligent discussion of the subject"* (Simpson, 2008).

[13] Report of the World Commission of Environment and Development, 1987: "Our common Future" also known as the Brundtland Report. (UNESCO, 1994)

consider the two terms together, we may conclude that the concept of 'future' links them in a dynamic relationship.

CONSERVATION = SUSTAINABILITY?

Future

In fact, the future is strictly connected to the past as innovation and development are strictly connected with history and heritage. For instance, in the architectural field, in the centuries architects, engineers, craftsmen, artisan and all the other professionals involved in the construction process, have carried out trials, experiments, reflections, tests and mistakes to reach always the best results in building practice. These results are based on a continuous process of creative combination of past and present experience and expertise thus transforming building traditions integrating attention to the climate and to the local environment, to construction materials, to cultural practice, to the social context and to the technological development to *"meet the needs of individuals and groups,"* (Crouch & Johnson, 2001), p. 25.

The World Heritage Convention (1972) did not explicitly mention the concept of sustainable development concept, which was adopted only 15 years later, but in a way it implicitly referred to it, by outlining the preservation of the balance between people and nature. In 2002, the Budapest Declaration On World Heritage recommended to "*ensure an appropriate and equitable balance between conservation, sustainability and development, so that World heritage properties can be protected through appropriate activities contributing to the social and economic development and the quality of life of our communities".* Art. 3c, Budapest Declaration On World Heritage, (UNESCO, 2002).

It is interesting to notice that, in 2005, the Operational Guidelines for the Implementation of the World Heritage Convention (UNESCO, 2016) stated that the *"protection and conservation of the natural and Cultural Heritage are a significant contribution to sustainable development"* (art. 6) and that *"[...] uses that are ecologically and culturally sustainable [...](which) do not adversely impact the outstanding universal value, integrity and/or authenticity of the property [...] (must be) culturally sustainable"*, (art. 119).

In 2010, the World Heritage Convention on conservation and sustainable development (UNESCO, 2010) defined sustainable development as a careful balance of environmental, social and economic dimensions in order to meet the needs of current and future generations. The document also underlined the fundamental role of World Heritage in fostering strong communities, supporting the physical and spiritual well-being of their individuals, and promoting mutual understanding and peace. The Convention stresses the importance of sustainable development as a condition for successful conservation.

The relationship between cultural heritage and sustainable development is an issue of growing interest for municipal, regional and national administration. The technical report *Cultural Heritage counts for Europe* noted that in 2014 the European Council of Ministers defined cultural heritage *"as a strategic resource for a sustainable Europe."* (J. Sanetra-Szeliga, 2015).

Additional evidence of the close relationship between conservation and sustainability, can be found in the Agenda 21 for Culture[14]. This document, signed by more than a hundred cities worldwide, promotes culture as the fourth pillar of sustainable development (alongside the other three fundamental dimensions, represented by the environment, the society and the economy, affirmed at the Rio + 20 UN Conference on Sustainable Development in 2012), (Joanna Sanetra-Szeliga, 2016), p.44.

Another demonstration comes from the *Hanzhou Declaration: Placing Culture at the Heart of Sustainable Development Policies*. This UNESCO declaration stresses the importance of culture as a source of meanings, creativity, and innovation addressing challenges and enabling sustainable development solutions. The *Hanzhou Declaration* stresses also the role of culture as "*knowledge capital and a sector of activity - to inclusive social, cultural and economic development, harmony, environmental sustainability, peace and security"* (Joanna Sanetra-Szeliga, 2016), p.44.

The relevance of a *"[…] continuing contribution of heritage"* (Matero, 2003), p. viii for a sustainable stewardship of the built environment has also been underlined by many scholars.

Furthermore scientific studies demonstrated that ancient buildings are more energy efficient than that ones built after the industrial revolution (Ratti, Raydan, & Steemers, 2003). Several scholars underscored that the recovery of traditional techniques, combined with advanced technologies, could assure sustainable conservation under the energetic, economic, cultural and social aspects (S. Fai, K. Graham, T. Duckworth, N. Wood, R. Attar, 2011). Significant in providing confirmation of the consolidated acknowledge of

[14] It was organized by the Committee on Culture of the World Association of United Cities and Local Government in 2004. It has the same values as Agenda 21 of 1992 has for the environment. The document defines the guidelines for local cultural policies inspired by the principles of cultural diversity, human rights, participatory democracy, sustainability, intercultural dialogue and peace (World Secretariat of United Cities and Local Governments (UCLG), n.d.).

the relationship between conservation and sustainability is the 2001 US/ICOMOS Symposium. The Symposium considered the role of multiple aspects - such as: design, technology, economics, mobility, social feasibility, development, etc. - in defining new paradigms for a sustainable conservation of built heritage (Matero, 2003). The Symposium consisted in a moment of reflection, identifying that *"Through the lens of sustainability [...] (conservation can) provide an alternative to imported solution that do not relate to or grow out of the existing cultural context."* (Matero, 2003), p. viii. Further evidence of the relevance of existing built environment for a growth sustainable from the environmental and economic point of view is provided by the United Nation Energy Programme. It estimates that *"[...] the embodied energy of a building is 20 percent (of the total building energy expenditure) if a building is operational for 100 years. [...] The shorter service life, the greater the ration of embodied energy to operating energy is."* (Carroon, 2010), p.7.

In line with these general considerations, the following sections attempt to identify possible principles aimed at a sustainable conservation questioning the role of intangible aspects associated with built heritage in this process.

The first principle could be the preservation of the established values of the existing building.

Secondly, in accordance with the reversibility of the intervention, new additions should be identifiable and harmonious in color, tone, text, and scale with respect to the existing ones. Retrofitting could be appropriate for historical buildings if the improvement of energy efficiency does not affect the authenticity of the building. However, it is always necessary to study the impact of retrofitting measures on conservation at both urban and building scales in order to improve the energy efficiency of heritage assets without compromising their character and value.

Thirdly, looking at the urban context, it is particularly important to assess the balance between heritage and energy conservation and the social and economic impacts of conservation. It is also important to explore how conservation can regenerate an area and raise its profile.

Figure 7 Example of adaptive reuse in Bagan, Myanmar. The former theater has been restored changing its use to a restaurant/bar. In this operation, the public nature of this place has been preserved, maintaining the relevance and meaning of the building as a space of aggregation for the local community. Image source: Author.

In line with these principles, Joanna Sanetra-Szeliga[15] claims that the reuse of existing historic buildings and the recovery of traditional building techniques may help achieving 'green goals', while training and education on the quality of historic structures can *"foster creativity and innovation"* (Joanna Sanetra-Szeliga, 2016), p. 44.

[15] Joanna Sanetra-Szeliga is a chief specialist at the Research Institute for European Heritage of the ICC and coordinator of the Anna Lindh Euro-Mediterranean Foundation for the Dialogue between Cultures in Poland. Author of several publications on EU cultural policies and financing, investigating the role of culture in regional development and intercultural dialogue, Sanetra-Szeliga is also a Ph.D. candidate and university lecturer at the Krakow University of Economics (Koen Van Balen & Vandesande, 2016), p.321.

Figure 8 Allegory of the ignorance in the Seminar of Venafro (Molise), Italy. The wall painting follows the allegorical description of ignorance by Cesare Ripa (1560-1622), scholar and writer, in his treaty *Iconologia*, (Valente, n.d.).

These considerations explain the title of this paragraph - *The costs of ignorance: the dichotomy between conservation and sustainability.* Indeed, the ignorance of the existing built environment and its associated technical, scientific as well as social aspects has evident consequences on the long-term impact of a conservation project.

Already in the XIX century Ruskin noted the possible benefits stemming from heritage conservation. Even if he identified these benefits as mainly associated with the social and cultural sphere, he claimed that the current generation does not have the *"right to deprive future generations of any benefits, because one of the fundamental conditions of man is to rely on the past […]"*(Jokiletho, 2002), p.179.

The social and economic relevance of conservation in the current context has then be noted by many scholars. Johannes Cramer and Stefan Breitling claimed that "*The shrinking of many European cities at the end of the second millennium is a clear sign that the design and construction of new buildings is in steady decline […] between 50% and 70% of all construction work and about half of the entire economic volume of construction now concerns work on existing buildings"* (Cramer & Breitling, 2007), p. 9. Conservation of built structures is becoming increasingly important also in its connection with the sustainability challenge. Society is becoming more aware of ecological issues, foreseeing in the conservation and preservation of existing structures a possible solution to avoid the destruction of resources, for instance, due to the thoughtless demolition of old buildings, a waste in both ecological terms and socio-economic values.

Furthermore, the economic consequences of conservation and maintenance of existing structures should also be considered in a long-term planning perspective. Indeed, as noted by Cramer and Breitling, *"The conservation and maintenance of existing values, the* *possibilities for conversion, further and interim use and finally the environmentally sound disposal of the building substance are key aspects that can become important economic factors. A building can be understood as a non-recurring investment, whose value can be continually increased through appropriate maintenance and clever development"* (Cramer & Breitling, 2007), p. 200.

Nevertheless, the sustainability of the conservation and reuse of built structures should be considered also under other aspects. One of them includes its social dimension. Built structures do not represent only an economic asset but also a whole set of knowledge and skills (in terms of technical and artistic competences). This fact is relevant not only to guide maintenance and future conservation projects but also as a starting point to seek environmentally sustainable solutions for new constructions, starting from the study of the existing ones.

The relationships among the different dimensions of sustainability and built heritage conservation should then be considered within the dynamic interplay between innovation and development.

The connection among invention and conservation can be found in the semantics of the term itself. Indeed, the word ‘invention’ derives from the latin verb *invenire* that means ‘to find’ (Dezzi Bardeschi & Gioeni, 2004). Therefore, we can assume that this finding process is based on a research activity that, in the architectural field, can be associated with the study of existing built structures.

Marco Dezzi Bardeschi wrote about the relationship between conservation and innovation underlining that, despite their differences, the two concepts integrate themselves in a continuum, linking the conservation of existing built structures to their promotion and continued use. On this issue, Rosa Anna Genovese stresses that the final aim of conservation is development (Dezzi Bardeschi & Gioeni, 2004) since effective and successful conservation projects are aimed at hosting living functions. This 'living component' can ensure the continuation of a building function and consequently its maintenance, justifying the meanings of the conservation action.

3.1.2 Traditional construction methods: "When is it worth to recover them?"

In addition to cultural and social values, historic structures constitute a significant tangible reference for the design of new buildings (Ma, Hsu, Lin, Tsai, & Chen, 2015). This leads to reflect on the selection process required to identify technical constructive aspects of historic structures. Such aspects can be useful in conservation or maintenance actions that preserve the adaptive features of historic buildings to the natural environment and that can be successfully re-interpreted in the new architectural design.

An interview with Professor Frank Matero[16], held at the University of Pennsylvania, in Philadelphia, United States, focused on the relevance of when, and to which extent, it is worth to recover traditional construction methods. The conversation highlighted that the concept of 'traditional' does not necessarily imply that a given artefact is 'correct' or 'worth' in absolute terms. In architectural terms, this conclusion is relevant for the

[16] Frank Matero is a Professor at University of Pennsylvania, School of Design. His expertise is in historic building technology with a particular focus on the conservation of building materials and issues related to "preservation and appropriate technology for traditional societies and places" (University of Pennsylvania School of Design, n.d.).

current conservation debate on when and why traditional building materials, construction techniques, methods or solutions should be employed or recovered.

Indeed, some mainstream practices of conservation workflows and choices should not be acratically considered as the best preservation solutions.

In line with these considerations, a correct approach could involve the investigation of the reasons that justify traditional constructions methods, decisions, and workflows in historical structures. Indeed, the choice of one particular kind of material out of a range of alternative choices can be related to several aspects.

For instance, economic[17] and technical[18] constraints or simple ignorance of better solutions can have brought about the adoption of local material and old techniques. Nevertheless, this adaptive process usually developed innovative uses of poor or locally available materials, balancing their missing mechanical (i.e. resistance) properties or aesthetical[19] features with innovative uses and assembling patterns.

In several cases, these constraints may prove to become strengths that promote innovation and creativity for an efficient use of local, low impact primary materials available at ‘km 0’. This consideration introduces the importance of a scientific method for the assessment of traditional materials and techniques. Possible solutions can be found in the Analysis of the Life Cycle Assessment (LCA) providing parameters and

[17] For instance, locally available materials can be cheaper but less resistant than more expensive stronger materials.

[18] For example, limitations in building site tools to manage hard or strong material in the assembling phase such as high fusion temperatures, hard workability, missing tools to properly move the materials (i.e. stone blocks or huge amount of bricks, etc.,).

[19] The traditional manufacturing of the so called ‘marmo finto’ (fake marble) of Rima, in Piedmont, is an outstanding example of traditional techniques that provide for the lack of real marble developing similar aesthetic effects with other available materials (mainly gypsum and canary grass) and with a specialized and trained manpower.

criteria to determine the relevance of traditional materials and techniques in the current context[20].

Furthermore, the assessment of the importance of tradition in the architectural conservation field does not have to be limited to traditional material and techniques but should be extended to maintenance and repair workflows[21].

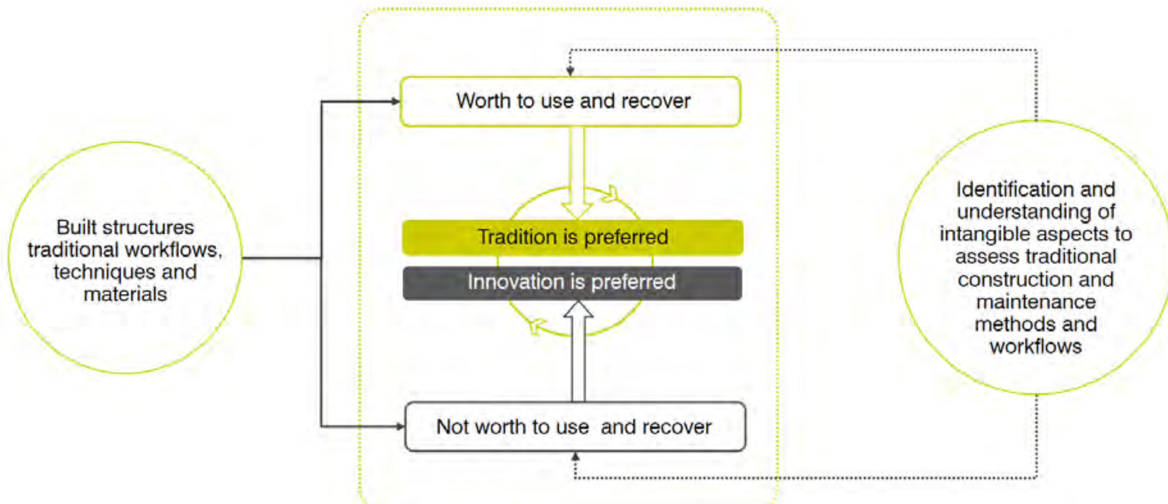

Figure 9 Diagram of the proposed approach to assess when it is worth to recover traditional construction methods. The diagram underlines the relevance of the identification of the intangible aspects of this process. Source: Author.

Therefore, the understanding of intangible aspects plays a key role to grasp pros and cons of traditional constructions aspects. Grasping these aspects can help to find out pros and cons of the traditional solutions in the AEC sectors. In addition, the assessment of advantages and disadvantages should consider change in needs and requirements due to the emergence of other issues, such as sustainability (in different perspective, taking into

[20] For instance, an analysis LCA can determine the significance of recovering traditional and locally available materials justifying it through its low transportation costs and therefore minimum environmental impact.
[21] Traditional workflows can, for instance, provide more compatible repairs and maintenance than innovative and mechanized processes.

account economic, environmental, social and cultural factors), reduction of energy consumption, climate change, local development, etc.

3.2 How to document the intangible aspects of built heritage?

Intangible aspects can also be defined as tacit aspects of knowledge that cannot be codified but can only be transmitted via training or gained through personal experience. It involves learning and skills but not in a way that can be written down. Tacit knowledge (Polanyi, 2009) is not easily shared. Although all people use such knowledge, they are not necessarily able to easily articulate it. It consists of beliefs, ideals, values, schemata and mental models, which are deeply ingrained in us and which we often take for granted. While difficult to articulate, this cognitive dimension of tacit knowledge shapes the way we perceive heritage. Therefore, the research aims at testing a way to codify tacit knowledge[22] in support of conservation practice.

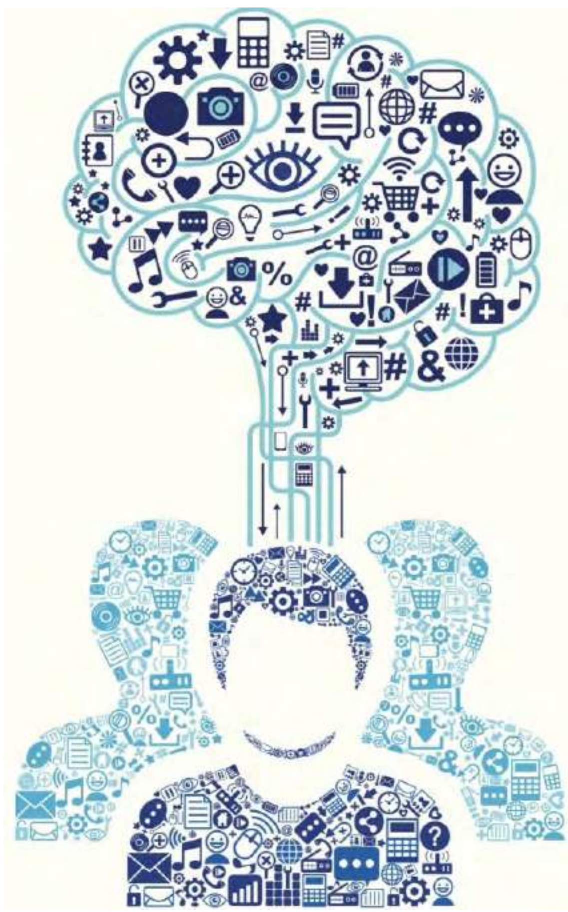

Figure 10 Symbolic illustration of tacit knowledge ("Tacit Knowledge," n.d.).

[22] Polanyi developed an original view of "tacit knowing." He believed that while declarative knowledge may be needed for acquiring skills, it is unnecessary for using those skills once the novice becomes an expert. Indeed, it does seem to be the case that, as Polanyi argued, when we acquire a skill, we acquire a corresponding understanding that defies articulation.

The potential role of the digitalization

In the current context, featured by the so-called 'digital revolution', the digitalization of the intangible values of cultural heritage can support these ideas with interesting results in the conservation practice. As Tamara Brizard, Willem Derde and Neil Silberman wrote: "*In recent years, digital heritage has begun to transform the process of re-creating and understanding the past. This new field, which integrates the traditional expertise of heritage management, museology, history, and archaeology with the powerful new tools of digital information technologies, has tremendous potential for addressing the new challenges and concerns of the heritage sector in the 21st century"* (Brizard, Derde, & Silberman, 2007).

New technologies can play a key role in the Cultural Heritage field. They can be a resource for the development of local communities, supporting the conservation of Cultural Built Heritage, and the dissemination of its values. Through IT supported solutions - i.e. visualization tools as virtual or augmented reality applications, participatory web platforms and databases as well as gaming strategies and social media - it is possible to share heritage values and information on historical sites. These values and information, which in the past have been the domain of only specialized scholars, can be shared with a heterogeneous and general public.

Hence, this study proposes a methodology and a possible strategy to document and manage the tacit knowledge integrating the "know-how" with the "know-what" and the "know-why" information in conservation practice.

The challenge: documenting the intangible dimensions

Many scholars have underlined the impossibility and the difficulty of measuring intangible assets. According to Douglas W. Hubbard, the three reasons why something should not be measure are:

1. Economic objection to measurements (i.e. economic feasibility of the measurements that would be too expensive);
2. General objection about the usefulness and meaningfulness of statistics and models (that in measuring heritage intangible values can be useless or not very effective);
3. Ethical objection (related to the subjectivity of the intangible dimension) (Hubbard, 2007).

The present study addresses these issues by trying to answer in particular to the economic objection.

It demonstrates how the efforts to measure the intangible values can be balanced, in a long-term perspective, by a return due to the preservation of the character defining elements, of the local *know how* (in terms of craftsmanship and manual capabilities) and of the specific capabilities of a place (in terms of technical knowledge) able to support the local production and to guarantee the promotion of cultural tourism.

As regards the general objection, this study tests the opportunity of a BIM model to structure and represent intangible aspects, related to the production and maintenance process of heritage structures, stressing their role in the conservation and promotion processes.

In documenting intangible aspects associated with a built structure, the following questions are considered:

- Why are we measuring?
- What really is the thing we are measuring?
- What is the decision this measurement is supposed to support?
- Why does this thing matter to the decision making process?
- What do we know about it now?
- How to move from unstructured information towards structured, consistently represented information?
- For whom are we measuring? (Hubbard, 2007).

In line with these questions, the study addresses the challenges of the documentation of the intangible aspects associated with historic built sites by considering how to:

a) Document the dynamicity of the intangible aspects.

b) Identify the wide range of scale of the intangible aspects.

c) Investigate and document the multi-scale dimension of the intangible aspects at:

- Urban level (i.e. spirit of a place vs. gentrification).
- Architectural level (i.e. craftsmanship, know how).

These considerations are the basis to understand the selection actions in the recording process. Another issue addressed in the study concerns how to make the BIM a 'smart' tool, able to interpret the stimuli of the heritage users.

The definition of an inventory approach

Several scholars claimed the relevance of an inventory. According to Antonio Gramsci's notion of inventory as awareness of what heritage really is, it is necessary understand the juxtaposition of its layers*: "The starting-point of critical elaboration is the consciousness of what one really is, and is knowing thyself as a product of the historical process to date which has deposited in you an infinity of traces, without leaving an inventory. The first thing to do is to make such an inventory."* (Hoare & Nowell Smith, 1999), p. 628.

Therefore, an inventory of the intangible aspects associated with a building should include two main phases:

- The first one concerns methods and techniques to document and represent intangible values;
- The second one consists in the identification of a strategy to update the inventory, by considering the transformation of intangible legacies.

The aim of this recording and documentation approach is to portray the combination of the cultural legacy of built heritage as well as the building's significance.

According to Umberto Eco "Theory of codes"[23], the inventory can be structured as a multileveled discourse (Eco, 1979), which combines material descriptive technical data (i.e. geometry, materials, etc.) with intellectual meanings and transformations of key concepts or system of thoughts – intangible aspects.

[23] The basic concept of the Theory of Codes is the definition of denotation and connotation. Denotation is the literal or obvious meaning of an expression/word, for example: the building façade is white. Connotation is a second-level code based on the first, as in metaphors, tropes, and double meanings. For example a red streetlight that, apart for it its literary meaning of stop to let pass other people, suggest additional cultural meanings such as the respect of the other and the acceptance of living a in a collective society (Eco, 1979).

In the case of built structures, an inventory provides the basis to formulate concrete plans to safeguard and disseminate intangible aspects associated with material building components. An improved accessibility of intangible heritage inventories and the possibility to update them by the public can encourage users' community creativity and self-respect.

To gather information on material descriptive technical data, intellectual meanings and associated transformations, information coming from the people directly or indirectly involved in the conservation issues are extremely useful. Direct observations and personal communications with different professionals, experts and local actors involved or affected by built heritage can be developed. This would provide integrations and a critical evaluation of the previously proposed methodological approach on the intangible documentation.

Considering the opportunities provided by new communication systems, such as social network and web platforms, their potentials should be explored. These applications can provide technical support to develop participatory documentation processes, thus increasing public engagement with heritage conservation. These aspects are deepened in the paragraphs *4.1 Information Technology (IT) and digital tools for Cultural Built Heritage: perspectives and challenges for conservation 2.0, 4.1.2 The potential of digital recording technologies and internet networks for conservation actions* and *5.2 Web platforms supporting participatory documentation for built heritage sites.*

In the identification of values and intangible aspects, for the development of a building inventory, the Nara Grid can be a useful tool to organize collected information.

Table 1 Nara Grid. Source: Van Balen, K. 2008. Experimenting with the 'NARA-grid', an evaluation scheme based on the Nara Document on Authenticity in *APT Bulletin.*

ASPECTS	DIMENSIONS			
	Artistic	Historic	Social	Scientific
Form and design				
Materials and substance				
Use and functions				
Tradition and techniques				
Location and settings				
Spirit and feeling				

If slightly integrated with three additional variables, the grid can provide an efficient framework to document some intangible aspects associated with heritage structures.

Table 2 Proposed Nara Grid integration. Source: Author.

INTANGIBLE ASPECTS ASSOCIATED	DIMENSIONS				GEOGRAPHIC AREA	KNOWLEDGE KEEPERS	KNOWLEDGE KEEPERS LOCATION
	Artistic	Historic	Social	Scientific			
Form and design							
Materials and substance							
Use and functions							
Tradition and techniques							
Location and settings							
Spirit and feeling							

By simply adding three columns to the Nara Grid, the identification of intangible aspects can be associated with a place (geographic area), with the people charged of keeping it alive (knowledge keepers) and with their location (knowledge keepers location).

To enable this information to orient the planning and design phases on built heritage structures, it is necessary to integrate it directly in the operative design and planning tools. This would allow such analyses to play a significant role in conservation actions. Recent developments in Spatial Information Systems opened up interesting opportunities to complement geometric database with semantic descriptions. This would provide the technological support to integrate inventories of intangible values in the operative design

tools. These aspects are deepened in Chapter 4 - *The potentiality of the 'Digital Revolution' for the conservation, documentation and management of Cultural Built Heritage* – which explores opportunities of Spatial Information Systems focusing on the Building Information Modelling (BIM); in Chapter 5 - *The Epistemic object: WikiBIM as a participatory documentation approach to managing design choices in built heritage contexts* – which considers how to effectively integrate intangible values in BIM systems; and in *Chapter 7 The Zètema of the Loka-hteik-pan temple* and *Chapter 8 Combined uses of BIM systems and Wiki approaches to collect and archive quantitative and qualitative information* that provide an empirical application of the proposed approach.
Features, documented and managed by the proposed approach, encompass information about heritage's tangible and intangible values, associating them with detailed geometrical and spatial information.

A review of initiatives and activities of documentation of intangible heritage
Some initiatives and projects employing digital tools to document and safeguard intangible cultural heritage have been analyzed in order to assess the main lessons learned from existing approaches. The reported projects have been selected according to their relevance for the research.

The European project CASPAR[24], for instance, is oriented to the development of tools for the management of archives in the artistic field for the documentation of performing arts.

[24] CASPAR is an acronym that stands for Cultural, Artistic and Scientific knowledge for Preservation, Access and Retrieval. It is a project financed by the European Union within the context of the Sixth Framework Programme. The project was launched in 2005 and includes among its main partners: the Centre national de la recherche scientifique (CNRS), the Université de technologie de Compiègne (UTC), the Institut Nationelle pour l'Audiovisuelle, Francia (INA), University of Leeds, Council for the Central Laboratory of the Research Councils (CCLRC), United Nations Organization for Education, Science and Culture (UNESCO), Institut de Recherche et Coordination Acoustique/Musique (IRCAM) and International Centre for Art and New Technologies (CIANT), ASemantics, MetaWare, Engineering and IBM/Haifa, Consiglio Nazionale delle Ricerche (CNR), the University of Glasgow and the University of Urbin. The different partners combine scientific, cultural and creative expertise with commercial partnes, experts in knowledge (Giaretta, 2006).

The project focuses on preservation through change. CASPAR aims at designing and developing a distributed, Open Archival Information System (OAIS)[25] – an archive system that provides access to flexible, sustainable, and interchangeable digital preservation services. The architecture of CASPAR is based on six main principles: Open Archival Information System (OAIS) compliance[26], technology neutrality[27], loosely-coupled architecture[28], domain independence[29]**,** preservation of intelligibility and knowledge dependencies and preservation of authenticity and digital rights[30].

One of the main principles of the CASPAR project is the 'preservation through 'access'. It means to develop effective preservation actions allowing constant open access to users who become the active actors charged of its maintenance through a constant use and updating of the archive.

The i-Treasures project instead aims at documenting intangible heritage elements. The focus of the project, promoted by the European Community, consists in the safeguarding and dissemination of the know-how embedded in artistic expressions including dances, forms of craftsmanship and traditional songs. The goal of the project is the development of an "*open and extendable platform to provide access to ICH resources, enable knowledge exchange between researchers and contribute to the transmission of rare know-how from Living Human Treasures to apprentices*" (I-Treasures, n.d.-a). The

[25] Brian Lavoie, associate research scientist at the Online Computer Library Center OCLC Office of Research, defines the Open Archival Information System (OAIS) reference model as *"a conceptual framework for an archival system dedicated to preserve and maintain access to digital information over the long term".* The purpose of this reference model consists in increasing awareness and understanding of key concepts in archiving digital objects. The OAIS model defines terminology and concepts to describe and compare data models and archival structures. It provides principles to preserve and access digital information and develop a framework to guide the identification and development of standards (Brian Lavoie, 2000).
[26] The components of the CASPAR should be compliant with the OAIS Reference Model, the main standard of reference in digital preservation.
[27] The term technology neutrality means that the CASPAR preservation environment will be implementable using new technologies as they emerge.
[28] It indicates how the project can be used employing different platforms.
[29] Applicability should be ensured to multiple domains/contexts, including both public and private organisations.
[30] Integrity and identity of the information should be guaranteed as well as the protection of digital rights.

project contribution goes beyond the digitalization of cultural contents, by developing new paradigms that combine web and IT solutions in support of information sharing and knowledge creation.

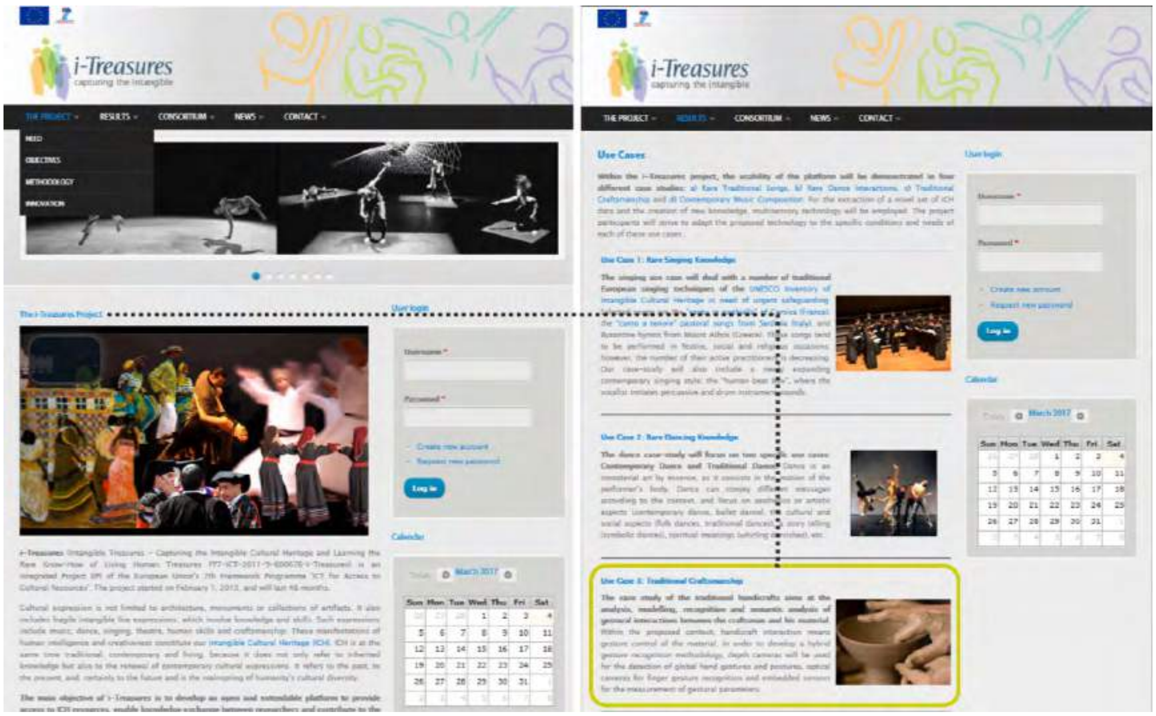

Figure 11 Screenshot of the i-Treasures website interface. Source: i-Treasure website (I-Treasures, n.d.-b).

One of the innovative aspects of the project consists in a methodological approach based on multisensory technology for the creation of information (I-Treasures, n.d.-a). This can be clarified by presenting one of the developed activities tested on the modelling, recognition and semantic analysis in traditional craftsmanship. Traditional handicraft is the most tangible manifestation of intangible cultural heritage. Starting from this consideration, the gestural interaction between craftsmen and the material to be modelled is studied. The analysis and documentation of the interaction between man and material in the production of handicrafts allow detecting the different steps employed and to assess, at the same time, gestural parameters. The project's researchers proposed this approach to measure several physiological aspects related to ‘artistic’ making process. This would allow the preservation of reputable know-how in different domains, from performative arts to handicraft.

From a technical point of view, depth cameras are used to identify and record used gestures (I-Treasures, n.d.-a). Using 2D, 3D and embedded sensors, the project is developing a hybrid gesture recognition methodology to study the know-how of pottery handicrafts making. The results are expected to allow the development of tools to transmit the skills (I-Treasures, n.d.-a).

The potential of i-Treasures opens up new perspectives in term of learning, training and knowledge transfer. Furthermore, the development of a digital archive for intangible know-how related to performative arts and craftsmanship can be useful to support economic development, projects in the field of tourism entrepreneurship and training initiatives.

Despite the proposed concept is very interesting, for both its innovative analytical framework content and the technologies employed, the present research does not assess this project as something feasible in the safeguard of the intangible knowledge associated with the production and maintenance of historic built structures.

Indeed, the proposed methodology would be very time- and cost-consuming and it would be not sustainable from a social and economic point of view.

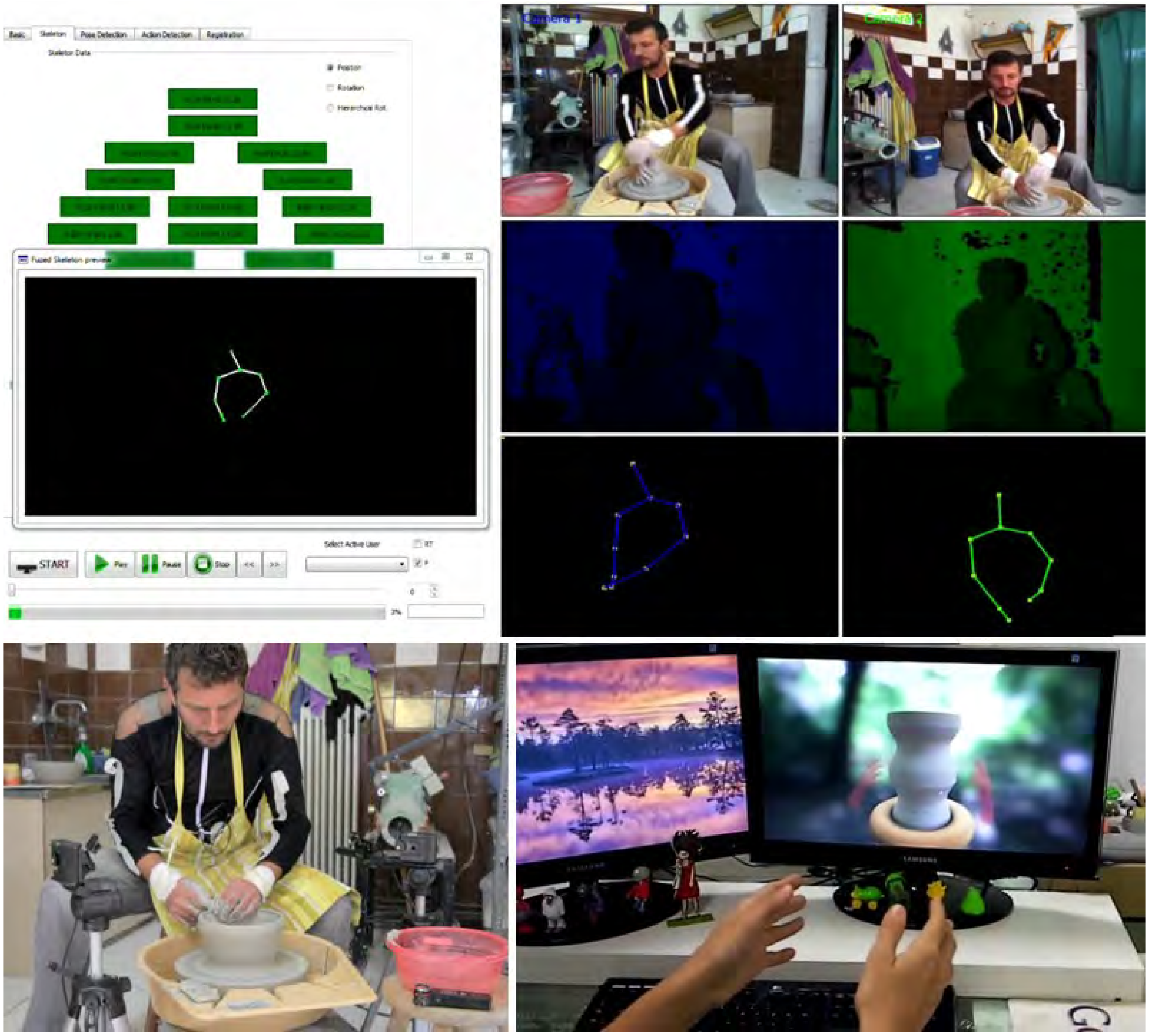

Figure 12 The i-Treasure project developed a strategy to create a 'model' of the fabrication process of traditional handicraft. The 'model' documents the gestural interaction between craftsman and the material to be modelled. This analysis documents the interaction between man and material in the production of handicrafts detecting the different steps employed and measuring at the same time gestural parameters. The results are then elaborated to develop applications, usually following gaming strategies to transmit the skills. Images source: Multimedia Technologies & Computer Graphics Lab, (i-Treasures, n.d.).

Another interesting project is the Atlas of the World's Languages in Danger. The Atlas consists of an online interactive digital application to provide updates and information on about 2500 languages in danger worldwide. This database can be implemented, edited and updated by the users' contribution.

The application allows information searching according to different criteria or 'levels of vitality' (UNESCO, n.d.-b) (vulnerable, definitely endangered, severely endangered, critically endangered, and extinct).

Most interesting aspects of the project consists in the operationalization of a participatory approach in the development of the Atlas. Indeed. The interactive Atlas provides an online geo-database to visualize, update and edit information. This stimulates involvement, participation, and interest in the project topic, turning users into active members.

This is relevant for the proposed Wiki approach, discussed in Chapter 8, that aims at enabling broad public participation and involvement in the conservation of tangible and intangible aspects of built heritage. Despite the *Atlas of the World's Languages in Danger* project deals with intangible elements that are not a focus of this research, the structure of its online database is an interesting source of inspiration for the proposed Wiki part of the WikiBIM epistemic object.

The most relevant feature is the connection between experts and community in the creation of the contents. These contents are provided by UNESCO experts in a first step and can be later implemented and modified by the public. Users can comment, and share information, on a language already in the database, advises about other languages to be inserted in the on-line database or suggest safeguard programmes. Furthermore, users can fill in a questionnaire that is available online, to determine the vitality degree of a language. The combination of the different answers to the questionnaire allows building a participatory image of the degree of actual usage of a language (UNESCO, n.d.-c).

This example of participatory cartography highlights some criticalities. Indeed, while it is easy to geo-reference tangible assets, what is the process to define territorial boundaries of intangible elements? The Atlas proposes as a possible solution to this issue the employment of points as a symbolic localization to associate a language with a wider territorial context. If this solution could apparently work for this kind of initiative, what about intangible knowledge related to built environments? Would a punctual localization be effective to localize firms and reputable know-how diffuse on a territory? These reflections are taken into account by the research that faces similar problems in defining effective strategies to gather, codify and process information through bottom-up approaches.

In the Atlas, points have been located in the centre of an area in which people speaking that language live. In other cases, the location indicated on the map corresponds to the location of the largest community that speaks that language.

In the case of isolated communities, multiple points have been used to indicate the presence of a language and the related information (i.e. different levels of vulnerability).

This project is an interesting example of a practical approach to the documentation of intangible heritage that can be extended to others intangible domains such as traditions, social and spiritual values, building knowledge, etc.

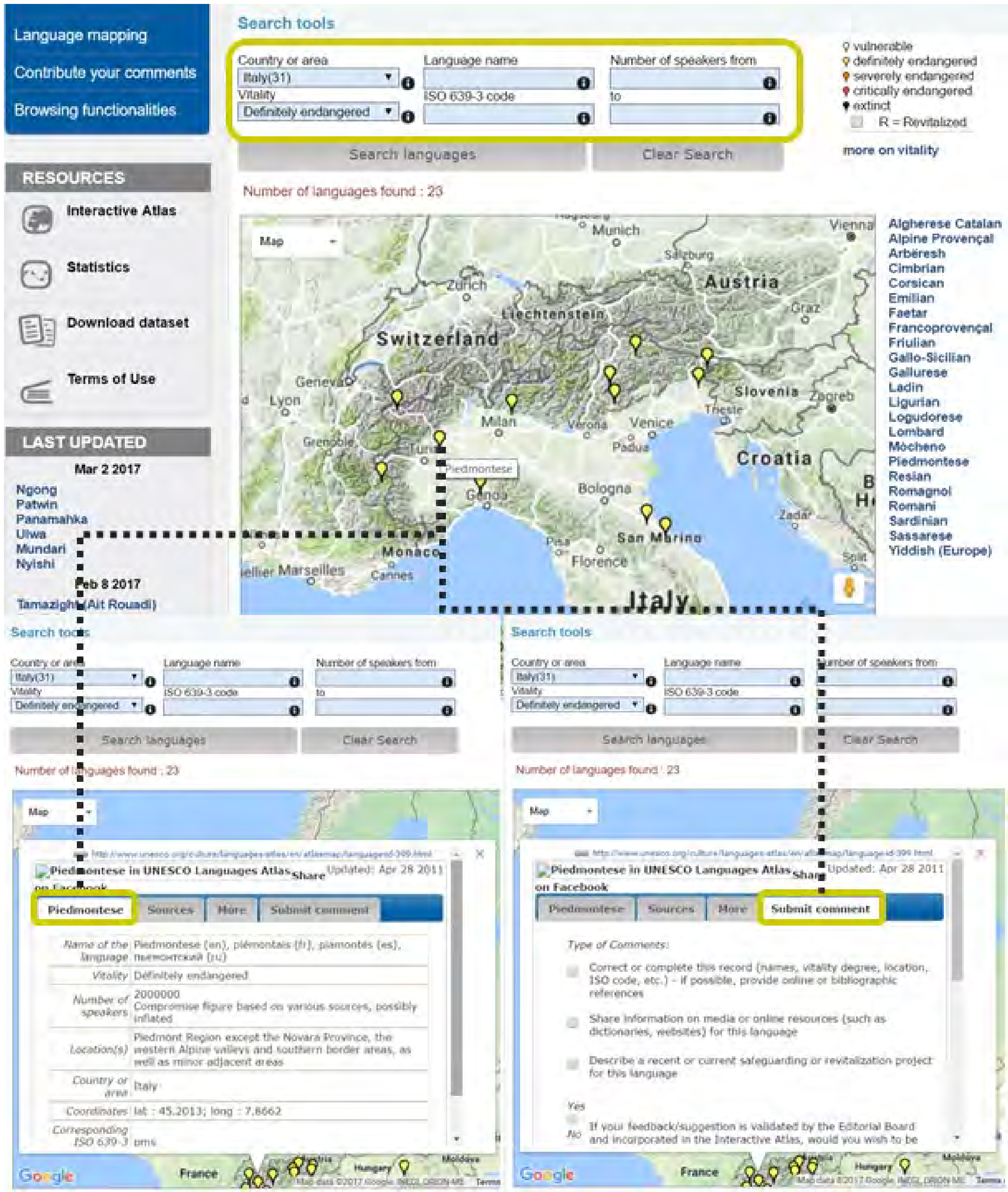

Figure 13 Structure of the Atlas of the World's Languages in Danger. The image shows the online platform interface and the function that allows public contribution. Image elaboration Author, images source: (UNESCO, n.d.-b).

Another interesting project is the IDEA, Istituto DemoEtnoAntropologico (Institute for Demography, Ethnography and Anthropology). This initiative has been developed in Matera[31], Italy, within the framework of the bid for the 2019 European Capital of Culture.

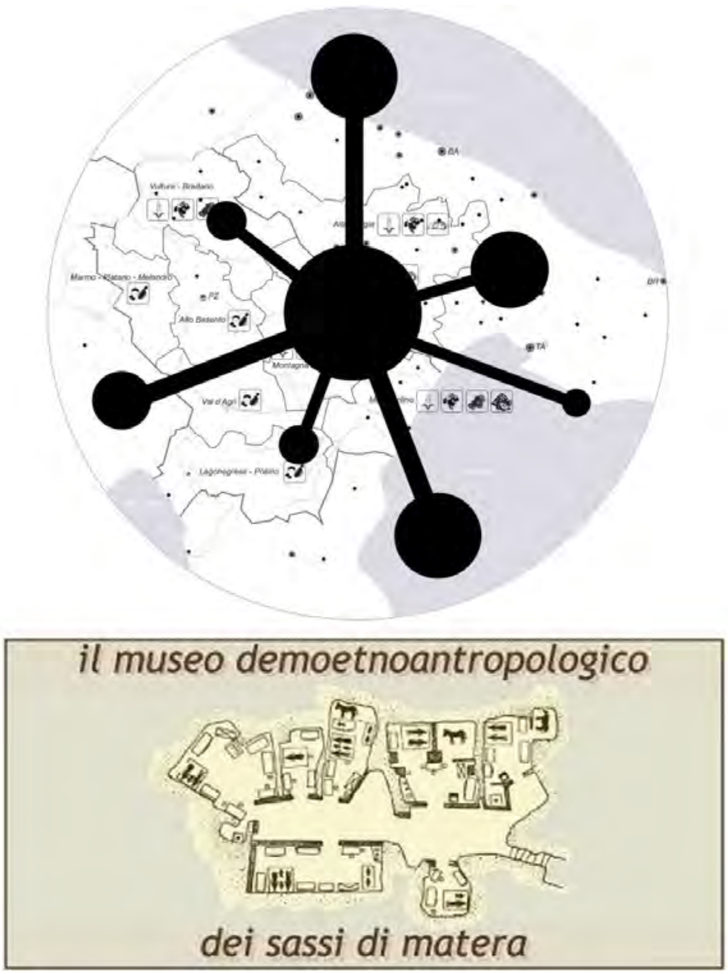

Figure 14 The image symbolizes the concept of the IDEA. Image elaboration: Author.

The project dates back to the ’50 when, in order to protect and preserve intangible heritage, local stakeholders conceived the establishment of a Museum of Demography,

[31] Matera is a small size provincial capital in the region of Basilicata, in the southern part of Italy. It is one of the oldest continuously inhabited sites in the entire World. Its first settlements date back to 9000 BC, embodying the development, through the millennia, of agricultural systems and urbanization. The focus of this stratification is the UNESCO site of “The Sassi and the Park of the Rupestrian Churches of Matera”. This site has been the first World Heritage Site in Italy recognized within the category of ‘Cultural Landscape’, due to the outstanding historic development of the town combined with the natural environment. The area of the Sassi (literally stones) hosted for centuries inhabitants together with their animals (indeed, the Sassi were used as houses hosting also the work animals, such as donkeys, as well as poultry, etc.), commercial and handcrafted activities. With the urban development of the XIX century, a process of marginalization and overpopulation of the Sassi began. This process led to the worsening of living condition within the Sassi, that suffered a complete decay, until the relatively recent rehabilitation projects were started in 1986, thanks to the national law n.771/1986 named “Conservazione e recupero dei Rioni Sassi Matera” (Conservation and recovery of the districts of Sassi of Matera). The law allocated 100 billion of Italian lire (around 110.000.000 of current American dollars) in order to preserve the historic area of the Sassi, converting it in a cultural and touristic site (Giura Longo, 1998). After its recognition as a World Heritage Site (WHS) in 1993, the city and the local population started to develop rehabilitation and conservation projects of the whole area. According to these considerations, the recent nomination of Matera as European Capital of Culture (ECoC) in 2019 is the opportunity to develop integrated actions for the conservation and enhancement of the city and its surrounding context. The combination of different elements characterizing the place identity such as the gastronomic heritage, handwork, craftsmanship, local events and traditions can lead to the rethinking of the boundaries of the WHS, including its tangible as well as its intangible values and meanings.

Ethnography and Anthropology. In 2010, Fondazione Carical elaborated an implemented project for the museum, to be located in the abandoned caves of Sasso Caveoso.

To strengthen the concept of a museum about the anthropological and ethnographic roots of the territory, the local administration planned the creation of the Istituto DemoEtnoAntropologico (IDEA). The Institute will include documents and artifacts of the daily life of the Sassi inhabitants. It will be the core of a scattered museum. The goal is to collect the archives of the Basilicata region altogether, creating a network of all the regional collections, a comprehensive virtual database, digitalizing under Creative Commons license all the documents in the different museums, preserving the physical objects in the museums' archives. These archives store artisanal utensils, agricultural equipment, art masterpieces as well as audio documents and ethnomusic files, photographic and cinematographic collections, letters and historical documents.

The most innovative feature consists in mapping the oral heritage of the city of Matera and of the Basilicata region, documenting traditional costumes, rituals, events, dialects and also wine and food production. The main goal of the whole operation is to make the intangible heritage of Basilicata open and accessible to everybody by improving collaboration and international exchange (Istituto Centrale per la Demoetnoantropologia, n.d.).

Always in Matera, the Museum of Virtual Collective Memory (MUV) is another interesting crowdsourcing initiative supported by a web platform. It consists of an open-data project which everybody may contribute to and take advantage[32] from. It is a virtual collection of materials, mainly pictures, of either public or private archives, building up

[32] In this case advantage is intended in terms of knowledge and cultural awareness.

an archive of collective memory. This approach, in line with the 2.0 trend make of the MUV the first participatory on-line museum of the memory. This platform is relevant since it allows to document and share intangible aspects intended as socio-cultural and spiritual values (Associazione Museo della memoria collettiva di Matera, n.d.).

Figure 15 Image source: MUV webpage (Associazione Museo della memoria collettiva di Matera, n.d.).

Table 3 Summary of the selected on-going and past initiatives and projects aimed at defining effective strategies to safeguard intangible cultural heritage. Source: Author.

PROJECT/INITIATIVE: CASPAR			
STRATEGY &TECHNOLOGY USED	AIM	STAKEHOLDERS	SOURCE
The project proposes solutions to digitally document immaterial objects such as performances, knowledge and skills. The main principle of the CASPAR project is the 'preservation through access'. This is intended to develop effective preservation actions, allowing constant open access to users who become the active actors charged of its maintenance through a constant use and update of the archive. Database constant use and usability indeed would allow access and interaction of users keeping alive their interest and maintaining at the same time the archive updated in terms of content and information accessibility (avoiding data longevity problems).	Facing the challenge of a growing amount of intrinsically fragile digital information, the project addresses this issue by building a framework based on existing and emerging standards to support end - to - end preservation 'lifecycle' for scientific, artistic and cultural information. The CASPAR project aims at developing a distributed Open Archival Information System (OAIS) system that provides access to flexible, sustainable and interchangeable digital preservation services. The final aim of the project consists in building up a common preservation framework for heterogeneous data, along with a variety of innovative applications. The project idea stems from the awareness of a shared knowledge and of the tools needed to manage it according to the world wide web approach[33].	Centre National de la Recherche scientifique (CNRS), the Universite' de Technologie de Compiègne (UTC) and the Institut Nationelle pour l'Audiovisuelle, (INA)	www.casparpreserves.eu http://www.dcc.ac.uk/resources/briefing-papers/technology-watch-papers/caspar https://www.ercim.eu/publication/Ercim_News/enw66/giaretta.html
PROJECT/INITIATIVE: i-Treasures			
STRATEGY &TECHNOLOGY USED	AIM	STAKEHOLDERS	SOURCE
The initiative develops a methodology to capture and analyze Intangible Cultural Heritage. In this process, different methods are employed. These include multimodal analysis and data fusion to enhance semantic metadata extraction by exploiting information across different modalities; semantic media interpretation by mapping a set of low-level multimedia features to high-level concepts. These techniques are used to document facial expression analysis (singing, music composition), body and gesture recognition (singing, dance, craftsmanship, music composition), vocal tract modeling (singing), sound processing (song, dance, music composition), electroencephalography (music composition). Multisensory technology, including 'image/signal processing' and 'pattern recognition', are used to document the performance artisans and artists creating 'models' that can be accessible to multiple users through gaming strategies, thus safeguarding existing knowledge through new modalities of training and learning.	Safeguarding and dissemination of the know-how embedded in artistic expressions including dances, forms of craftsmanship and traditional songs are the main goals of the project. Addressing these goals, i-Treasures aims at developing new ways for cultural expressions connecting the past with the present making it relevant in the contemporary world. Therefore, the project developed an open platform to access Intangible Cultural Heritage resources. The platform overtakes the simple digitalization of intangible heritage, proposing new paradigms to the analysis and modelling of the Intangible Cultural Heritage.	European Community	http://i-treasures.multimedia.uom.gr/drupalprivate/node/1 http://i-treasures.eu/content/objectives-i-treasures

PROJECT/INITIATIVE: ATLAS OF THE WORLD'S LANGUAGES IN DANGER			
STRATEGY &TECHNOLOGY USED	AIM	STAKEHOLDER	SOURCE
The Atlas consists in an online geo-data base, within the UNESCO web platform. It enables to visualize and geo-reference languages in danger and to classify their vulnerability level according to a predetermined scale. Users play a key role in the identification of the endangered languages. The online platform enables them to contribute to the creation and update of the Atlas, benefitting from the support of a user-friendly web platform.	The Atlas, aim is to promote a global database through a geographic interface and to provide a dialogue platform between communities, specialist, national and international authorities.	UNESCO	http://www.unesco.org/languages-atlas/
PROJECT/INITIATIVE: Museo della Memoria Collettiva – MUV			
STRATEGY &TECHNOLOGY USED	AIM	STAKEHOLDER	SOURCE
It is a crowdsourcing initiative supported by a web platform to catalogue and collect shared material (mainly photos). The on-line web platform also allows downloading images and information available on it. To load images a log in is required.	It consists in an open-data project which everybody may contribute to and take advantage from. It is a virtual collection of materials, mainly pictures, of either public or private archives, building up an archive of collective memory. This platform allows to document and share information on intangible aspects (mainly associated with the socio-cultural and spiritual dimension).	Associazione Museo della memoria collettiva di Matera	http://www.muvmatera.it/aspFoto/raccolte.asp
PROJECT/INITIATIVE: I.D.E.A. Istituto DemoEtnoAntropologico			
STRATEGY &TECHNOLOGY USED	AIM	STAKEHOLDER	SOURCE
It is a comprehensive virtual database, digitalizing under Creative Commons license documents and objects. The most innovative feature consists in mapping the intangible heritage of the city of Matera and of the Basilicata region, documenting traditional costumes, rituals, events, dialects and also wine and food production.	The goal is to digitalize the archives of the Basilicata region altogether, creating a network of all the regional collections, a comprehensive virtual database. These archives store artisanal utensils, agricultural equipment, art masterpieces as well as audio documents and ethno-music files, photographic and cinematographic collections, letters and historical documents. The main aim of the whole operation consists in making the intangible heritage of Basilicata open and accessible to everybody improving collaboration and international exchange.	Fondazione Carical, Ministero dei Beni e delle Attività Culturali e del Turismo, (MiBACT) Istituto Centrale per la Demoetnoantropologia	http://www.idea.mat.beniculturali.it/

3.2.1 The Rapid Ethnographic Assessment Procedures (REAP)

The so-called Rapid Ethnographic Assessment Procedures (REAP) is a methodology developed along the lines of ethnographic enquiries which is informed by the basic tenets of ethnography, while providing results in a relatively short period. It combines different methodological approaches including cognitive, ethnographic, discourse, phenomenological and observational analyses (Low, 2002).

This methodology, adapted from the investigations carried out in rural areas for the design of development projects, relies on three principles: triangulation methods, iterative process of information collection and analysis and system perspective (Low, 2002), p. 35. These principles are fully compatible with the approach proposed by the present study, and for this reason, the research considers the REAP as an efficient and effective method for the documentation of intangible heritage. Indeed, this method allows a rapid assessment of a social and territorial contexts, by identifying how social, cultural and economic aspects are connected. Designed for the collection of qualitative data, the REAP enables to discover local knowledge that can be potentially used for planning development actions and conservation initiatives. Within the REAP methodology, different types of information come from multiple investigations: collection of historical and archive documents[33], physical traces mapping[34], behavioral mapping[35], transect walks[36], individual interviews[37], expert interviews[38], focus group discussions[39], impromptu group interviews[40,] participant observation[41], and analysis[42] (De La Torre, 2002), p. 37-38. These analyses are triangulated in order to make final outputs more

[33] It is the first step of the REAP method. It consists in the review of historical and archival documents to understand history and consequently socio-cultural and urban transformations (Low, 2002).

[34] It consists in the analysis of physical traces clues of unconventional or unknown activities on a site. These analyses are carried on early in the morning. The results provide more complete understanding of social practices and activities, in and around a site. Traces can range from bottles, trash, clothing, food leftover, pieces of car or motorbike, cigarette butt, furniture (chairs, stools, etc.) providing indirect clues of night social practices and human activities (Low, 2002).

[35] It consists in recording people activities locating them in a temporal framework and in a graphic context. It is useful to develop analysis on people flows during the day and to understand every day activities and happenings in a site (Low, 2002).

[36] It consists in roaming interviews with few local community members (usually one or two). The roaming feature of the transect walks allow a direct understanding of the conversation topic seeing the object of the discussion in real time. This kind of guided tour or walk of a site also allow to learn about a site from its community members point of view (Low, 2002).

[37] They consist in individual interviews to selected community representatives. Number, categories and profile of the interviewed people change depending on the specificity of each site and on the project requirements (Low, 2002).

[38] They consist in interviews addressed to selected experts in different areas affecting site and community life. For instance, experts can include representatives of local merchants, professors, head of departments, ministries, chief of religious community, etc., (Low, 2002).

[39] These groups are composed by selected people that can play a key role in the understanding of the site and of the local population. These groups are usually made of few people (six to ten individuals) selected as representative actors of a site and within a local community (Low, 2002).

[40] Through this method, data are collecting in a group context, providing at the same time education opportunity for a community. These groups, usually take place in open or public spaces (Low, 2002).

[41] These observations are developed by researchers that record their impressions periodically. These analyses provide contextual information about the interaction between users and communities (Low, 2002).

[42] This is the last step of the REAP method. It consists in the organization and interpretation of all the information gathered through the analyses described above (Low, 2002).

reliable. The triangulation of this methodology is important because usually, the researcher does not know the best question to get people confidence and therefore to convince informants to share with the interlocutor local knowledge and information (Low, 2002). Elaborated information can be used to identify cultural and working activities, community interests, needs, and concerns as well as to gather context-related information.

Table 4 Type of information that can be collected from the ten methods of the REAP methodology. Adapted from Low Setha, Anthropological –Ethnographic Methods for the Assessment of Cultural Values in Heritage Conservation, (Low, 2002).

METHOD	TYPE OF INFORMATION COLLECTED
Historical & Archive Documents	Historical awareness to understand the transformations of a site and the relationship among space and communities.
Physical Traces Mapping	Description of night activities useful to have a comprehensive understanding of social activities related to a site and its surroundings.
Behavioral Mapping	Identification of cultural activities on a site.
Transect Walks	Intangible aspects including meanings and values of a local community associated to a site and community needs' understanding.
Individual Interviews	Specific information, feedbacks, opinions and requirement related to specific topics.
Expert Interviews	Community leaders points of view and opinions on events and socio-cultural and economic context and transformations.
Focus Group Discussions	Shared opinions, needs and requirements on specific issues.
Impromptu Group Interviews	Group consensus and perspective on proposed issues.
Participant Observation	Impressions of everyday life, participant interaction with users and community.
Analysis	Map of heterogeneous information

In the heritage field, this method, used by the National Park Service (NPS) historical parks in the USA and then adopted by the Getty Conservation Institute (De La Torre, 2002). The REAP methodology allows to document and analyze intangible aspects associated with built heritage by taking into consideration three basic principles: (a) a system perspective; (b) triangulation methods; and (c) an iterative process of data collection and analysis (Avrami, Mason, & De La Torre, 2000), p. 35. This three-pronged approach tries to compensate for the short time framework available for assessing the situation on the ground, by resorting to a rapid assessment procedure[43] that aims at identifying the elements of local constructive systems and how they interrelate with the socio-cultural and territorial systems.

This methodology is open to the integration of data and information by oral sources and the coding of recorded experiences and performances by means of multimedia and web-based support devices, by using local informants, comparing information on similar procedures in a cross-regional, cross-cultural perspective, and contextualizing the resulting analysis on the basis of careful considerations of local social and cultural variables.

Benefits of this method can be grouped into two main areas: community empowerment and conflict management.

Applicability of the REAP includes, but is not limited to, the assessment of socio-cultural values. It produces an organic description of a site and of related local and non-local communities and of relevant near sites (Low, 2002). In the heritage field, it can be also used to document embedded intangible values and knowledge still alive in the local community. Furthermore, information provided by these analyses allow accessing the local knowledge of a place, by understanding how it grew out of the experience and how at the same time it symbolized that experience (Low, 2002).

The use of REAP within the current research has required adjustments to the specificity of the context. The overall research fieldwork lasted about one month, spent both in on-site data gathering and recording through digital techniques, and qualitative information collection by means of REAP. The main REAP methods used for the research were direct

[43] Indeed, according to Avrami E., Mason R., De La Torre M., *"Rapid assessment is especially relevant when time constraints preclude use of intensive qualitative methods by a single researcher and when the different perspectives of the team members (including local participants) are essential for understanding the situation"* (Avrami et al., 2000), p. 36.

observations such as behavioral mapping, transect walks, participant observations, personal communications and historical and archival research.

The results of different sources of information were triangulated for determining their reliability. For this purpose, REAP techniques were applied by using control questions to different informants. REAP were iterated over time in different villages in the research area.

Although participants were not selected on the basis of a statistical sample, they were identified by making sure that they broadly reflected the diversity of the local population with respect to such criteria as: role within the community, occupation (in areas relevant to conservation), education, gender, and age.

The resort to formal and informal REAP techniques in order to gather information and data that question West-driven approaches to heritage conservation raises issues of possible contradictions, because such techniques are grounded in a scientific tradition deeply rooted in the West. However, the research hypothesis, by aiming at testing the relevance of integrating tangible and intangible dimensions of heritage for conservation strategies, assigns great importance to the local knowledge of actors and stakeholders from the communities in the research area. As such, reflexivity has been playing an essential role for questioning the possible Western bias that the research could inadvertently reinforce through the use of scientific analytical methods. This has essentially impacted on the research in two ways. Firstly, during the iteration of the REAP during fieldwork, the initial hypothesis has been further specified and refined by taking into account the actual feedback and views expressed by local experts and actors engaged in conservation in Bagan. Secondly, the research has been carried out as part of a collaborative efforts that has involved also a local PhD researcher in the field of conservation. Interactions and professional exchanges with her have also contributed to reducing the possible bias inherent to any participatory research effort in the field of heritage conservation.

3.2.2 Social media and digital platforms

With the consolidation of social media and social network, photography has become the most popular technique through which people share thoughts, ideas and values.

This trend consolidated in the last years as evidenced by the increasing number of photo-based applications. Evidence can be found in different popular and widespread applications such as Photovoice, Instagram with 600 million of users (The Statistic Portal, n.d.), Tumblr (550 million of users) (The Statistic Portal, n.d.) and Pinterest (150 million of users) (The Statistic Portal, n.d.) just to mention some of them.

Due to the availability of tools to take and share images, photography becomes an easy and effective technique to be considered for strategies of participatory documentation of Intangible Cultural Heritage.

For instance, Photovoice is an organization offering participatory photography applications. Aware that photography overtakes cultural and linguistic barriers to document events and concepts, Photovoice designs and delivers tailor-made participatory photography to describe places, happenings, and social situations. It exploits methods of digital storytelling, making users active actors of the contents they want to share through photography. Henceforth, users emphasize the particular aspects of places, monuments, situations, etc., from a subjective point of view.

This becomes particularly relevant in conservation practices if we consider that, since cultural heritage is a "*dynamic notion"* (Joanna Sanetra-Szeliga, 2016), p. 44, it can support architects in the value recognition, by taking advantage from updated and shared information.

These considerations are relevant for the epistemic object, the WikiBIM, proposed by this research. The methodological approach of Photovoice, consisting in gathering information on personal points of view from multiple users, is on the basis of the proposed Wiki approach to build a participatory[44] BIM.

Within this framework, digital photography can play a key role, particularly if combined with social media. Starting from the consideration of how anthropologists used photographs to communicate intangible aspects of culture (Lorenz & Kolb, 2009), an analysis of the use of photography in communication and social aspects needs some reflections.

Photo sharing is a very widespread practice on Internet, offering several publication modalities and tools to edit and manage images. Photographic database such as Flickr, Picasa, etc., allow creating digital photographic albums sharing them with other users. These tools allow sharing different perspectives, providing at the same time significant visibility of the information shared (Wang & Burris, 1997).

[44] In this case, participatory should be intended in a broad sense. The WikiBIM aims at documenting and collecting information to characterize architectural elements with associated values and construction process, materials' provenance and location of the craftsmen firms and artisanal laboratories.

In the selection of the most efficient approaches to gain information through bottom-up logics, an analysis of the most popular photo-based social networks needs to be carried out. This analysis provides information on the most popular social networks that employ photos as the main medium of information sharing. The chart below presents a summary of the selected social networks and web platforms, indicating for each one a brief description and the number of users.

Table 5 Most popular social networks and web platforms employing images as a main communication medium. Source: Author.

APPLICATION TITLE	DESCRIPTION	USERS (million)	SOURCE
Instagram	It is a photo-sharing application. It is connected to other networking platforms such as Twitter, Facebook, Tumblr and Flickr. This application has huge potential in marketing and promotion strategies (brand, event and products promotion).	600	https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/ https://www.instagram.com/?hl=it
Pinterest	Pinterest is a social network based on images and video sharing. It allows users to built album to catalogue images (coming from different sources). It is compatible and can be integrated with other social networks such as Facebook, Twitter, Flickr and websites.	150	www.pinterest.com/ blog.pinterest.com/en/150-million-people-finding-ideas-pinterest
Tumblr	Tumblr is a microblogging website. Users can post photos, videos, and text blog entries. There is no character limit even if the site is organized and presented in a way that favors shorter texts. Apart from content creation, Tumblr allows re-blogging thus sharing posts by other. It allows users interaction giving the possibility to follow other users	550	https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/ Golbeck Jennifer, introduction to Social Media Investigation: A Hands-on Approach Syngress, 2015.
Snapchat	It is an app for mobile communication devices (smartphone and tablets) to send and receive photos and videos. The app allows	300	https://www.statista.com/statistics/272014/global-social-networks-ranked-by-
	the users to include in the images and video drawings and text and to determine a temporal framework (from one to ten seconds) in which the recipient can visualize images and video before the file disappears from the recipient's device. Messages can be viewed only once. The app also allows storytelling through the 'stories' function. This compiles the snaps that create a narrative, as they appear in chronological order. Further, the memories function allow the creation of personalized albums that can be downloaded and saved. This information can then be re-shared.		number-of-users/ http://searchmobilecomputing.techtarget.com/definition/Snapchat
Pinterest	It is a catalog of ideas. It allows sharing images and concepts. Through the application functions, it is possible to share ideas, create blogs, and share images.	150	https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/

Laura S. Lorenz and Bettina Kolb claim that participatory "*visual methods (are) one way to generate understanding of the wider context and develop a shared body of knowledge that, ideally, integrates the knowledge of social scientists and the daily life knowledge of research participants about their health and communities"*. In a speculative thinking, this assumption - published in the *"International Journal of Public Participation in Health Care and Health Policy*" - can be extended to the heritage conservation field. Indeed, participatory visual methods, employing photographic techniques, can generate systematic understandings of users and more generally community needs and values. This is valid in facing community health care as well as in supporting decision making in heritage conservation actions. As in health systems, decision-making can be improved by broadening the range of data available (Lorenz & Kolb, 2009), heritage conservation can benefit from participant-generated visual data in identifying heritage values and localizing production places associated with built heritage maintenance and conservation.

As regards digital platforms and their potential role in the documentation and safeguard of intangible cultural heritage, some projects and initiatives need to be mentioned.

An interesting initiative developed in the Italian context is the Intangible Search. It consists of an online inventory aimed at disseminating intangible cultural heritage knowledge (E.CH.I., n.d.).

The project, implemented by the Lombardy Region in collaboration with national and international partners, is based on the principles of the UNESCO Convention for the Safeguard of the Intangible Cultural Heritage, 2003.

Figure 16 Home page of the Intangible Search online platform (E.CH.I., n.d.).

An online archive has been developed within the European project E.CH.I. – Italian Swiss ethnographies for the enhancement of Intangible Cultural Heritage. Intangible Search consists in a collaborative project that foresees the participation of communities and, particularly, of the keepers of intangibles knowledge.

The online inventory helps to disseminate this knowledge by promoting the living heritage that originates oral traditions, languages, performing arts, social practices, events, rituals, skills and technical knowledge.

In the web platform, information is structured according to three criteria: TAG (words related to intangible heritage procession, social practice, decoration, etc.), area (i.e. places of intangible heritage such as Lombardy, Piedmont, Aosta Valley, Ticino, etc.,) and category (performing arts and entertainment, oral traditions, rituals, naturalistic knowledge and technical knowledge). For each catalogued intangible element, an information page – containing multimedia files, audio, video, geo-referenced information detailed description – is provided.

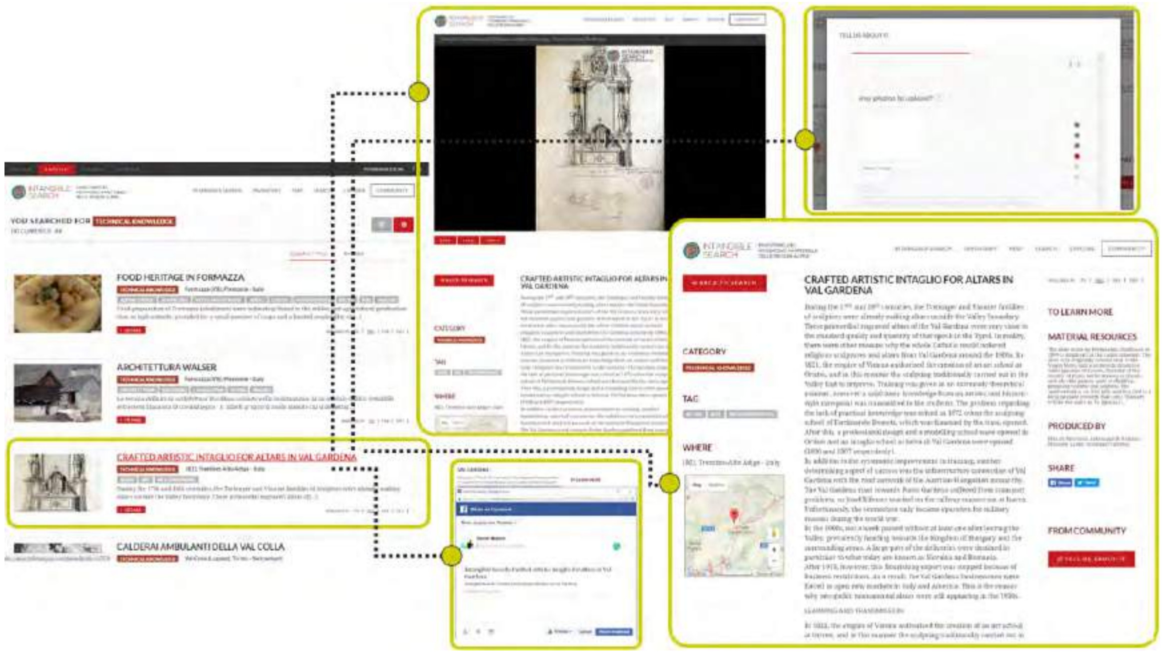

Figure 17 Example of the information provided for the Crafted Artistic Intaglio for Altars in Val Gardena. For this intangible element categorized as technical knowledge and tagged with the words 'Altar', 'Art' and 'Woodworking', location (using the google map platform), additional sources, detailed description, link to sharing platforms (facebook and twitter) and a community space to share information (comments, images and video) are provided. Image elaborated by the Author. Information source: Intangible Search website (E.CH.I., n.d.).

The platform also provides other two different modalities.

The first one allows accessing information ordered according to three criteria: Title, Area, and Category.

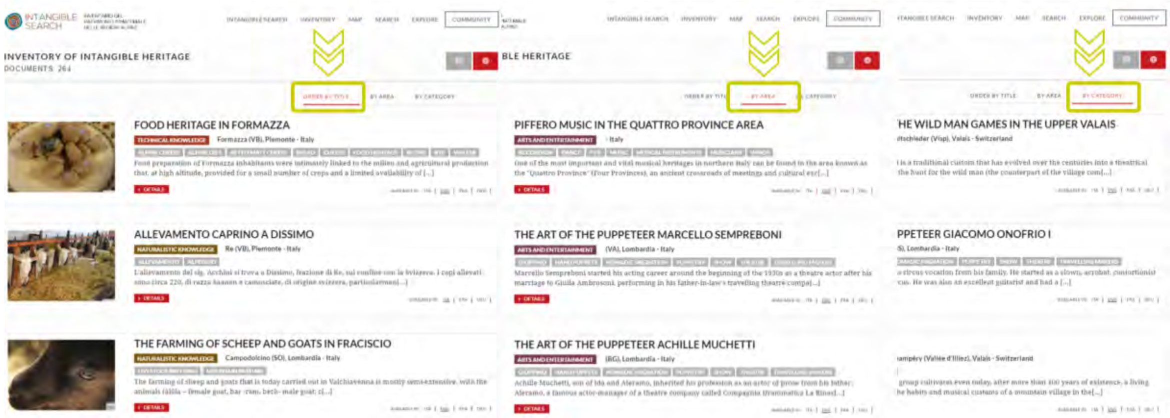

Figure 18 Intangible search platform showing the access to inventory Information through three established criteria. Image elaborated by the Author. Information source: Intangible Search website (E.CH.I., n.d.).

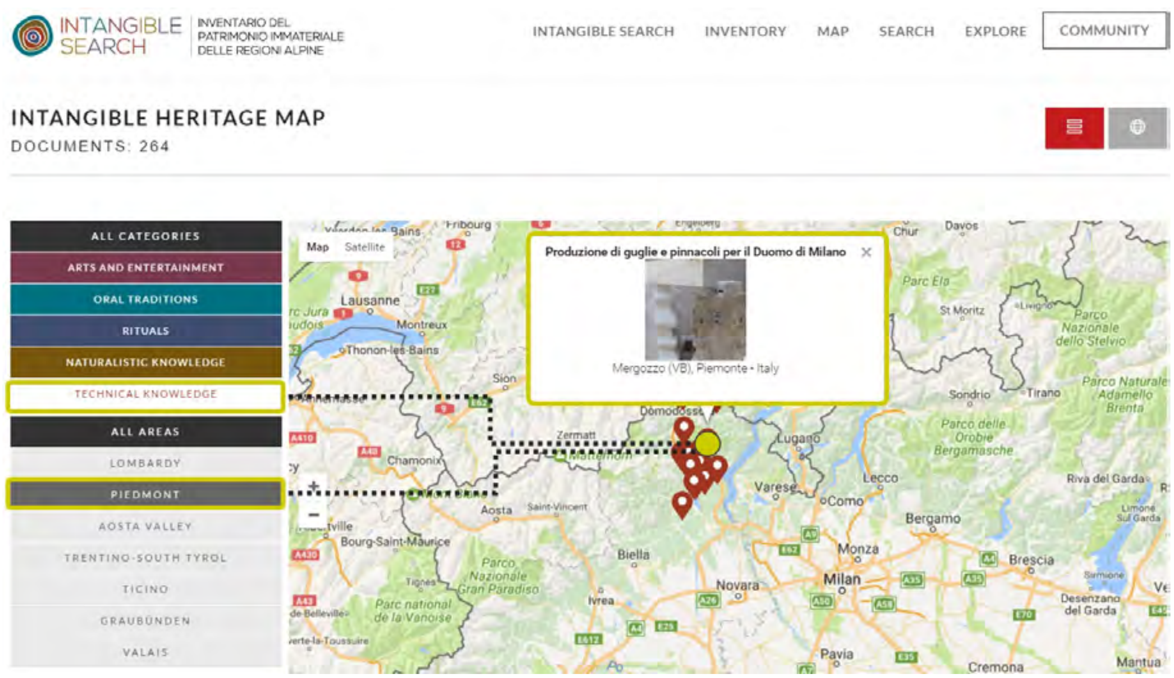

Figure 19 Information search through the geographic database. Image elaborated by the Author. Information source: Intangible Search website (E.CH.I., n.d.).

The second modality allows to access information according to two criteria: categories (arts and entertainment, oral traditions, rituals, naturalistic knowledge and technical knowledge) (E.CH.I., n.d.) and geographic area (Lombardy, Piedmont, Aosta Valley, Trentitno-south Tyrol, Ticino, Graubunden and Valais) (E.CH.I., n.d.). GIS tools are used to visualize and identify the location of the archived materials.

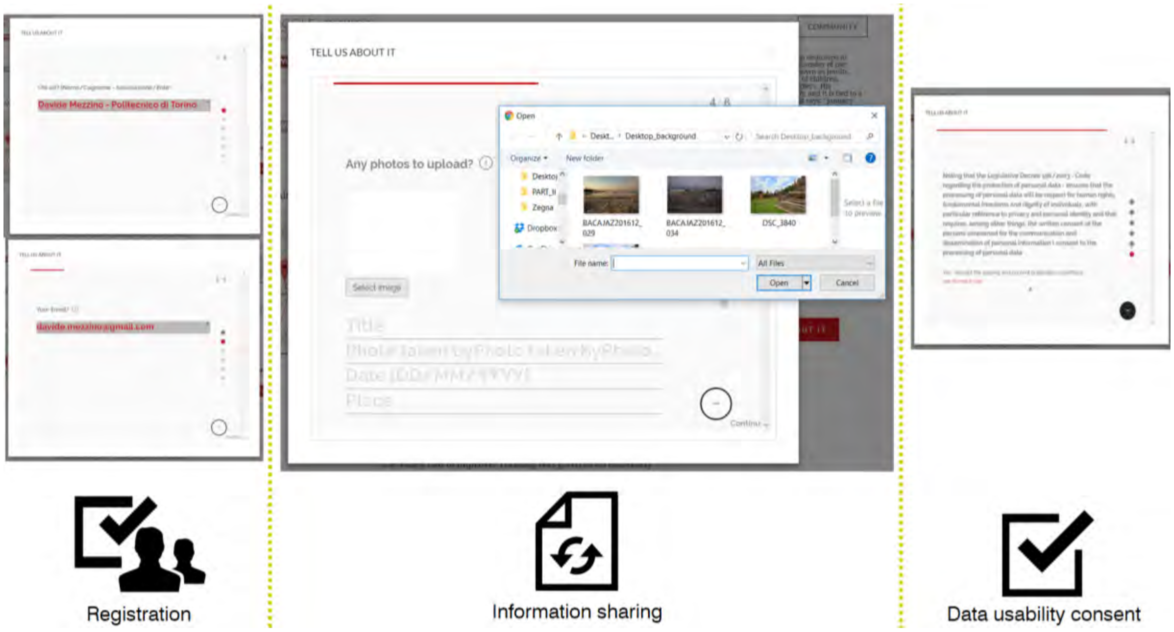

Figure 20 Workflow to share information on a selected intangible element. Image elaborated by the Author. Information source: Intangible Search: website (E.CH.I., n.d.).

To prevent the risk of fake news a registration through real users name and surname, company and email address are required. Once this step is concluded it is possible to leave text comments, upload images or video with the related metadata (title, photo/video author, date, place). Finally, the user needs to consent to the use of the personal information uploaded.

Apart from i-Treasure, other digital web platforms promote or could potentially support the preservation of intangible cultural heritage. A selection[45] of these is listed in the table below. Each initiative is presented describing:

- strategies and technologies used;

[45] The selection has been developed according to three main criteria: 1) participatory approach; 2) replicability in different contexts and 3) potential use in the conservation of intangible aspects associated to built heritage.

- geographic area;
- the scale of intervention;
- area of interest;
- conservation of tangible aspects;
- conservation of the intangible aspects.

Table 6 Digital web platform supporting tangible and intangible heritage conservation and promotion. Source Author.

PROJECT / INITIATIVE	STRATEGY & TECHNOLOGY USED	GEOGRAPHIC AREA	SCALES OF INTERVENTION	AREA OF INTEREST	INTANGIBLE HERITAGE
LibraRisk	It is an online web platform to gain information through bottom-up logics. The aim of the platform consists in prevent and manage catastrophic events affecting built environments, including heritage sites	Founded in Italy. It presents high replicability	Urban and territorial contexts and landscapes	Risk preparedness, social, cultural heritage	High potential to preserve intangible aspects embedded in built structures
Jecoguides	It is an app of augmented reality to provide interactive information on monuments, urban contexts, and landscapes. It is available for mobile communication devices (smartphones and tablets). It creates interactive experiences for the interpretation and promotion of museums, monuments, historic centers and landscapes.	Founded in Italy, it presents high replicability worldwide	Built Heritage, Urban and territorial contexts and landscapes	Cultural Heritage sites promotion, storytelling	Relevant for the dissemination of intangible elements associated to heritage sites.
sigecWeb MODI-AEI	It is a technological platform to collect and inventory intangible entities associated with the demo-ethno-anthropological aspects as well as with the intangible cultural heritage. This platform establishes the standard of the Italian Central Institute for Cataloguing and Documentation (ICCD) developed according to the article 12 of the UNESCO Convention for the safeguarding of the Intangible Cultural Heritage (2003)	Founded in Italy, it is applicable in other contexts	Cultural Intangible elements	Documentation, Inventory, Archiving	Relevant for intangible elements documentation and inventory
EUROPEANA	Europeana is an open Digital Library sharing cultural resources widespread in Europe. These resources include, but are not limited to, books, magazines, movies, maps, photos, music, virtual models etc. It is a reliable source of information for European collective memory and an open online visualization platform of the European cultural heritage.	Founded in Europe	Cultural Heritage	Digital Library, Documentation, Inventory, Archiving	Relevant for intangible elements documentation and inventory in an known and international platform with wide visibility.

Most of these initiatives deal with the documentation of cultural intangible heritage associated with, but not limited to, built structures. Purposes of this documentation initiative and projects range from the promotion of heritage sites through storytelling

(Jecoguide) to the prevention of the consequences of catastrophic events, that can be also extended to the intangible features of built structures (LibraRisk); from bottom-up strategies to improve the knowledge of intangible heritage and prevent its loss (Intangible Risk), to documentation, archiving and inventory solutions applicable to cultural intangible heritage (sigecWeb MODI-AEI and EUROPEANA).

The reported initiatives are just some examples of ongoing actions, providing an overview of approaches and technologies that could be employed in the design of the WikiBIM approach.

This analysis is relevant to understand the availability and current uses of web platforms and applications that have played, or can potentially play, a relevant role in supporting participatory strategies to document cultural intangible heritage. Constant growth in term of applications' number and users, as well as the rapid development of the same, should be taken into consideration.

PART II THE RESEARCH APPROACH: DIGITAL REVOLUTION AND HERITAGE CONSERVATION

4 Chapter: The potentiality of the 'Digital Revolution' for the conservation, documentation and management of cultural built heritage

The 2016 World Development Report *Digital Dividends* notices that the digital revolution has brought about easier communication and information, expanded opportunities, improved service delivery and free digital products. This led to immediate private benefits, also creating a profound sense of social connectivity and the perception of a global community (World Bank Group, 2016), p.2. Consequences on the Cultural Built Heritage field can be grouped into three main areas:

1) Digital technologies are radically expanding the amount of information available, decreasing at the same time information costs. This trend has facilitated searching, matching, and sharing of information affecting workflows of multiple sectors (World Bank Group, 2016), including the Cultural Heritage one.
2) New web platforms and internet networks can overcome the time and budget constraints to communicate effectively with the public about the significance of heritage resources, in terms of scientific, social or aesthetic aspects as well as communal memory.
3) Evolution and advances in digitalization can support the understanding and management of built heritage. IT-supported documentation techniques - including

but not limited to laser scanning, photogrammetry, LIDAR, digital photography, remote sensing as well as augmented and virtual reality applications - provide the possibility to visualize, access and manage cultural built assets at different scales.

This opens up interesting opportunities in terms of conservation, engagement and promotion.

Figure 1 Symbolic representation of the combination of digital technologies and Cultural Heritage. Source: (123RF, n.d.).

The convergence of ‘digitalization’ processes, and the deepening of analytical instruments for data gathering and analysis in the architecture and conservation field is a promising development.

It may contribute to a more sustainable and sustained management of the built environment. Within this context, web platforms, IT-supported recording techniques and BIM systems play a key role by providing tools to open up opportunities of collaboration among different actors, and by ensuring a more efficient management of the multiple dimensions of built heritage.

At the same time, the present research considers that, on one hand, current developments in web-based data collection strategies and solutions, as well as techniques and tool of digitalization, documentation and visualization, can promote sustainable and sustained development. On the other hand, this trend poses new challenges such has information reliability, information provenance and democratization issues as regards the sharing of information with all stakeholders concerns. The following paragraphs address these issues by considering the opportunities of web platforms, Information Communication Technologies (ICTs), IT-supported documentation workflows and spatial information systems and by focusing in particular on the potentials of BIM for cultural built heritage.

4.1 Information Technology (IT) and digital tools for Cultural Built Heritage: perspectives and challenges for conservation 2.0

Jacques Ellul[1], in his book the *Technological Society*, evidences that technique has so much importance that it forces all sociological phenomena to submit to its reference machine (Ellul, 1967). The French philosopher also warns about the risks of a mechanized society where the technique[2] has become autonomous, separating from tradition (Ellul, 1967), p. 19.

Aware of these considerations, this paragraph and the following ones deals with the consequences of the applications of technological development in the field of cultural built heritage in terms of opportunities, challenges and deceiving aspects.

According to Mingquan Zhou *"A new era of information richness is coming after the Stone Age, the Bronze Age, the Agricultural age, and the Industrial age*"(Zhou, Geng, & Wu, 2012), p. v. Zhou outlines that the consequences and implications raised by such process poses new challenges in the heritage field, because "*this new era presents us as*

[1] Jacques Ellul was a French philosopher, sociologist and writer. Professor of History and the Sociology of Institutions on the Faculty of Law and Economic Sciences at the University of Bordeaux. He authored almost sixty books and more than a thousand articles over his lifetime. His main focus is on propaganda, the impact of technology on society, technological tyranny over humanity, and the interaction between religion and politics (Chastenet, n.d.).

[2] Jacques Ellul deems that technique is the most important fact in modern world. Nevertheless, he warns about the distinction between technology or technique and machine. He claims that technology covers a wider field, and is related with all the actions implemented to accomplish an objective (Ellul, 1967).

[...] researchers and global citizens the responsibility and mission to use information technologies to protect and save cultural heritage for future generations"(Zhou et al., 2012), p. v.

More specifically, how does the digital protection enabled by the "new era" (Zhou et al., 2012), p. v, affect preservation research, practice and intervention methods in the domain of cultural built heritage? How does the combination of information technologies and digitization - such as data acquisition, model representation and operation, virtual restoration, digital management and web-based retrieval - influence built heritage conservation processes?

The issue of how to address IT-supported techniques and digital tools for heritage conservation has been already outlined by many scholars who recognized that *"[...] the development of informational technology, such as artificial intelligence, virtual reality, multimedia, broadband network, and databases, has provided effective tools for heritage protection [...]"* (Zhou et al., 2012), p. 1.

Opportunities for the use of new technologies for the conservation and promotion of Cultural Built Heritage are promoted by international organizations, NGOs and research institutes, at both international and local levels. Indeed, knowledge and management of monuments and cultural sites can be strongly supported by new communication technologies. The International Council on Monuments and Sites (ICOMOS)[3] promotes the use and research of innovative technologies for the protection, conservation and promotion of Cultural Heritage sites. More specifically, it is *"dedicated to promoting the application of theory, methodology, and scientific*

[3] In the general UNESCO framework of providing international support for Cultural Heritage protection, the international advisory body ICOMOS was created in 1965 (ICOMOS, n.d.) as an outcome of the Second International Congress of Architects and Specialists of Historic Buildings held in 1964. During that meeting the first ICOMOS document, the Venice Charter, was developed and approved (Hera Barros, 2014).

techniques to the conservation of the architectural and archaeological heritage" (ICOMOS, n.d.).

Concerning the growing relevance of the interpretation of information, due to the increasing diffusion of IT solutions within conservation processes, ICOMOS ratified in 2008 the *Ename Charter Secretariat* (ICOMOS, 2008). The Charter aims at updating and completing the 1964 Venice Charter, by establishing seven main principles for information interpretation and sustainable presentation[4]. The document underscores the importance of interpretation and presentation activities aiming at increasing public knowledge and understanding of a cultural heritage site, including IT-supported activities.

Challenges associated with the use of these technologies are noticed by Mingquan Zhou who claims that *"[…] to preserve history culture, propel culture protection, and accomplish digital protection, is a challenging problem […]"* (Zhou et al., 2012), p. 1.

Mingquan Zhou, Guohua Geng and Zhongke Wu provided a first schematization of the uses of digitalization technologies in the heritage field[5]. Applications developed in this area cover, but are not limited to, the following aspects[6]:

[4] The seven principles include:

- *access and understanding*, emphasizing that information interpretation and presentation programs should support and facilitate (physical and intellectual) public access to cultural heritage;
- *information sources*, stressing the importance of scientifically recorded evidences for information interpretation and presentation;
- *context and setting*, affirming the relevance of the cultural, historical, social and natural context for interpretation and presentation of heritage sites;
- *authenticity*, underscoring the need of respecting basic principles of authenticity in interpretation and presentation according to the 1994 Nara Document;
- *sustainability*, noting that cultural heritage interpretative plans should pursue social, environmental and financial sustainability and should the same time, be sensitive in order to consider the natural and cultural context of a heritage site;
- *inclusiveness*, arguing that interpretation and presentation of cultural heritage sites should derive from collaborations among different actors and stakeholders;
- *research, evaluation and training*, stressing their importance in the interpretation of heritage sites (ICOMOS, n.d.).

[5] The authors described the main research topics in terms of technological developments including: 1) modeling, simulation and rendering technologies to support the researches and previsions; 2) technologies to record with high accuracy heritage sites; 3) heritages information technologies to generate flowcharts of conservation processes (Zhou et al., 2012).

[6] These aspects have been evidenced as relevant for the research scope.

1) Categorization and digital archives of cultural heritage, and digital techniques to build cultural resource databases;

2) Virtual reconstruction and rehabilitation of built structures, digital simulation and visualization[7] technology of cultural spaces and procedures;

3) Support to the transmission, and continuity, of traditional craftsmanship.

4.1.2 The potential of digital recording technologies and internet networks for conservation actions

According to Mingquan Zhou, Guohua Geng and Zhongke Wu, the digitalization of cultural heritage is defined as the *"[...] process of digitalizing the movable or unmovable cultural heritage using contemporary remote-sensing and virtual technologies to achieve 2D or 3D digital archiving, for the merits of protection, reparation, restoration, and archaeological research."*(Zhou et al., 2012), p.2.

Therefore, digitalization in cultural built heritage can be applied at different levels:

a) Documentation and Digital archiving as the starting point in built heritage conservation;

b) Repair and restoration;

c) Research to understand, document and visualize intrinsic tangible and intangible values of built heritage;

[7] Mingquan Zhou, Guohua Geng and Zhongke Wu clustered the main digital spatial representations into six main types:
- Point could;
- Polygon mesh/triangle mesh;
- Volume graphics;
- Constructive Solid Geometry Representation;
- Surface models;
- Procedural models (Zhou et al., 2012).

d) Communication and dissemination to increase heritage engagement and provide democratic participation and involvement in conservation processes (Zhou et al., 2012), p.2.

The different application levels evidence the potential of emerging digital technologies in the sector of cultural heritage.

Digital technologies allow the collection of built heritage information in single common platforms, and the integration of various results into consistent databases. Furthermore, over the years, in addition to the traditional instruments for carrying out direct surveys, efficient and technologically advanced tools have been employed. These include non-contact devices, such as long and short-range laser scanners, digital single-lens reflex (DSLR) cameras[8], total stations, Satellite remote sensing and GPS[9].

For instance, in terms of recording, the growing popularity of Laser scanning techniques has strongly affected the cultural heritage field. This technique allows capturing information and generating colorized 3D pointcloud model of scanned objects (from artistic objects to buildings and landscapes). It acquires data in short time and with a high accuracy level. It is becoming an efficient way for collecting built heritage information.

Photogrammetry, both terrestrial and aerial, is also a widespread technique to create 3D pointcloud model of historic or generally existing buildings generating colorized 3D point cloud, mesh models and orthographic imagery.

In understanding the potential of these technological advances, it is important to consider the level of engagement by them, thus assessing their potential impact. The

[8] DSLR cameras allow taking photographs that, apart from traditional uses, can be employed as a technique for 3D acquisition. Image-based modeling or Photogrammetry enables the automatic processing of digital images and the extraction of 3D reconstructions of the photographed subjects.

[9] Nevertheless, information acquired with these techniques is not often readily accessible to the broad public, because of difficult information processing, management and visualization for those who do not have specific theoretical and practical skills.

engagement level of each technique is related to the level of human interaction and involvement needed. In laser scanning techniques, for example, it is not required a high involvement of the user in the data acquisition phase, while user interaction is necessary for the data processing phase to merge different scans in a comprehensive point cloud[10]. Additional criteria for assessing advanced recording technologies to document built heritage are: accuracy, time, cost, the level of user-friendliness, etc. In line with the outlined aspects, the following table presents an assessment of current techniques employed in heritage recording. Considering that each heritage site presents specific characteristics and requirements, a classification of the available techniques to be potentially employed in heritage documentation is significant to understand their characteristics and appropriate uses.

[10] Instead, in hand measurements the involvement of the surveyor is very high, in both the data acquisition phase and the data processing one.

Table 1 Table presenting pros and cons of different Heritage documentation techniques. Adapted from Fereshteh Hassani (Hassani, 2015). The remote sensing section does extensive reference to the: *"Primer on Natural Hazard Management in Integrated Regional Development Planning"* developed by the Department of Regional Development and Environment Executive Secretariat for Economic and Social Affairs Organization of American States ("Primer on Natural Hazard Management in Integrated Regional Development Planning," 1991).

TECHNIQUE			PROS	CONS
IMAGE-BASED TECHNIQUES	Photogrammetry	Panorama Photography	Quick data capture, simple, low-cost, free accessible software, effective presentation of objects, color and texture data, ease of use in GIS, the possibility of presentation in web pages, high level of attraction for users.	Requires pre-planning for photography, needs processing and viewer software, limitation of movement in the interior spaces.
		Terrestrial Photogrammetry	Short fieldwork period, cost effective, accurate, non-intrusive, texture and color data, cheap portable equipment, outputs can be processed in common CAD software, ease in generating an archive.	Requires pre-planning and the knowledge in photography. It is influenced by the accuracy and resolution of the camera. Obstacles limit the integrity and accuracy of the outputs. It requires highly skilled operator (possibly experienced) for data processing.
		Aerial Photogrammetry (employing Unmanned aerial vehicle – UAV - drones)	Real-time capability, fast image acquisition, cost-effective, short interruption times, texture and color data, proper coverage of target, proper for inaccessible and dangerous areas.	Requires skilled experts for acquiring and processing data. It is dependent on the wind conditions. Obstacles limit the integrity and accuracy of this recording technique.
	IR Camera		Non-destructive appropriate for damage evaluation such as moisture and rising damp, identification of hidden structures and older layers, high accuracy, capability of combining with RGB images and 3D models	Requires high skilled experts to integrate data with other sensors and techniques. It is affected by weather conditions.
NON-IMAGE-BASED TECHNIQUES	Traditional Terrestrial Survey	Hand survey	Low cost, simple to apply by non-experts, requires low cost and accessible equipment, helpful where visibility is limited.	Low accuracy, time-consuming, hard and long field work period, problems in documenting curved and highly detailed objects, difficulty in documenting inaccessible features, influenced by human errors.
		Theodolite Measurement (Total Station)	Cost-effective when the number of surveyed points are limited. It allows to reach high accuracy measurements.	Long fieldwork period, color and texture data cannot be documented, dependent on the climate conditions, need for a skilled operator.
		Global Navigation Satellite Systems (GNSS or GPS)	Provides location coordinates in the global geographical system, highly useful in combination with other techniques.	Expensive in data acquisition with high accuracy (the cost depends on the accuracy of the GPS type), not applicable in indoor spaces.
	Laser Scanner	Terrestrial Laser Scanner	High accuracy, high speed, non-intrusive, large amount of data, documenting complex surfaces and objects, can be applied in dark spaces and at nights.	Expensive, it requires highly skilled operator and specific software for the data processing. Difficulties in storing data due to big dimensions of the scanned data (depending on the settings in the data acquisition phase). Time-consuming data processing. Scans are affected by obstacles, dust reflective surfaces, sunlight and rainy weather.
		Light Detection and Ranging (LIDAR)	High accuracy, high speed, non-intrusive, appropriate in documenting mass targets and large-scale sites, data acquisition in vegetated areas, large amount of data.	Expensive, it requires highly skilled operators, weak in documenting edges, noise and gaps, difficulty in storing due to large data.

COMBINATIVE TECHNIQUES	Photo Laser Scanner		High accuracy, short field work period, cost-effective, large amount of data, texture and color, appropriate for complex surfaces.	Expensive, requires highly skilled operators and specific software to process and manage data. Time-consuming data processing.
	Structured-light	Structured Light	High accuracy data, automatic process, high accuracy in matching process.	Requires highly skilled operators and specific software.
		Kinect	Low-cost, field work period, applicable in documenting small objects and interior spaces, texture and color data.	High skilled operator for programming (if needed) and data processing are required. Time-consuming processing.
		DAVID Laser Scanner	Low-cost, quick, ease of use, accessible equipment, appropriate in documenting small objects, texture and color data.	High skilled operator for programming (if needed) and data processing.
REMOTE SENSING	Aerial Remote Sensing	Aerial Photography	Easy interpretation, has the advantage of offering instantaneous scene exposures, superior resolution, ease of handling and stereoscopic capability, the interpreter familiar with photographs can easily interpret these scenes.	It cannot be used at any time in any weather, photography is limited to the optical wavelengths which are composed of ultraviolet (UV), visible, and near-IR portions of the electromagnetic spectrum.
		Radar	Radar can map thousands of square miles per hour at geometric accuracies. An area can be surveyed much more rapidly by radar than by aerial photography, and the final product provides an excellent synoptic view.	Interpretation problems, interpreters need to know something about how the image is formed in order to interpret it correctly and to appreciate fully the potential and limitations of radar.
		Thermal Infrared Scanners	It is a valuable method of obtaining thermal infrared imagery with reasonable spatial and thermal resolution.	The persistent movement of the aircraft on three axes with limited stabilization causes distortions, resulting in images that are difficult to interpret and whose location is difficult to identify.
	Satellite Remote Sensing	Landsat	Since the Landsat series of satellites have been operational for a long period of time, there is a very large database available, both in areal coverage and in repetitive coverage, through different seasons and during periods of natural disasters. Landsat exists in four spectral bands at 80m resolution. The variety of spectral bands in visible and near IR range provides adequate spectral coverage and allows computer enhancement of the data for this purpose.	Interpretation problems, needs of the user to know something about how information is formed in order to interpret it. Resolution limitations. The maximum resolution is 80m.
		SPOT satellite	The SPOT (Système Probatoire pour l'Observation de la Terre) satellite with its High-Resolution Visible (HRV) multispectral sensors ranges from the green wavelength into the near IR. The HRV coverage is in three spectral bands at a spatial resolution of 20m.	Resolution limitations. The maximum resolution is 20m.
		Satellite Radar Systems	An important advantage consists in penetrating thick clouds and moisture. This allows to accurately map humid areas otherwise too obscured by clouds and rain. The long wavelengths of these radar systems permit potential subsurface penetration between 2m and 3m in extremely dry sand.	It is more used to map landforms, geologic structures and soil types.
		AVHRR	Advanced Very High-Resolution Radiometer (AVHRR) large swath width of 2253km provides daily (day and night) coverage of the inhabited parts of the earth.	Resolution limitations. The resolution is very low (1.1 km).

Most of the reported recording techniques are usually not used individually. GNSS, for example, is often used to control airborne photogrammetry, while terrestrial laser scanning often relies on control points provided by terrestrial survey instrumentation, such as a Theodolite Measurements. Further examples can be found in Remote Sensing techniques, where satellite images need ground verification and integration with other recording techniques to offer details and records of small areas.

According with these considerations, the following section classifies technologies into three main groups:

- 3D documentation;
- digital inventorying;
- Remote sensing and earth viewers.

In the area of 3D documentation, image-based techniques offer affordable solutions that could be applied in recording shape, geometry, color and conditions of cultural built heritage.

One of the emerging techniques that are increasingly adopted in 3D recording is the multi-image photogrammetry. Due to its cost and time effectiveness, it is broadly employed in built heritage documentation. This technique can offer significant reductions in survey costs and a good quality of the final results (McCarthy, 2014). Furthermore, multi-image photogrammetry is highly automated and consequently more user-friendly than other techniques[11]. It can also be a tool for engaging community participation allowing people to collaborate actively in the conservation processes. This aspect is particularly useful in case of emergencies. Additionally, advances in digital photography and aerial photogrammetry, due to the development of Small Unmanned Aircraft (SUA) such as an Unmanned Aerial Vehicle (UAV), are increasing the

[11] Further, it allows the possibility to combine large groups of images rather than pairs (McCarthy, 2014), making this technique more cost-effective and less time-consuming.

suitability of image-based techniques in recording inaccessible sites or in precarious conditions[12].

Photogrammetric techniques can be divided into terrestrial and aerial photogrammetry.

Terrestrial photogrammetry (close range) is a very cost efficient technique. It needs only cameras to take photos and software to process them. The range of available software is very wide and there are also many open-source applications that can be employed in the images processing phase to generate a 3D model.

Aerial Photogrammetry combined the employment of drones and photogrammetric software to produce 3D model. Most of Unmanned Aerial Vehicle (UAV) drones are affordable and portable. Indeed, due to the development of drones market, it is possible to purchase a basic drone at a cost that can range from 30 euro to 1000/1500 euro. Furthermore, most drones have a compact equipment presenting good portability features (most of them can be carried on in a backpack).

In terms of inventories, digital advances provide several opportunities. In addition, the diffusion of digital solutions made possible the availability of open source and generally free solutions to develop and structure inventories.

Within the category of low-cost technologies, an inventory system that should be mentioned is Arches. The system, developed by the Getty Conservation Institute (GCI) and World Monuments Fund (WMF), is a web-based and geospatial information system designed to create and manage heritage inventories. Arches is an open-source geospatial web application for cultural heritage inventory and management. Its open-source nature - the software is released under an open-source license - makes it

[12] Another positive feature of multi-image photogrammetry is its flexibility. Indeed, it can be applied to historic building recording, as well as small finds recording and topographic survey. Because of the minimal skills and previous knowledge required, local stakeholders can be easily trained. It can also be applied to historical images database to reconstruct lost heritage (as in the case of the reconstruction of the Bamiyan Buddha statue) (Gruen, A., Remondino, F., Zhang, 2004).

affordable. It can be used as a tool to create digital inventories describing: types, locations, extent, periods, materials, and conditions of heritage resources (Vafadari, 2015). It is designed for managing information about immovable cultural heritage, using international standards. It can be customized, updated, and extended with new features by communities of heritage professionals and IT specialists[13] (Vafadari, 2015). Arches is user-friendly and customizable with an open system code that can be configured and extended to meet the particular needs of adopters. It allows viewing, creating, editing, and querying data[14]. Therefore, the system can be used as an effective tool for the protection, monitoring and management of heritage places[15] (Myers, Avramides, & Dalgity, 2013).

[13] Despite the freely availability of the system, in deploying Arches it is important to take into account some considerations: a) Arches may need to be customized and configured in order to meet the specific needs and requirements of different situations (the customization process requires services of experts in open-source tools, data management and GIS); b) it is necessary to identify a server to host and install the system as well as a database administrator to maintain it and provide ongoing technical support; c) human and material resources are needed for data extraction and transformation into a format that could be imported into Arches (Vafadari, 2015).

[14] The software has been developed to serve a variety of organizations with different needs and it has been designed to maximize flexibility (i.e. adopters may control the degree of data privacy that their system contains). The system does enforce and promote the standardization of data through validation and controlled vocabularies, including thesauri. Arches incorporates internationally adopted standards for heritage inventories, as well as international standards for heritage data and information technology, to promote data sharing and longevity regardless of technological advances. Data within Arches are structured into four primary categories:

- Heritage Resources (all types of immovable heritage: architectural and archeological sites, landscape, urban and maritime heritage).
- Activities (historical events and current activities such as investigation, designation, protection and management).
- Actors (historical and contemporary main characters, national and international organizations, ONGs, etc.).
- Documents (text, images, etc.).

Arches manages relationships among data organized under these themes, so that for instance a particular actor may be related to multiple activities, heritage resources and documents. The information here reported is extensively based on the article "Changing the Heritage. The Arches Open Source System" by David Myers, Yiannis Avramides, and Alison Dalgity (Myers, Avramides, & Dalgity, 2013).

[15] Its source programming is code open, giving the possibility of customizing, upgrading, or improving the software that is open to modification by different individual users to meet their needs.

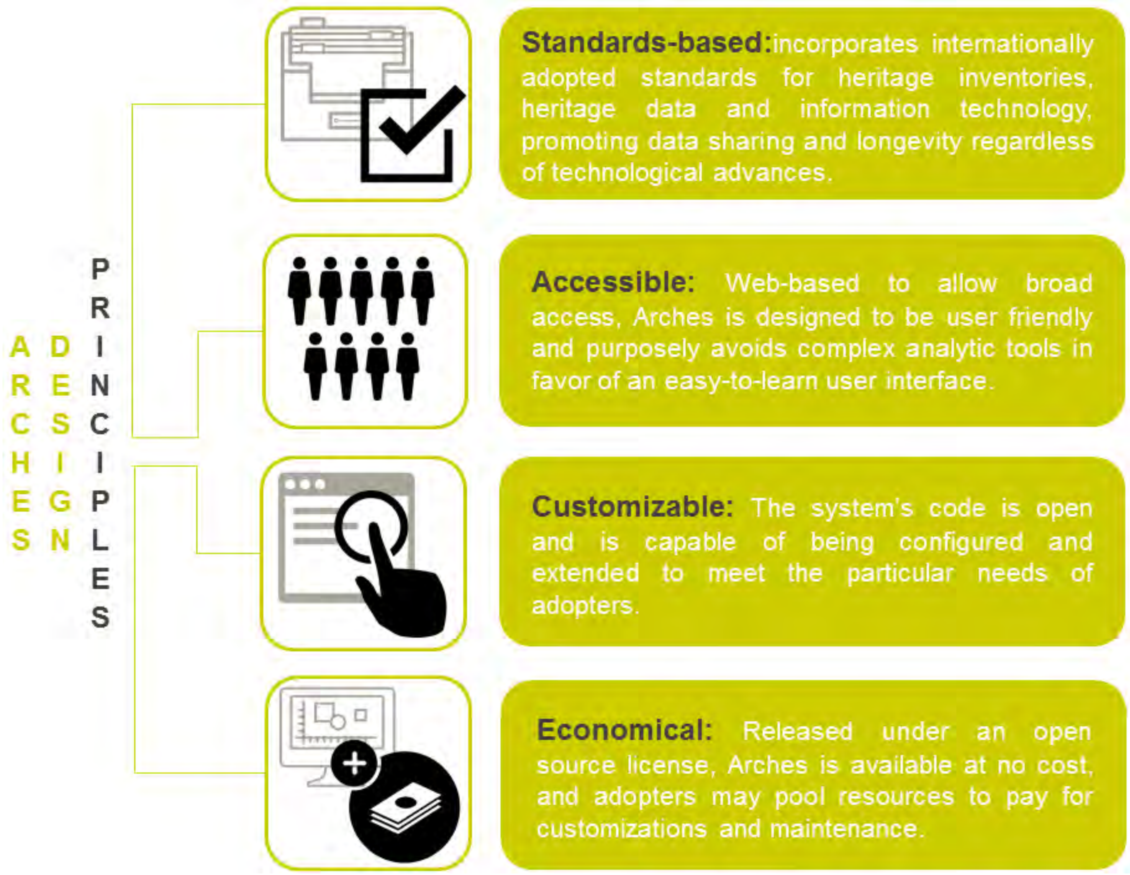

Figure 2 Arches design principles. Image source: "Changing the Heritage. The Arches Open Source System (Myers, Avramides, & Dalgity, 2013).

Remote Sensing (RS)[16] and earth viewers are powerful technologies for collecting useful information on built heritage in a short time frame[17]. Remote Sensing[18] deals with imagery from diverse sensors which capture complementary data in different spectral and spatial domains[19].

[16] Remote Sensing is a technology for samping electromagnetic radiation to acquire and interpret non-immediate geospatial data from which to extract information about features and objects on Earth's land surface.

[17] According to Rosa Lasaponara and Nicola Masini: "*the increasing development of ground, aerial and space Earth Observation technologies and the tremendous advancement of Information and Communication Technologies (ICT) have focused a great interest in the use of remote sensing and computer science for supporting cultural heritage applications*" (Lasaponara & Masini, 2009).

[18] The advantages of Remote Sensing consist in providing: regional views, repetitive views of the same area, geo-referenced digital data, a broader portion view compared to the spectrum of the human eye and sensors able to focus on a very specific bandwidth.

[19] For example visible and microwave, from space to ground.

Furthermore, it offers the possibility to compare pre - and post - event imagery in order to detect relevant changes ("RapidMap," n.d.). More specifically, Remote Sensing provides relevant support in the following fields:

- Disaster mapping and monitoring;
- Damage assessment;
- Targeting.

Remote sensing can be extremely useful for heritage planning, conservation and disaster management. It allows collecting information relating to objects/places without being in physical contact with them.

Satellite imagery[20] is the main outcome of this technique. It is mainly produced by satellites that offer accurate, frequent and almost instantaneous data over large areas in any part of the world (Lewis, 2009). In terms of affordability, the relevance of remote sensing is also related to the decreasing costs of data and software as well as to the quickly constant development of Information Communication Technology (ICT). Furthermore, tools such as Google Earth are increasing the levels of policymakers' interest in, and users' confidence with, satellite imagery[21].

Finally, considerations on the opportunities of these recording techniques should focus on the following aspects:

- What types of technologies can provide effective support to heritage conservation?
- When and why to use different technologies depending on the natural, socio-cultural and economic context as well as on the site typology and requirements?

[20] The advantages of Satellite Images are: the coverage of large areas, the cost effective and time efficient data acquisition, the multi-temporal, multi-sensor and multi-spectral features, the overcoming of inaccessibility and the fast extraction of GIS-ready data.

[21] From a technical point of view, according to Sian Lewis, the most useful satellite images for disaster management are that ones in the visible wavelength (waveband 0.4-0.7 mm), useful for building stock assessment (employing sensors such as: Advanced Very High Resolution Radiometer -AVHRR, Moderate Resolution Imaging Spectroradiometer - MODIS and IKONOS) and digital elevation model (employing sensors such as: Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Panchromatic and Remote-sensing Instrument for Stereo Mapping - PRISM) (Lewis, 2009).

- How to use technology based solutions in different situations?
- Who are the users and promoters of these technologies?

The following table addresses these issues in the employment of technology-based solutions for built heritage documentation.

Table 2 Relevant aspects to consider for employing technology-based solutions for built heritage documentation. Source: Author.

WHAT technology	WHEN to use it	WHY to use it	HOW to use it	WHO can use it	Deployment CONSIDERATIONS
Satellite monitoring and mapping	▪ Before any intervention and or emergencies to have base maps to classify heritage sites. ▪ During and after emergencies and or intervention to have real time base maps.	▪ Land monitoring ▪ To track and monitor changes induced by natural causes (i.e. floorings, earthquakes, etc.) as well as human causes (bombing, intentional demolition).	▪ Combine satellite maps with aerial imagery and ground surveying to a comprehensive documentation and monitoring of sites' changes.	▪ Heritage operators ▪ Decision makers ▪ Planners	▪ Technical specifications include: format, resolution and type of maps needed ▪ Skills required to combine satellite maps with other records ▪ Basic knowledge for maps interpretation ▪ Costs ▪ Time
Aerial mapping	▪ Before any action or intervention to map built heritage sites. ▪ During and after interventions and emergency situations, to produce updated maps for the design and implementation of protection actions.	▪ Mapping heritage site to track and monitor changes (destructions, transformations, collapses, etc.). It is effective to identify and monitor changes induced by natural and human causes carried out over large areas.	▪ Combine aerial imagery with ground surveying for a comprehensive documentation and monitoring of sites changes. ▪ It is a source of basic information to plan protection actions.	▪ Heritage operators ▪ Planners ▪ Decision makers	▪ Technical specifications include: format, resolution and type of maps needed ▪ Skills required to combine aerial maps with other records ▪ Costs ▪ Time
Geospatial GIS solutions	▪ Before any intervention to map and document built heritage sites. ▪ During and after interventions or emergency situations, to	▪ To have geo-referenced information and attributes associated to heritage sites. ▪ Exploit the possibility of planning different	▪ Use it to visualize, question, analyze and interpret data in order to assess threats in heritage sites and plan	▪ Heritage operators ▪ Planners ▪ Decision makers ▪ IT operators/ experts	▪ Technical specifications: software and computers required (i.e. minimum disk space depending on size and type of data to store) ▪ Skills and knowledge required to gather, collect, manage and

	produce updated geo-referenced information.	scenarios in order to adopt the most effective solution.	informed and effective responses.		visualize information • Costs (tools, software, cost of work and system maintenance) • Time required to set up the GIS platform and elaborate information
Photogram-metry	• Records useful to plan the project developments to have records of built heritage structures • After interventions or emergency situations, to gather timely and cost-effective updated records and monitor heritage structures and sites.	• To have timely and cost-effective digital records of shape, geometry, color and conditions of heritage structures and sites.	• Provide tools (cameras), software and basic training for the data acquisition and data processing phase. Drone support in case of inaccessible areas should also be considered. • If possible, combine this technique with hand measurements or with Total Station records in order to have precise geometric information.	• Heritage operators • Experts in 3D documentation	• Technical specifications include: resolution required, tools (cameras) performances and eventual support equipment (Airborne Photogrammetry, UAV drones, tripods). • Theoretical knowledge and practical skills required in data acquiring as well as in data processing phases. • Costs (tools, software, cost of work). • Time (data-acquisition and data-processing).
Laser scanning	• Data useful in the planning phase to have in short time high definition records of built heritage structures and sites. • Records useful after interventions or emergencies, to have high definition updated records to monitor heritage structures and sites.	• To have detailed digital records of heritage structures and sites with high definition.	• Provide tools (laser scanner), software and basic training for the data acquisition and data processing phases. • Drone support in case of inaccessible places from the ground.	• Heritage operators • Experts in 3D documentation	• Technical specifications: resolution required, eventual tools' support (Airborne Laser Scanning, UAV/UAS Laser Scanning) and tools performances. • Theoretical knowledge and skills required in data acquiring and data processing phases. • Costs (equipment, software, cost of work). • Time (data-capturing and data-processing).
Digital Inventory	• Data useful before interventions or emergencies to have a repository of built heritage sites. • During and after interventions or emergencies to have updated repository of historic sites.	• Gather, collect and manage information related to geometry, shapes, values, land use, extensions and conditions of built heritage sites. • Use collected information to design informed actions.	• Develop training courses for professionals and volunteers in the field of heritage to fully exploit the potentials of digital inventories. • Set up information retrieving criteria.	• Heritage operators • IT experts/ operators • Planners • Decision makers • Volunteers • Local and non-local organizations, associations institutions	• Technical specifications include: data considerations (*How to manage data of all types and formats? How much of it? What kinds of file formats do you have?*), database customization, sensible data, data format (verify possibilities to move various data formats into inventory file formats). • Skills necessary to develop and maintain the inventory • Costs (including setting and maintenance). • Time required to collect and archive information.

Mobile mapping	▪ During interventions or emergencies to develop real-time mapping.	▪ Gather and collect real-time information useful to develop fast and informed protection actions	▪ Exploit social network functions and information shared on digital platforms to develop real-time maps documenting conditions of heritage sites.	▪ Heritage operators ▪ IT experts/operators ▪ Volunteers ▪ Local and non local organizations, associations, institutions and communities.	▪ Technical specifications: technological solutions to select, collect and combine required information ▪ Skills and knowledge required to interpret select, and combine shared information ▪ Costs including equipment for data capturing and data processing ▪ Time to develop operative maps

4.2 Internet networks and web platforms for conservation actions: opportunities and challenges

Challenges of technological innovation for built heritage recording also include the potential role of internet networks.

The proliferation of mobile communication technologies, web platforms, social networks and access to diverse and - at times - overwhelming quantity of information (text messages, tweets, UAV imagery, photos, videos, etc.,) may empower people to become active participants in decision-making processes in several fields.

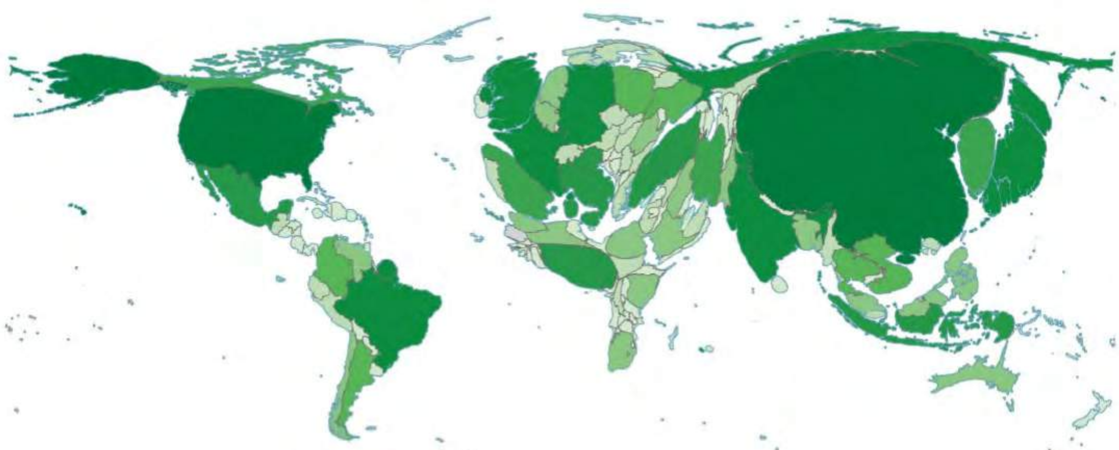

Figure 3 The world based on internet population. Source: World Bank (World Bank Group, 2016b).

As described by Michael Lascarides and Ben Vershbow, Clay Shriky[22] noticed that these trends increase the *"opportunities and challenges faced by institutions seeking to take advantage of the internet to do work traditionally handled within an organization's walls"* (Ridege, 2014) p. 115.

This has been also evidenced by Patrick Meier in the case of emergencies, whereas people become active participants in disaster response, producing and sharing information that can also be useful for heritage protection (Meier, 2015). From the *Libya Crisis Map* during the Arab Spring - to map people movement, health, logistics, etc. - to *Ushahidi.com* - used in Haiti to develop crisis maps (Meier, 2015) - communities use social media to communicate with the world in order to speed up emergency responses. Within this framework, much of the information shared (including visual, audio and written information) may be employed to document the conditions of heritage sites in real time, thus developing effective protection actions.

Apart from enhancing emergency responses, people's willingness to share comments and data on built heritage sites may improve and strengthen collaborative attitudes and increase participation in the decision-making process and conservation choices. Examples can be found in several participatory projects, such as the *Crowdsourcing in Brooklyn, What's on the Menu? Jecoguides*, and *Crowding Out the Archivist?*, just to mention some of them (Ridege, 2014).

[22] Clay Shriky is an internationally recognized expert who specialized on the analysis of the social and economic effects of Internet technologies. On this subject he published several books including: *Here Comes Everybody: The Power of Organizing Without Organizations* (2008), *Cognitive Surplus: Creativity and Generosity in a Connected Age* (2010) and *Little Rice: Smartphones, Xiaomi, and the Chinese Dream* (2015) (Shirky, n.d.). Clay Shriky stresses the growing usefulness of networks and new technologies and how they *"are enabling new kinds of cooperative structures to flourish as a way of getting things done in business, science, the arts and elsewhere, as an alternative to centralized and institutional structures, which he sees as self-limiting".* (TED conferences, n.d.)

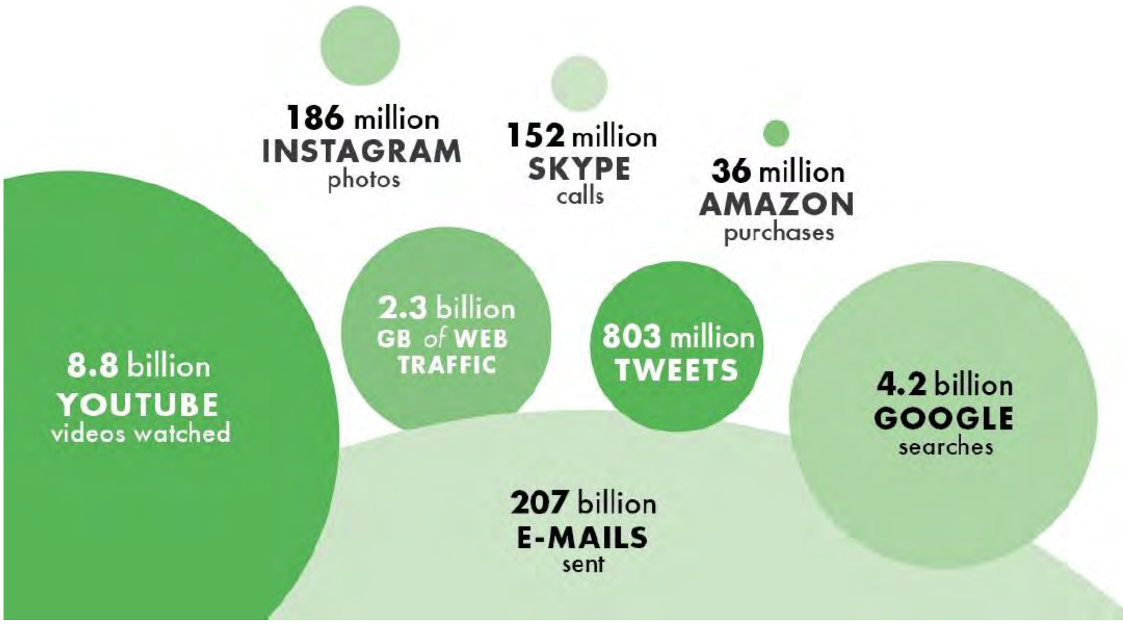

Figure 4 A typical day in the life of the internet. Source: World Bank (World Bank Group, 2016a).

How can interactive applications stimulate users?

The growing role of interaction in the digital revolution shows that people (especially young generations) enjoy and expect not only to passively stand on, but consume, produce and share, as indicated, for example, by new means and levels of interactivity between people and TV. Indeed, people, differently from the past, interact by using the TV as a tool for sharing comments and ideas about what they are watching with other people on social media through their mobile devices (such as smartphones, tablets, laptops, etc.,) (Garito, 2016). This example demonstrates people's new attitudes and expectations on information. They do not accept anymore to passively acquire it, but constantly prefer to act on it, by engaging with what they are listening to, or looking at, through experience- and perception-sharing on social media supported by new technologies.

Therefore, in the field of Cultural Heritage, it is necessary to explore and test new modalities of, and approaches to, cultural information and dissemination, thus opening up the field to new relations with the wider public and the local territory.

Challenges and opportunities of new tools and technologies to test and put into practice the theoretical concepts

As Marta de la Torre and Randall Mason noticed, "*discussions of values, of how social contexts shape heritage and conservation, and of the imperative of public participation, are issues that challenge conventional notions of conservation professionals' responsibilities*" (Avrami, Mason, & De La Torre, 2000) p.3. The authors stress that, currently, conservation is facing two main challenges: the first one concerns power sharing in the project phases, and the second one consists in the coordination and management of collaboration in heritage conservation. Broader participation by a wider range of actors challenges the roles and responsibilities of professionals and experts involved in the conservation processes.

The relevance of digital archives and web platforms to different Built Heritage contexts

Digitalization processing is affecting all sectors of our life and our society. The digitalization of documents and information affects governance systems in the public sector (legal offices, hospitals, civil registries, service delivery systems, etc.,) and the private sector alike.

Recently, digitalization of collections, libraries and archives have interested the Cultural Heritage field. Museums, archives and cultural institutions are digitalizing many of their collections and material, sharing them in open web platforms.

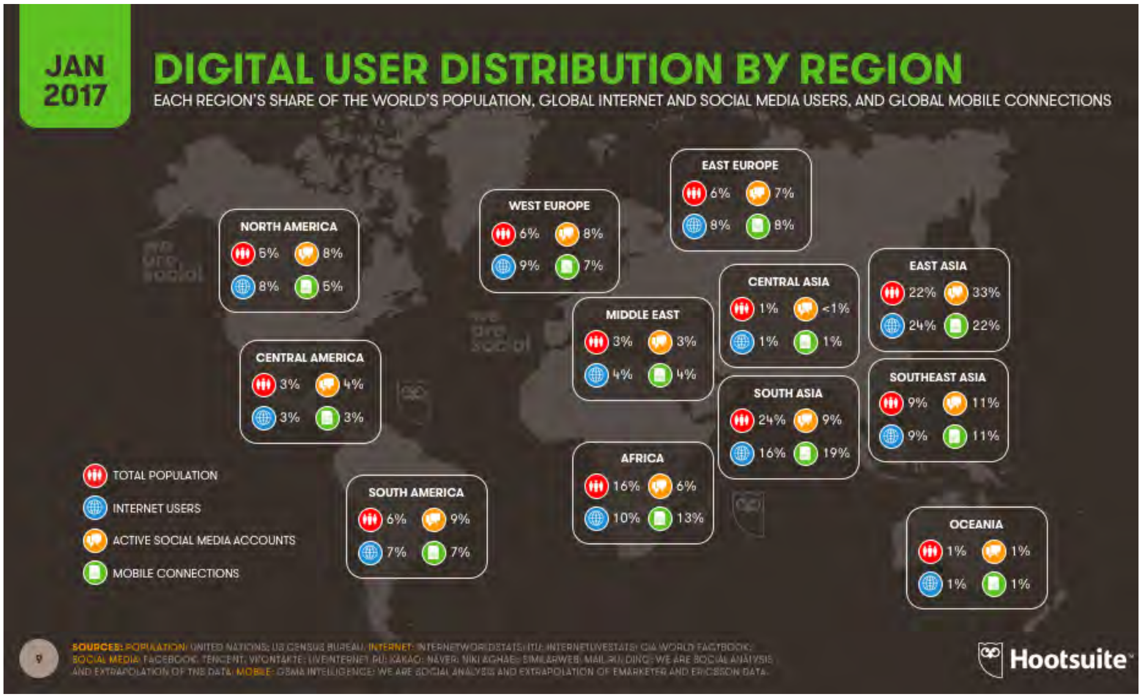

Figure 5 World map of the distribution of internet users, active social media accounts and mobile connection calculated in relation to the population. Image source: We are social website (we are social, 2017).

There is no question that these processes allow basic access to collections and materials even if further considerations need to be made in term of metadata, information accessibility and data longevity.

Indeed, as described by Michael Lascarides and Ben Vershbow, *"[…](digitalized) materials must be intensively processed following digitization in order to make their richest contents accessible […]"* (Ridege, 2014) p. 114. For example, historical maps – in order to be queried and navigated by users - need geo-rectification to the existing geographic coordinate system; newspaper, books and historical documents, in general, need optical processing to allow the extraction of searchable text (manual cleanup can be also required); and in the case of registers, information requires extraction and expert interpretation to be structured and made accessible (Ridege, 2014), p.114.

These are just some of the critical issues faced during digitalization processes. Apart from technical challenges, other criticalities concern the costs of these processes, particularly considering the overall shrinking of financial resources in the cultural sector.

Nevertheless, one of the strengths in the digitalization processes of cultural resources consists in the public relevance of such operations. Therefore, key issues for policy makers and practitioners include:

- *How to exploit public participation?*
- *How to create collaborative interfaces to gain public support and stimulate at the same time public interest and involvement in cultural heritage?*

Building on the successful examples of web applications based on voluntary collaboration - such as Wikipedia, Internet Archive, Project Gutenberg, Freebase, Europeana, Flickr Commons, Tumblr, etc., - is it possible to devise strategies aimed at stimulating public interest and participation?

Hence, this paragraph illustrates a critical analysis of the state of the art in term of web platforms used in built heritage contexts. Considerations and reflections of the approaches and methodology used and of their limits and opportunities are developed. On a final note, possible further developments that can be addressed by the proposed research are described.

The Strategic Research Agenda (SRA) - developed in 2014 by the EU Joint Programming Initiative, Cultural Heritage and Global Change (JPI-CH) (Joint Programming Initiative for Cultural Heritage and Global Change, 2014) to address the challenges of cultural heritage protection as well as economic growth – identifies the potential of digitalization as one of the main and most influential aspects in the cultural heritage field. Indeed, digitalization plays a key role in the conservation and democratization processes of cultural heritage.

Bearing in mind the international context, some reflections should be developed. The first one concerns the sustainability of digitalization in its social dimensions. Indeed, one aspect to consider in such processes is the users' involvement and active participation. The second main issue is related to the economic sustainability of digitalization processes.

In terms of practical applications addressing these reflections, an example is provided by Europeana, a digital European library for culture (Europeana, n.d.-a). The aim of the system is to "involve private actors in digitizing cultural material and make it available through Europeana" (Commission, 2015). Hence, the purpose consists in digitalizing the heritage documents of each user and attract people to explore and discover its virtual collections, increasing cultural heritage knowledge (Europeana, n.d.-b). The system is structured like an information portal containing different Cultural Heritage resources, including different kinds of written documents, images and multimedia files. The vision consists in making culture *"openly accessible in a digital way, to promote the exchange of ideas and information"*(European Commission, 2015).

Employing standard metadata, different organizations and institutions can collaborate to the digitalization process of European cultural heritage resources. Metadata support users in their understanding of the object, by locating it in a wider cultural context.

In terms of support to economic growth, Europeana is a *"hub for the creative industries and facilitates economic activity based on digitized cultural resources"*(European Commission, 2015). Indeed, the digitalized material can be reused mainly for learning and educational purposes (documentaries, animations, etc.) and for developing tourism applications and activities.

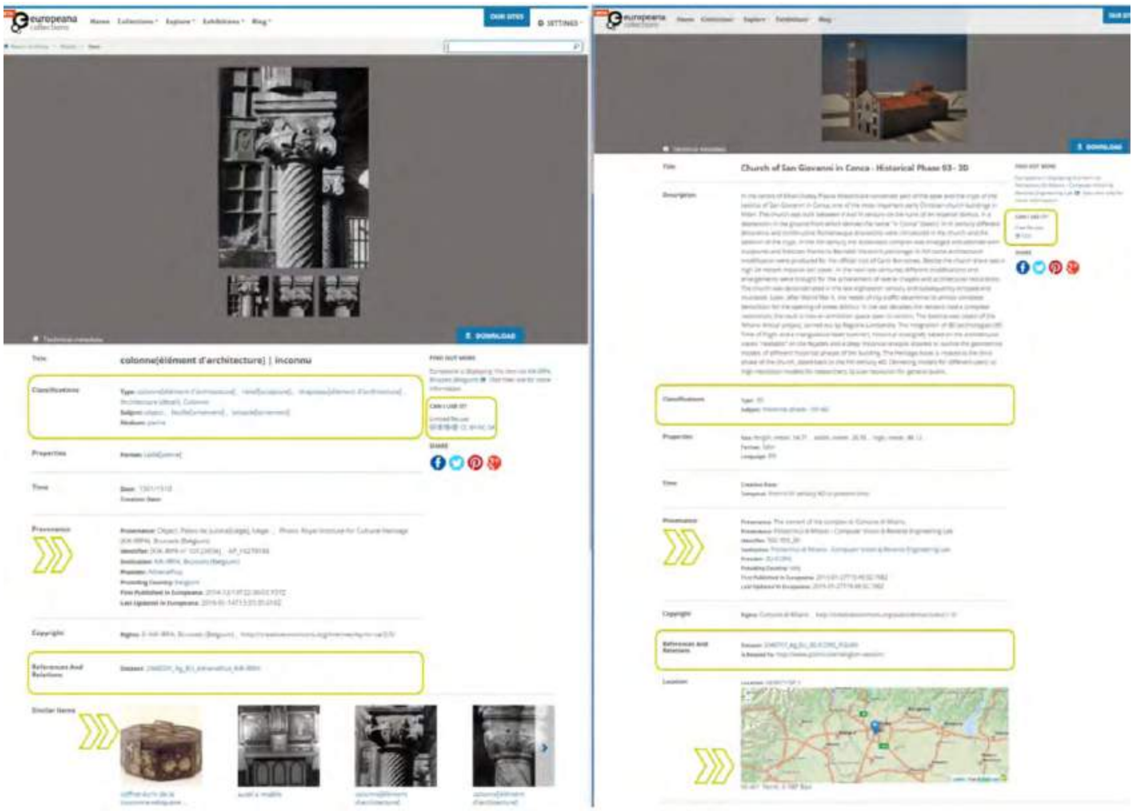

Figure 6 Examples (left) of the metadata sheet of an architectural object, a column with capital, in the Europeana database (Europeana Collections, n.d.-b) and (right) of the metadata sheet of the 3D model of the Church of San Giovanni in Conca (Europeana Collections, n.d.-a).

The analysis of the Europeana system is particularly useful for this study in order to understand possible solutions of information gathering and collection in an open database designed through bottom-up or crowdsourcing approaches. Particularly relevant is the metadata organization to catalogue and structure the information shared by users. Furthermore, it is interesting to notice the compatibility aspects of the platform available with any software platforms, including Windows, Mac OS and Linux, as well as any browsers (with no need of plugin). Further, Europeana is suitable not only for small objects, books, videos, images and audio records, but also for architectural objects and whole archeological and architectural sites[23]. All these aspects are considered in the development of the designed Wiki approach to share, gather, collect and interpret intangible information related to technical and tangible aspects of the built heritage.

4.3 Digital 3D modelling for historic buildings: Building Information Modelling (BIM) potentials and applications

The model, as an architectural tool, has been used for generations as a starting point in the architecture practice. It enabled members of the profession to foresee the development of large-scale construction on small scale models. This method is one of the most ancient approaches to the practice of architectural design (Mezzino et al., 2015).

As anticipated in Chapter 1, paragraph 1.3.4 *Architectural knowledge representation: the opportunities of 3D models*, already in the XV century, Leon Battista Alberti considered models as the best tools to study and develop an idea as well as the finest tools to improve drawing documentation. Moreover, the model was conceived as a tool to test the distribution features of a building and to meditate on its position, orientation, the location of the main walls, and appearance of the facades and suitability of the roof. The model is a good and flexible tool to change, move, review and rethink the designing choices until everything fits together: *"I have often conceived of projects in the mind that seemed quite commendable at the time; but when I translated them into*

[23] An example is the CARARE project that gathered contents – including 3D models and virtual reality content - related to architectural and archeological heritage. The project aims at consolidating the network of organizations and institutions that work for the safeguard and protection of built heritage world wide (CARARE, n.d.). Another more recent project is 3D ICONS. The project, started in 2012, aimed at establishing a procedure for the 3D reproduction of built heritage structures. The defined procedures concern also the technical, legal and organizational issues of a 3D digitalization project (ICONS, n.d.).

drawings, I found several errors in the very parts that delighted me most […] finally, when I pass from the drawings to the model, I sometimes notice further mistakes in the individual parts, even over the numbers.” *De re Aedificatoria,* Book IX, 10 (Alberti, 1998).

In the book IX of the *De re Aedificatoria,* Alberti claimed that models are useful to correct the imperfection of the ideas and that they should be used for practical purposes such as the organization and management of a building site (Mezzino et al., 2015): *“[…] models should be employed not only at the outset but also during construction, so that on their advice we may determine in advance what is necessary and make preparations in order to avoid any hesitation, change, or revision after the commencement of the work, and so that we may form a concise overall picture of the whole, in order that appropriate and useful materials might be procured, stored, and made readily available.” De re Aedificatoria*, Book IX, 9 (Alberti, 1998).

Alberti stated the importance of a model for design choices, for understanding spatial relations as well as for cost analysis. He claimed that models allow calculation, experiments, cost assessment, providing information about width, height, and depth of the structures of its composing elements. According to these considerations, in the Book II – materials - he stressed the importance of the model in providing a precise indication of the costs of each building elements: *“(the model)[…]will provide a surer indication of likely costs – which is not unimportant – by allowing one to calculate the width and the height of individual elements, their thickness, number, extent, form, appearance and quality, according to their importance and the workmanship they require. In this way it is possible to form a clearer and more certain idea of the design and quantity of the columns, capitals, bases, cornices, pediments, revetment, flooring,* *statues, and everything else relating to the construction of the building and its ornamentation." De re Aedificatoria,* Book II. P.34 (Alberti, 1998).

Recently, computer science technological development influenced the AEC sector changing modalities of information collection and visualization. Within this framework, 3D models and information databases have been developed.

Since the '80s the development of parametric software and applications, for mechanical system design, started to innovate the design workflow (Osello & Rinaudo, 2016). This concept is rooted in the generation of the Building Information Modelling (BIM), defined at the end of the '70s. Since then, BIM evolved and expanded increasingly *"[…] both as a social phenomenon and a technological space."* (Lévy, 2012), p. 30.

As reported by S. Logothetis, A. Delinasiou, E. Stylianidi, *"[…] BIM technology differ from the 3D CAD because are "smarter" and can present the information more detailed; contained information and data for the whole "construction project" such as: drawings, structural elements, mechanical systems, materials' measurements, data suppliers, scheduling and financial data"* (Logothetis, Delinasiou, & Stylianidis, 2015), p.178.

The term BIM was firstly used in the late '70s by Phil Benstein and Professor Charles Eastman. The former was attached to the industry field (vice president of strategic industry relations at Autodesk) and the latter to the academic world (professor at the Colleges of Architecture and Computer Science at Georgia Institute of Technology). First BIM implementations were developed in the ArchiCAD platform by the Graphisoft company within the framework of the Virtual Building concept (Logothetis et al., 2015).

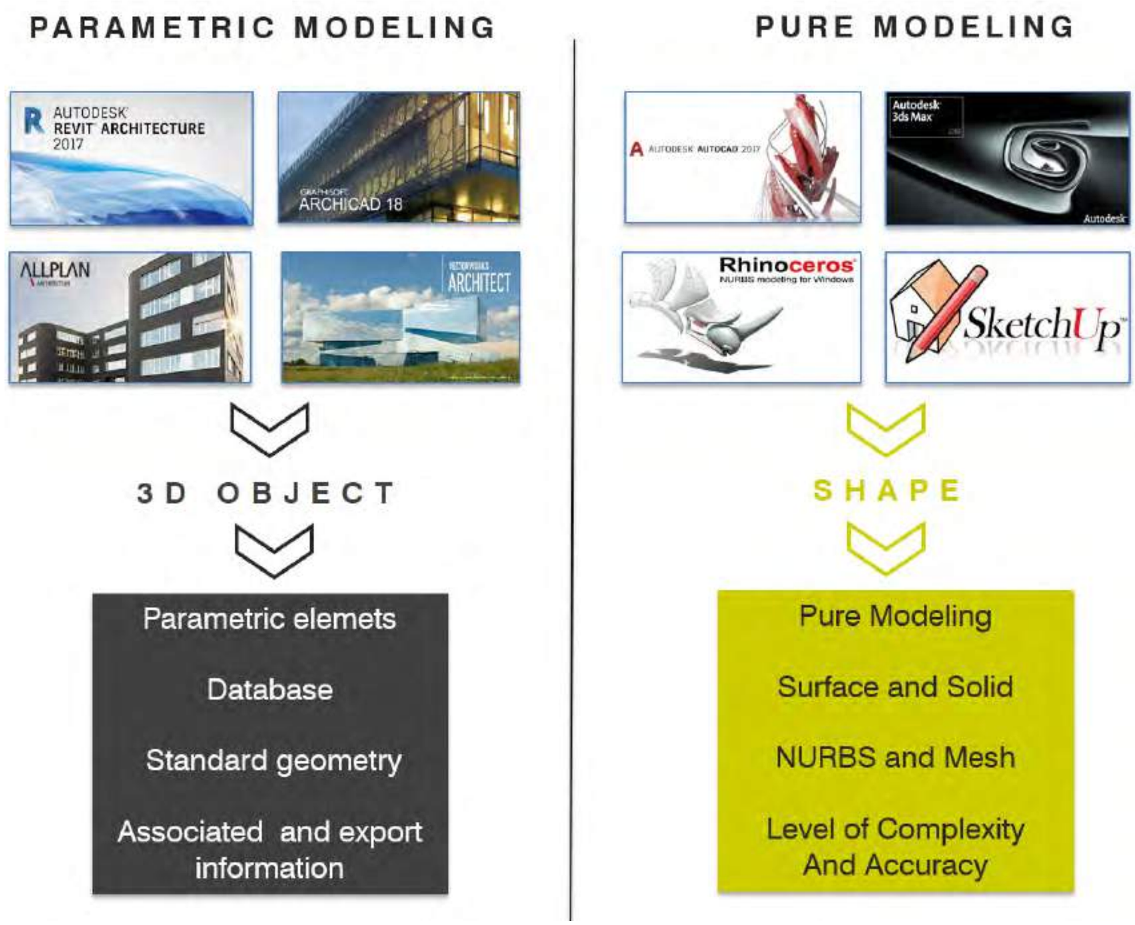

Figure 7 The diagram reports the difference between parametric and pure modeling. Image adapted from Banfi F. "*Building Information Modeling - A novel dynamic parametric approach applied to Built Heritage*" (Banfi, 2016).

Eastman defines BIM systems as *"a modelling technology and associated set of processes to produce, communicate, and analize building models"* (Lévy, 2012) p.4. According to Lévy, BIM can be defined as an *"architectural software environment in which graphic and tabular views are extracted from data-rich building models composed of intelligent, contextual building objects".*

In this case, the word "modelling" does not mean only a three-dimensional geometry; it is a combination with descriptive semantic information. Overcoming pure modeling applications, such as AutoCAD, 3DStudioMax, Rhinoceros and Sketch up, BIM requires parametric modelling software such as Archicad, Revit, Allplan and Vectorworks, allowing the generation of parametric elements, database, standard geometry and the export of associated information.

The BIM systems allow the development of digital representations of architectural objects into 5 dimensions (5D). These include not only (3D) primary spatial dimensions (width, height and depth), but also the temporal dimension (4D) and the fifth one (5D) intended as costs (Logothetis et al., 2015).

The impact of BIM on the AEC sector is recognized by Eastman, Teicholz, Sacks and Liston who noticed that "*[…] the most promising developments in the architecture, engineering and construction (AEC) industries with BIM technology and accurate virtual model of a building is constructed digitally. When completed, the computer–generated model contains precise geometry and relevant data needed to support the construction, fabrication, and procurement activities needed to realize the building*" (Eastman, Teicholz, Sacks, & Liston, 2008).

Despite parametric modelling allows to document and disseminate the building 'knowledge', it usually does not allow to create complex shapes that characterize historic buildings. This system allows the creation of 3D virtual environments as well as of data sets, including information such as properties and quantities of the components associated with the building geometry (Osello & Rinaudo, 2016).

Currently, several software applications with BIM functions are available in the market. These include, for example, AllPlan, ArchiCAD, Autodesk Revit, Vector Works, Bentley Building, Generative Components and Digital Project (Osello & Rinaudo, 2016). Main BIM software providers, such as Autodesk[24], emphasize advantages of BIM in the project development. Bentley, developer of the Generative Components software, describes BIM advantages as a representation tool for both graphic and semantic information. Another software provider, Graphisoft, producer of Archicad, stresses the importance of the smart elements that constitute a BIM and its simulations properties.

These BIM products can be grouped in three main types of applications: 1) 3D modelling, 2) visualization, 3) calculation and analysis (Logothetis et al., 2015).

Table 3 Commercial and open-source BIM tools available on the market. Adapted from Logothetis, Delinasiou and Stylianidis, *Building Information Modelling for cultural heritage: a review* (Logothetis et al., 2015), p.179.

PRODUCT NAME	BIM MANUFACTURER	PRIMARY USE	FUNCTION SUPPLIER	WEB LINK
Revit Architecture	Autodesk	Creating and reviewing 3D models	Architectural Modelling and parametric design.	www.autodesk.com
Bentley Architecture	Bentley Systems	Creating and reviewing 3D models	Architectural Modelling	www.bentley.com
SketchUpPro	Google	Conceptual 3D Modelling	Conceptual Design Modelling	www.sketchup.google.com
ArchiCAD	Graphisoft	Conceptual 3D Architectural Model	Architectural Model Creation	www.graphisoft.com
TeklaStructures	Tekla	Conceptual 3D Modelling	Architectural 3D Model Application	www.tekla.com
DProfiler	Beck Technology	Conceptual Design and Cost Estimation	3D conceptual modelling with real-time cost estimating	www.beck-technology.com
Vectorworks Designer	Nemetschek	Conceptual 3D Modelling	Architectural Model Creation	www.nemetschek.net
Affinity	Trelligence	Conceptual 3D Modelling	A 3D Model Application for early concept design	www.trelligence.com
Edificius	AccaSoftware	Architectural BIM Design and 3D object CAD	Architectural Modelling	www.accasoftware.com
Vico Office	Vico Software	Conceptual 5D Modelling	5D conceptual model generate cost and schedule data	www.vicosoftware.com-
Revit Structure	Autodesk	Structural	Structural Modelling and parametric design	www.autodesk.com
SDS/2	Design Data	Structural	3D Structural Modelling and Detailing	www.dsndata.com
RISA	RISA Technologies	Structural	Full Suite of Structural Design Applications	www.risatech.com

[24] Autodesk is producer of the BIM software Revit Architecture.

Robot	Autodesk	Structural Analysis	Bi-directional link with Autodesk Revit Structure	www.autodesk.com
Green Building Studio	Autodesk	Energy Analysis	Measure energy use and carbon footprint	www.autodesk.com
Ecotect	Autodesk	Energy Analysis	Weather, energy, water, carbon emission analysis	www.autodesk.com
Structural Analysis Design Detailing, Building Performance	Bentley Systems	Structural Analysis/Detailing, Quantity Take-off, Building Performance	To measure, assess and report building performance.	www.bentley.com
Solibri Model Checker	Solibri	Model Checking & Validation	Rules-based checking for compliance and validation of all objects in the model	www.solibri.com
TeklaBIMSight	Tekla	Model Viewer	Combine models, check for clashes and share information	www.teklabimsight.com
xBIMXplorer	Open BIM	IFC viewer	Open, view IFC files and navigate through a model	http://xbim.codeplex.com
Solibri Model Viewer	Solibri	Model Viewer	Open all Standard IFC Solibri Checker Files	www.solibri.com
Navisworks Freedom	Autodesk	3D Model Viewer	Open, view IFC files and navigate through a model	www.autodesk.com

The impact of BIM in the AEC sector is also consequence of the interoperability of BIM model to the development of Database (DB), Augmented Reality applications (AR), Finite Element Analysis (FEA), Energy Management (EM), Work Breakdown Structure (WBS) and Life Cycle Analysis (LCA).

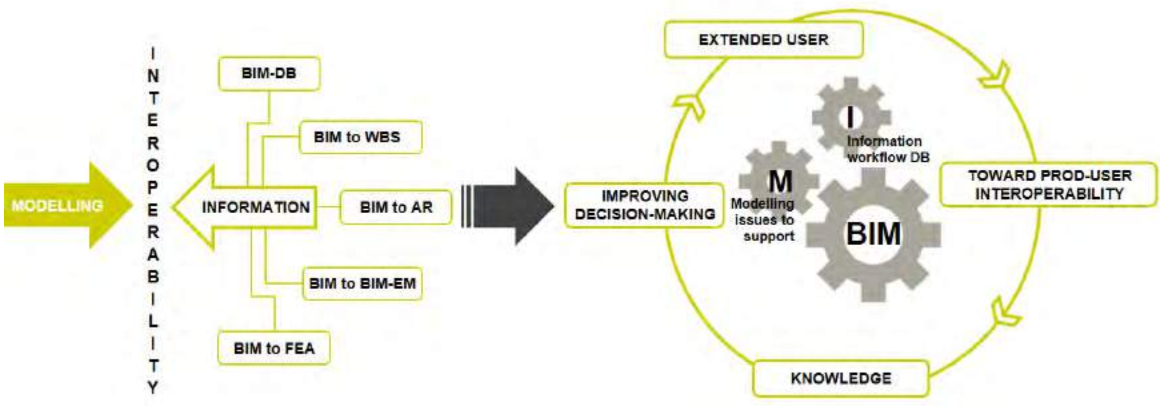

Figure 8 Image adapted from Banfi F. "Building Information Modeling - A novel dynamic parametric approach applied to Built Heritage" (Banfi, 2016).

Furthermore, a BIM environment allows information to be collected, visualized and managed by the different professionals involved.

According to the National BIM Report 2016 (Waterhouse & Philp, 2016), the adoption of BIM in the architectural field is exponentially growing. In 2011 the BIM users were

13% while in 2016 the percentage raised to 54% and it is expected to grow up to 86% (Waterhouse & Philp, 2016).

The same report illustrates interesting information about BIM usage. From the report emerges also that BIM is mainly employed for public buildings rather than private ones.

According to Adam Matthews, Europe has currently the greatest number of government-led BIM programmes worldwide (Waterhouse & Philp, 2016). Nordic countries such as Norway and Finland developed the first BIM standards followed by the Netherlands, UK, and Italy and lately Germany, France and Spain. The European commission itself promoted the use of BIM in delivering public works (Waterhouse & Philp, 2016), p. 8.

Governments are encouraging BIM development because its application can reduce the time and costs in the AEC field. In the current context of general spending reviews and reduction of public expenditure,[25] this is particularly relevant for governments and public agencies (Waterhouse & Philp, 2016).

Last but not least BIM developments can address the challenge of combining the reduction of consumption of natural resources thus contributing to environmental sustainability[26] compounded with economic sustainable standards (Waterhouse & Philp, 2016).

[25] It is a direct consequence of macro issues such as bearing the cost of an ageing population, rising social welfare and national debt and budgetary constraints faced by governments (Waterhouse & Philp, 2016).

[26] The construction sector has significant impacts on environmental sustainability. Indeed, built environment is one of the largest consumers of natural resources and producers of carbon emissions, accounting for about 40% of the world annual resource consumption (Waterhouse & Philp, 2016).

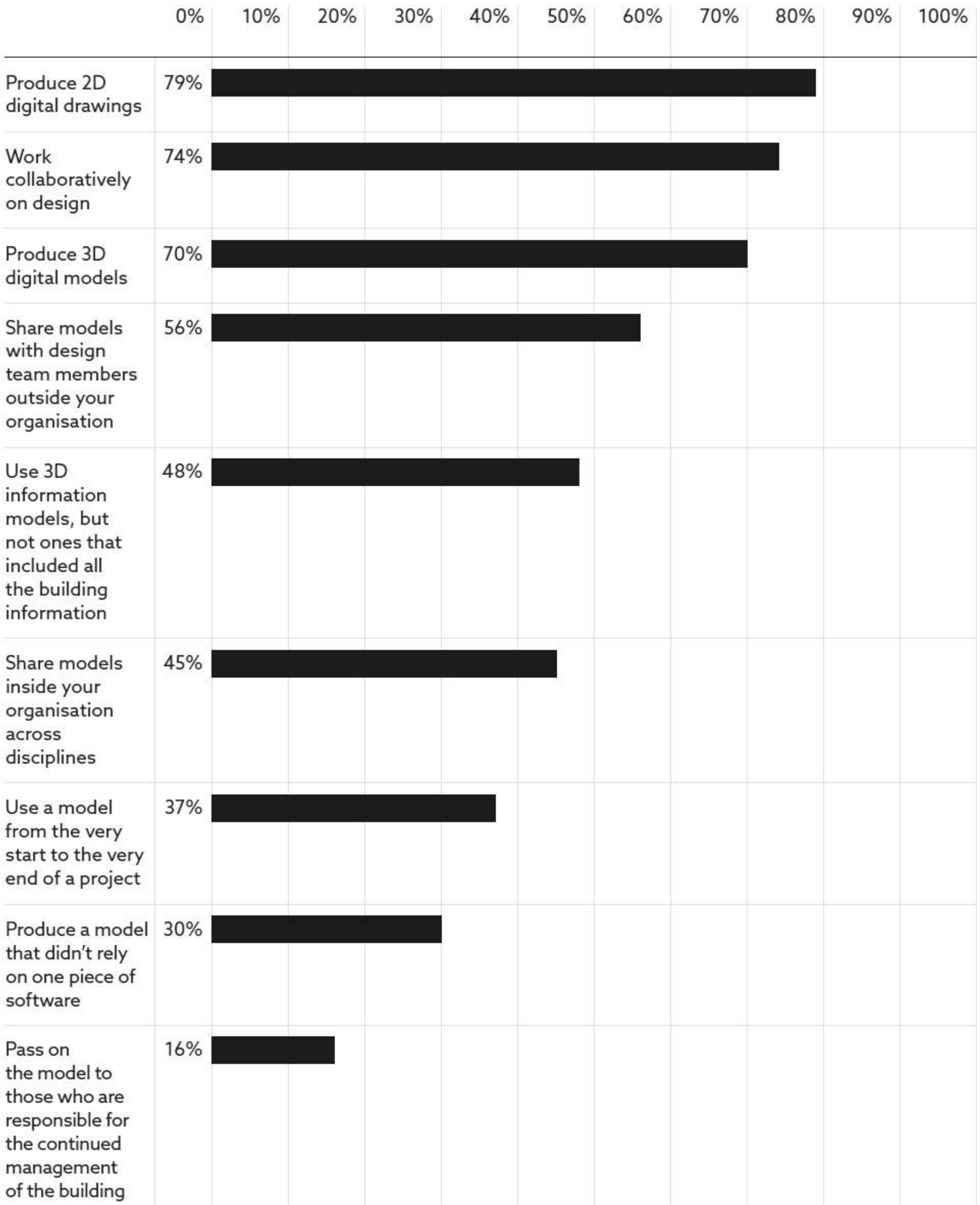

Figure 9 BIM uses. Source National BIM Report 2016 (Malleson, 2016), p. 34.

The above figure shows that currently BIM usage is restricted to the design stages, while only 16% of the total cases employ the model in the management stage to "*organize and define maintenance and replacement schedules"* (Waterhouse & Philp, 2016), p.35.

The component-based structure of BIM systems can provide great opportunities to manage and plan design as well as conservation actions. The BIM components consist of parametric objects stored in object libraries within the software database (Logothetis et al., 2015). These parametric objects can be seen as the digital translation of tangible architectural components used to construct both new and existing structures. Furthermore, these components, modelled into three dimensions, can be associated with semantic information (on structural layers, mechanical properties, energetic material performances, costs, acoustic data, hypermedia-links, etc.), thus making the model more comprehensive or, as noted by Logothetis, Delinasiou, and Stylianidis, "intelligent" (Logothetis et al., 2015), p.178.

In the last years, BIM applications have been extended to the cultural built heritage field. Logothetis, Delinasiou and Stylianidis underscore that *"[...] architects, archaeologists, conservationists, engineers regard BIM as a disruptive force, changing the way professionals can document and manage a cultural heritage structure. The latest years, there are many developments in the BIM field while the developed technology and methods challenged the cultural heritage community in the documentation framework*" (Logothetis et al., 2015), p.177.

In the case of built structures, BIM allows virtual modelling of recorded structures, independently from the techniques employed in the data acquisition phase (i.e. hand measurements, EDM, photogrammetry and laser scanning). The model, developed from the information collected through a field survey, assembles different building components in a comprehensive model. The level of detail of the model and its correspondence to the reality depends on the accuracy of the records (such as pointclouds, measurements, etc.) as well as on the precision of the modelling phase.

In the field of built heritage, the advantages of BIM are defined by Banfi F. in terms of:

- Geometric coordination;
- Information and design development;
- Drawing Production;
- Schedule Production;
- Clash Detection and Resolution;
- Procurement;
- Project Execution Plan;
- Performance/Specification purposes (Banfi, 2016).

Additional benefits are evidenced by Logothetis, Delinasiou, and Stylianidis in terms of remote reviewing of the building exterior and interior; studies and analysis considering the environmental context; possibilities to create temporal scenarios; visualization of renovations and adaptations; better understanding in building in three dimensions for a broader public. (Logothetis et al., 2015).

In terms of information development, BIM applied to historic structures provides opportunities in terms of knowledge of materials and constructions techniques, building pathologies and damages, efficient traditional or innovative repair and conservation methods.

Furthermore, a BIM of built heritage buildings supports maintenance processes, budgeting for repairs and maintenance and full studies of proposed renovation and conservation projects.

For these reasons, several studies currently focus on the application of BIM to existing structures and historical buildings. Due to such factors as incompatibility of information, missing information, irregular and complex geometry of built structures, some challenges need to be faced (Ma, Hsu, Lin, Tsai, & Chen, 2015). On-going applications are experimenting the feasibility of BIM as a 3D parametric database to model and store qualitative and quantitative information on historic buildings. This would provide accurate information to manage and conserve historic structures, sustaining not only the original design concept but also values and embedded information useful for its resilience.

First applications of the BIM in the built heritage was developed by Yusuf Arayici[27] in 2008. He stressed the relevance of BIM application toward the characterization of architectural elements modelled in 3D environments, thus developing *"intelligent, multifunction and multi-representational data*" (Logothetis et al., 2015), p.117.

Maurice Murphy and his research team and collaborators are developing the Historic Building Information Modelling (HBIM) integrating BIM approach in the built heritage field. He addresses the concept of HBIM as a prototype library of parametric heritage object (Murphy, McGovern, & Pavia, 2013).

Applications of BIM systems to the management of built structures evidences several advantages.

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[27] Dr Yusuf Arayici is a Reader in the School of the Built Environment (SOBE) at the University of Salford, Manchester, UK. He lectures in Computer Aided Design, Building Information Modelling and urban regeneration. He is currently leading interoperability specification development in the Design4Energy Project (2013-2017), aiming to develop a BIM based integrated platform for energy efficient design and retrofit, particularly researching into the development of an IDM based interoperability specification development for collaborative BIM based design practice at level 2 and level 3 BIM use for the energy efficient building design and optimisation. He also plays a leading role for scenario development in the Multidisciplinary approach to plan smart specialisation strategies for local economic development (MAPS-LED) project (2015-2019). He is author of more than 60 publications and two books on BIM titled: "*Building Information Modelling*" published in 2015 and "*Requirements Engineering for Computer Integrated Environments In Construction*", providing technical guidance for BIM development and implementation, published in 2010 (University of Salford, n.d.).

In relation to visualization, it allows achieving dynamic 3D visualization of the modelled object, with a level of detail depending on records accuracy, project requirements and inputs provided. Furthermore, BIM allows to model and visualize inner constructive elements behind building surfaces.

In terms of characterization, the model allows recording properties, assembly techniques as well as qualitative information and provenance of materials of the modelled structure. BIM has got a potential role in documenting physical and technical aspects as well as embodied knowledge of built heritage.

Regarding data sharing, the parametric properties of BIM systems, the application programming interface (API) and the development of iCloud database are increasing BIM's attractiveness (Ma et al., 2015). These characteristics provide great opportunities in the heritage conservation field, *"[…] a system of multidisciplinary activities where each professional is user and provider of […] information"*(Osello & Rinaudo, 2016), p. 114.

The possibility of developing data statistics from the model is another advantage of the semantic characterization of 3D models in a BIM environment. Components structure and properties, as well as material specifications, can be easily exported and visualized in multiple formats.

BIM definitions, concepts, and potential applications for Cultural Built Heritage

In 2007, the *National Building Information Model Standard Project Committee* defined the BIM as a horizontal method of information exchange, about the whole life cycle of a building that employs open technologies promoting a digital reproduction of a building containing a geometric and semantic description.

Anna Osello differentiates between Building Information Modelling and Building Information Model. She defined the former as a *"[...] insieme dei processi applicati per realizzare, gestire, ricavare e comunicare informazioni tra soggetti a livelli differenti, utilizzando dei modelli creati da tutti i partecipanti al processo edilizio, in tempi diversi ed anche a scopi non uguali tra loro, per garantire qualità ed efficienza attraverso l'intero ciclo di vita di un manufatto".* By Building Information Model, instead, she means only the digital 3D model illustrating the *"[...] caratteristiche fisiche e funzionali di un manufatto. Tale rappresentazione è costituita da oggetti digitali corrispondenti alle componenti del mondo reale come muri, porte e finestre con associate relazioni, attributi e proprietà*" (Osello, 2012), p. 33-35.

In line with these definitions, BIM opportunities in conservation processes are evident, particularly in terms of management. BIM systems are effective tools for the management of built structures because of their semantic properties associated with 3D features.

Indeed, analyses in a 3D environment allow a better precision in terms of:

- Estimation of surfaces or volumes that need interventions;
- Evaluation of cost previsions of the material, tools and techniques to be employed.

In most of the cases, tools for 2D analysis show limitations in guaranteeing high accuracy in estimating the volume of rooms and materials and relative costs entailed in conservation operations.

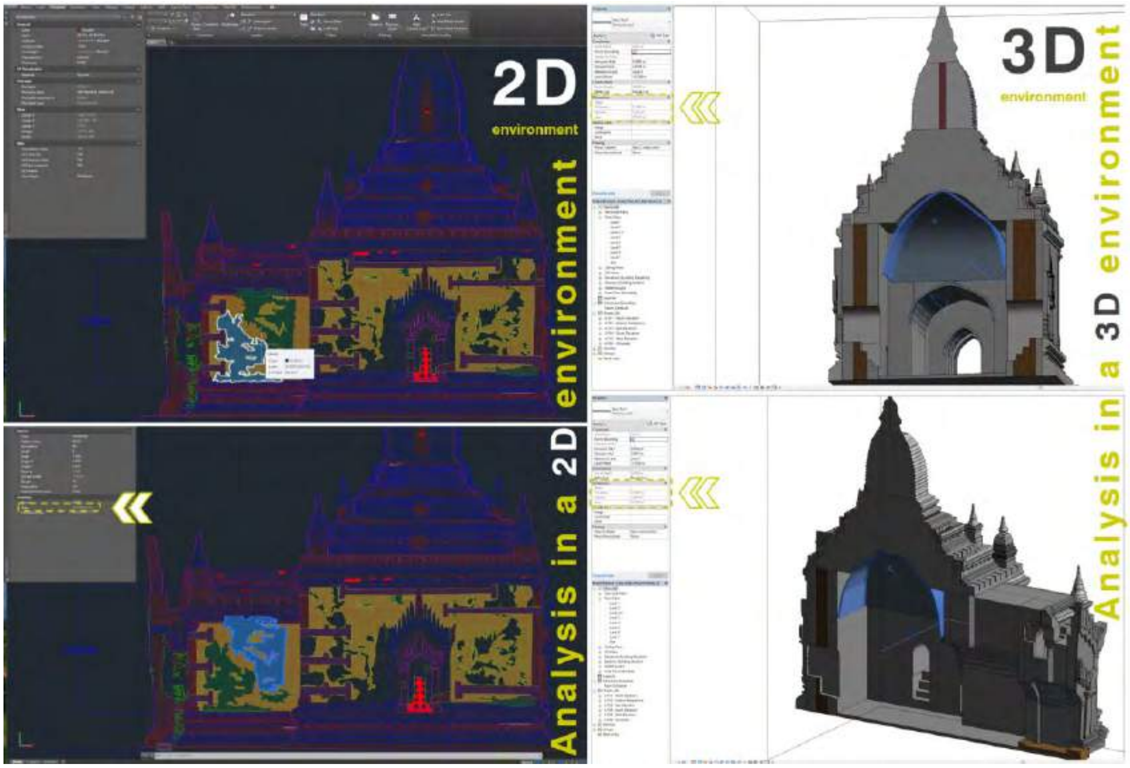

Figure 10 Example of the limits of the analysis that can be carried out within a 2D environment compared with the one that can be developed in a 3D BIM environment. Software used: AutoCAD 2016, Autodesk Revit 2016. Image source: Author.

For instance, 2D analyses developed through different supports - such as orthophotos, CAD drawings, etc., - provide a good basis for estimating the amount of the surfaces to be repaired, restored, or recovered in the case of façade or floors (horizontal and vertical surfaces).

Nevertheless, how to gain the same information with a similar accuracy in case of three-dimensional components? If an orthophoto is efficient to estimate the amount of damaged surface of a façade, how to calculate the damages of a barrel or cross vault?

Furthermore, even with architectural components with simple geometry, such as walls, the estimation of areas and volumes from the two-dimensional analysis is not usually reliable.

For example, in case of a wall with a significant out of plain, the calculation of areas and volumes from 2D measured drawings, repeated for long distances, becomes a relevant source of error. This is evident in the case of huge buildings such as Basilicas, Cathedrals, Palaces, big Public buildings, etc. These errors can result in relevant inconsistencies in the calculations of areas and volumes required for cost computation.

On the basis of such considerations, it is possible to assert that BIM systems are an effective tool to actualize conservation for the practical management of conservation aspects and in terms of both geometric and semantic modelling. In Chapter 7 and 8 additional uses and potential of semantic and geometric modelling of BIM systems in the application to historic structures is proposed.

5 Chapter: The Epistemic object: WikiBIM as a participatory documentation approach to managing design choices in built heritage contexts

Most of the international and inter-governmental organizations have recognized the relevance of a broad public participation in public choices to achieve the Internationally Agreed Development Goals (IADGs) such as the Millennium Development Goals (MDGs), replaced by the Sustainable Development Goals in 2016.

This trend strongly affects Heritage Conservation that deals with public tangible movable and immovable objects, intangible heritage, and more generally communal memory.

Reflecting on effective approaches that can be used to support and improve participation dynamics the connection with digital tools is evident and finds international affirmation. For instance, the meeting of the United Nations on E-Participation: *Empowering people through ICTs*, hold in Geneva, Switzerland in July 2013[1], has documented the value of e-participation as "*an effective tool for empowering citizens through Information Technologies (ICTs)"*[2].

In the built heritage field, the challenge consists in the application of diffused and constantly evolving ICTs solutions to implement and facilitate participation and engagement in heritage.

[1] The meeting was organized by the Division for Social Policy and Development (DSPD) and Division for Public Administration and Development Management (DPADM) of the United Nations Department of Economic and Social Affairs (UNDESA).

[2] UNITED NATIONS, E-Participation: Empowering People through Information Communication Technologies (ICTs). Aide Memoire, Geneva, Switzerland 24-26 July 2013, p. III.

Examples of projects with a relevant IT content can be found in national as well as international initiatives at different scale including, landscapes, cities, museums, monuments, architectural complexes, etc.

The growing number of these initiatives (reported in the paragraphs *1.3.5 Conservation and digitalization in the internet era, 4.1.2 The potentials of digital recording technologies and internet networks for conservation actions, 4.2 Internet networks and web platforms for conservation actions: opportunities and challenges* and *5.2 Web platforms supporting participatory documentation for built heritage sites*) evidences the new needs of both public institutions and, more generally, cultural heritage stakeholders to involve and engage the broad public and 'users' of these cultural assets and their willing to share knowledge and opinions.

In line with these considerations, the proposed WIKI approach to gather crowdsourced information to be structured and elaborated in a Building Information Model (BIM) would provide an effective support to document, manage and disseminate information related to intangible cultural aspects and tacit knowledge associated with historic buildings such as methods of construction, materials selections, maintenance strategies, etc.

This integration of efficient Spatial Information Systems and web-based participatory approaches (either web-based or involving direct contact with people) would provide a reliable platform of embodied knowledge to enable communities, both of experts and non-experts, to learn and at the same time act, make judgments and contribute to conservation process.

Additionally to these considerations, tested in the site of Bagan[3], the aim of the proposed epistemic object stems from three main issues.

The first one is the scarcity or loss of ancient documents related to a site. In many cases, only incomplete 2D drawings are available. Further, they are not extremely reliable in terms of measurements' accuracy and can present interpretations' challenges. This appears more evident considering how these records were often complemented by written and oral descriptions. Furthermore, historic buildings were maintained and restored mainly by craftsmen which executed every job combining design and construction (or repairs).

Secondly, in modern building processes, craftsmen no longer lead the construction processes. Further, economic crisis, globalization processes are threatening the specialized craftsmanship needed in the conservation of heritage structures. Indeed, new sources of economic income, social and cultural change migrate professionals from the traditional craftsmanship production to other sectors (such as tourism, industry, etc.). As consequence, this leads to the loss of specialized craftsmen based on experience and memories.

Thirdly, the relationship between information sharing in built heritage conservation is becoming a topic issue. This should be analyzed in the broader framework of the recent innovations in the design and project management tools, in the information strategies to

[3] See chapter 6 *The living religious heritage site of Bagan, Myanmar* and Chapter 7 *The case of the Loka-hteik-pan temple*.

collect and manage data and in the participative dynamics, strongly affected by the revolution brought by social media and web communication platforms.

These considerations provided the basis on which the epistemic object has been structured.

5.1 Theoretical framework of the epistemic object

Continuity of tradition is critical in ensuring cultural identity. Nevertheless, it is important to remember the dynamic nature of traditions, of memory and cultural identities. Aware of these considerations, communities can play a key role in managing past, present and future through active subjective interpretation rather than 'translations' imposed or proposed through a top-down approach by a cultural or political elite.

Since conservation is a critical and interpretative act, which aims and purposes are in a constant change, communities should be continually questioned in the evaluation and modification of such purposes.

These reflections, justify the research of participatory approaches for meaningful and shared conservation actions. In line with these considerations, the proposed approach aims at making accessible the meanings of past for the present (and future) communities.

Further, a thorough awareness of the cultural significance of a place and of aspects and phenomena affecting its future can guarantee informed conservation actions.

In this framework, strategies to gather and manage information collection and analysis, relevant in the decision making phase, appear crucial. In line with the Burra Charter, the

Wiki logic can help to determine and understand the cultural significance of building and places based on opinions and ideas of a broader community.

Archiving, collecting and managing information related to built heritage assets, are key aspects that can notably advantage from digital opportunities. Digital techniques and tools are crucial to archive and manage not only the spatial and technical aspects of built structures but also the valuable know-how of craftsmen that, to a certain extent, can be documented in digital data format (Ma, Hsu, Lin, Tsai, & Chen, 2015).

Importing the concept of "internet of things"[4] in built heritage knowledge, the challenge consists in exploring the opportunities provided by information collection strategies and spatial information systems for the management of the geometric and semantic component of historic buildings.

Built heritage conservation can benefit from internet things concept. For instance, information on heritage object's multiples aspects can be provided, thus supporting informed conservation actions.

Current BIM systems provide the technological support to integrate the gap between a 3D spatial representation and information associated with the visualized object. This enables a design tool to visualize and manage information associated with objects in the conservation-planning phase[5].

The integration of this tools with a wiki approach would improve interaction between citizens, policy-makers as well as the technical and scientific skills involved in conservation processes.

[4] Internet of things is the extension of Internet to the world of material objects and places. The application of internet of things logic can provide for example information on how an object has been realized, with which techniques, by whom as well as required skills and tools.

[5] BIM systems provide a software solution to integrate a different kinds of information in a consistent database supporting the development of conservation choices.

Legitimation of the proposed idea can be found in international documents such as the Amsterdam Declaration (1975), the Granada Convention for the Protection of the Architectural Heritage of Europe (1985), the Noto Charter (1986).

The Amsterdam Declaration underlines the need to develop an organic documentation of building techniques, skills, and knowledge related to the architecture and conservation fields. The Declaration stresses the relevance of these actions to preserve, promote and disseminate the traditional knowledge and skills that run the risk to disappear.

Granada Convention reiterates the need for effective actions to contrast the loss of un-evaluable knowledge and skills in the craftsmanship, also in relation to architecture, relevant for the socio-cultural and economic development of a territory.

The Noto Charter reaffirms the key role of training for the operators in the conservation and maintenance of built heritage structures. Training and dissemination become necessary due to the constant disappear of craftsmanship activities connected to traditional and adaptive building techniques.

Relying on these considerations, the following paragraphs articulates the sources of inspiration to outline the approach of the proposed epistemic object.

5.1.1 A wiki approach for participative documentation of built heritage sites

The term wiki has transcended many disciplines, including the architecture and the cultural heritage field. Its main characteristics are related to participation and involvement through the technological support. The proposed approach extends the wiki logic to cultural heritage documentation interpreting the wiki approach as a source of social innovation in the conservation practice. This approach aims at exploring whether the combination of a wiki approach with traditional methods for the knowledge of a heritage site is possible, analyzing limits, opportunities, and consequences that this entails.

What is Wiki?

A Wiki is a web-based application enabling all viewers to change the content. This makes the wiki approach simple and easy to use for cooperative work.

The origins of Wiki applications dates back to 1995, when Ward Cunningham[6], developed WikiWikiWeb (Ebersbach, Glaser, & Heigl, 2006).

The term WikiWiki derived from a Hawaiian word meaning "quick", a metaphor of the programming characteristics of wiki software in which content can be made available quickly and easily (Ebersbach et al., 2006).

More specifically, from the operative point of view, WikiWikiWeb server technology *"enables the creation of associative hypertexts with non-linear navigation structures: Typically, each page contains a series of cross-links to other pages, The reader decides which page he or she will read next"* (Ebersbach et al., 2006), p.13. This reduces

[6] A software engineer from Portland, Oregon, U.S.A.

obstacles of communication design allowing externally generated content. Further, regular users do not require particular sophisticated or additional software (Ebersbach et al., 2006), p.13. Last but not least the strength of the WikiWikiWeb consists in its user-friendly features that enable the participation of a large number of communities that otherwise would not have been able to use this technology.

In 2001, the success of the free online encyclopedia Wikipedia made the ‘Wiki’ approach and logic popular worldwide (Ebersbach et al., 2006). TikiWiki, MediaWiki, UseModWiki, WakkaWiki, twiki, Wikitravel, Wikitionary, Wikitosh, Jurawiki and PhpWiki are just some examples of the popularity boom of the Wikis in different fields.

The Wiki approach was firstly intended for software development while is now used in several fields (Ebersbach et al., 2006). Indeed, Wiki applications can be used in an open, web-based content management system as knowledge management tool for planning and documentation in different fields, including, for instance, the cultural heritage one.

The relevance and the success of the Wiki phenomenon do not rely only on its technological innovation but also on its social dimension. This reciprocal relation between social progress and technological innovation determines the success of the Wiki approach (Ebersbach et al., 2006).

Scholars and experts of open source solutions claim how this approach can generally guarantee “*higher quality, better reliability, greater flexibility and lower cost”* (Open Source Initiative, n.d.).

The concept at the base of the wiki or more generally of open source approaches is not anything new even in the architectural field. Participation and inclusion can be found in some architectural expression such as public areas – squares and parks - and public buildings – covered markets, libraries, stadiums, schools, hospitals and places of worship such as churches, synagogues, temples, mosques, etc. – that entail a democratic use of the space.

In terms of operative strategy in the architectural field, a Wiki approach could exploit the potential of the "campanilismo" (parochialism) phenomena in order to collect information on built structures from the local communities that grew and live next to and/or in these buildings. This does not automatically imply that they know better these historic structures just because they are part of their everyday life but because local people can provide information on current and potential values of those historic buildings. Further, in many cases, locals are the keepers of the histories and technical aspects associated to buildings.

Figure 1 Examples of public spaces that illustrate the philosophy of the wiki approach involving participation and inclusion in architecture. In the order: the Carlo Alberto square, Turin; Gallery Umberto I, Naples; St-Paul's-Cathedral, London. Image elaboration: Author.

Considering these isues, this approach could be adopted in heritage documentation workflows applying this logic to traditional approaches (such as direct observations, personal communications, etc.) as well as to web-supported applications.

5.2 Web platforms supporting participatory documentation for built heritage sites

Mingquan Zhou, Guohua Geng and Zhongke Wu evidence that heritage conservation is based on a shared and participative approach claiming how *"Protection of the cultural heritage and historical legacies is the key foundation to keep the cultural bonds between people, which is also the prerequisite to maintain the cultural pluralism and the creativeness in the world, and to promote development together."*(Zhou, Geng, & Wu, 2012), p.1.

Therefore, this paragraph faces how web platforms can support participatory information sharing and collection through existing interface platforms.

Indeed, as Bertacchini, Feraco, Pantano, Reitano and Tavernise outlined a *"huge quantity of active users (the prosumers) will produce and enjoy the contents using the Open Source technology"* (Bertacchini, Feraco, Pantano, Reitano & Tavernise, 2008), p.1.

Therefore, this paragraph explores some potential applications that can enable users to become prosumers of their cultural built heritage.

The following chart proposes an analysis of the existing and most popular websites and social networks allowing of text, photos and videos sharing. These considerations are relevant to understand how to exploit existing social media and sharing platforms to gather comments, ideas, images and videos. These can play a key role in built heritage conservation processes in:

- allowing communities to constantly share updated information about change and pressures on historic structures;
- creating heritage communities gaining crowdsourced information on values associated with historic structures;
- developing shared on-line repository that can be investigated and analyzed for conservation and management purposes.

Table 1 Most popular website for photos sharing. Source: Author.

NAME	BRIEF DESCRIPTION	RELEVANCE	SOURCE
facebook	Facebook is a social networking service. It is operated and privately owned by Facebook, Inc. Users must register before using the site and users can create a personal profile, add other users as friends, upload pictures and exchange messages, after registering. The last innovations regard the possibility to localize pictures taken by mobile devices; in this way pictures, but also comments or messages, are localized in a map. Finally, other applications, such as Instagram or Foursquare are already connected with this social platform.	Facebook allows any users (who is 13 years old and above) to share pictures, videos, comments, tags, status and links. The site is free. There are more than 70 languages available and it counts more than 800 million active users. Facebook is the largest social-networking site with an educational focus. Its potentials as widely shared online repository can be investigated and analyzed to find image-records of transformed or lost heritage site.	http://facebooktenzin.blogspot.ca/2012/01/brief-summary-of-facebook.html
Instagram	It is a free photosharing and social network. It allows users to take pictures, applying digital filters and sharing with other users. Its strength consists in the possibility of sharing contemporary pictures in many other social networks, encouraging, in this way, the community development.	This online mobile photo-sharing, video-sharing and social networking service it is relevant to share with a huge public (more than 150 million of users) information in real time about any kind of topic including changes, destructions and/or damages (of heritage sites).	https://instagram.com/explore/tags/description/
Flickr	It is an image hosting and video hosting website. Flickr is a popular website for users to share photographs, with an online	Its 87 million registered members make this website relevant for sharing information about heritage site conditions.	https://en.wikipedia.org/wiki/Flickr

	community, the service is widely used by photo researchers and by bloggers to host images that they embed in blogs and social media. Photos and videos can be accessed from Flickr without the need of any registration. An account must be made in order to upload content onto the website. Registering an account also allows users to create a profile page containing photos and videos that the user has uploaded.	Further its interoperability with different mobile operating systems such as: iOS, Android, PlayStation Vita, Windows Phone and its optimized mobile website, makes it available to a huge range of users also in poor countries where expensive mobile devices (such as iphone) are not very diffused.	
SmugMug	The website allows to collect and manage photos, preserving their original resolution. The privacy issues are respected preserving identity of private photos.	SmugMug website is integrated with several social media allowing images sharing. It is also relevant for its privacy policy to protect users profile (particularly useful in case of conflicts).	https://www.smugmug.com/pro
Phanfare	Phanfare is a popular website boasting top notch features such as RAW support with up to 100MB image size uploads. Phanfare websites include full-screen slideshows. Photos can be uploaded either from the computer and from mobile devices (tablet, mobile). The website has a fee charge.	Website interoperability: relevant to share photos on Facebook and Twitter and on other social network. The preservation of the quality of images and video uploaded can be adopted also by other web platforms.	http://www.phanfare.com/home.aspx
Photobucket	Photobucket is a very popular choice for quick and easy photo sharing. With a free account, it allows to store photos, videos and GIFs, and share them by email or social sites like Facebook and Twitter.	Photobucket is efficient to fast sharing photos and integration with other social media platforms like Facebook and MySpace. Possible synergies with other social media and platforms can be considered.	http://photobucket.com/
Picasa	Picasa is an image organizer and image viewer for collecting and editing digital photos, plus an integrated photo-sharing website. In Picasa image geotagging is also available.	Relevant for the possibility of organize, visualize and share photos with no charges. Geotagging procedure could be replicated in other application in order to reference the images.	https://picasa.google.com/
Google+ Photos	Google has begun to redirect users from the old Picasa URL (picasweb.google.com) to Google+ Photos, which currently still offers a way to return to the old Picasa Web Albums interface during this transitional period.	The relevance and applications are similar to Picasa.	https://picasa.google.com/
Google Photos	Google+ Photos is going to switch into Google Photos.	The relevance and applications are the same as Google+ Photos	https://plus.google.com/+googleplus/posts/d1XubVAZ5hV
MySpace	It is a social networking website offering an interactive, user-submitted network of friends, personal profiles, blogs, groups, photos, music, and videos. Each user can choose to invite friends to create profiles or link to existing ones, creating a social network that can be exponentially expanded as users with similar tastes, interests or shared friends are discovered and added. MySpace is designed also for mobile application.	The huge number of users network and different kinds of information that can be uploaded in the website make Myspace relevant for sharing and collecting information related to heritage sites.	https://en.wikipedia.org/wiki/Myspace http://techterms.com/definition/myspace
Pict	Pict is a very simple photo sharing site enabling users to quickly and easily upload and share images. It is a basic photo sharing site that allows to: quickly upload images to Pict.com, get links to uploaded images and	The relevance is that Pict doesn't require registration to upload photos. This is particularly interesting to preserve and protect user's privacy.	http://download.cnet.com/Pict-Uploader/3000-13455_4-10911881.ht

The following chart instead illustrates the most popular web platform for video sharing.

Table 2 Most popular website for videos sharing. Source: Author.

NAME	BRIEF DESCRIPTION	RELEVANCE	SOURCE
facebook	Facebook is a social networking service. It is operated and privately owned by Facebook, Inc. Users must register before using the site and users can create a personal profile, add other users as friends, upload videos and exchange messages, after registering.	Facebook allows any users to share videos, comments, tags, status and links. The site is free. There are more than 70 languages available and it counts more than 800 million active users. Its potentials as widely shared online repository can be investigated and analyzed to find video-record of changed or lost heritage sites.	http://facebooktenzin.blogspot.ca/2012/01/brief-summary-of-facebook.html
SmugMug	The website allows to collect and manage videos. The original videos' resolution is preserved. The privacy issues are respected protecting the videos' ownership identity.	SmugMug site is integrated with social media allowing videos sharing. Its privacy policy to protect users' profile (particularly useful in case of conflicts) are also relevant.	https://www.smugmug.com/pro
youtube	YouTube is a video-sharing website. The site allows users to upload, view, and share videos. It makes use of WebM, H.264/MPEG-4 AVC, and Adobe Flash Video technology to display a wide variety of user-generated and corporate media video. Available content includes video clips, TV clips, music videos and other content such as video blogging, short original videos, and educational videos. Unregistered users can watch videos, and registered users can upload videos to their channels.	It is the most used platform to freely share videos. Thanks to applications such as Zamzar (http://www.zamzar.com/url/), SaveMedia (http://savemedia.com) or other online web sites, videos can be easily downloaded for free (only internet connection is required). This website is widely used by researchers and operators in the heritage conservation field as well as by tourists and visitors. It is an important online and free accessible database where it is possible to find videos documenting heritage sites..	https://en.wikipedia.org/wiki/YouTube
Tumblr	It is a microblogging platform and social networking website. The service allows users to post multimedia and other content to a short-form blog. Users can follow other users' blogs, as well as make their blogs private. In 2015, Tumblr hosed over 261 million blogs.	The blogs provide an effective online open platform to share and collect videos related to heritage sites. Nevertheless, currently most of the videos' topics are not related to cultural heritage.	https://www.tumblr.com/ https://en.wikipedia.org/wiki/Tumblr
Phanfare	Phanfare is a popular website, boasting top notch features supporting HD video up to 20 minutes in length. Phanfare websites include full-screen slideshows. Videos can be uploaded both from the computer and from mobile devices (tablet, mobile). The website has a fee charge.	Relevant to share videos on Facebook and Twitter (website interoperability). This website has got some potential as videos repository that can be used to gain videos of heritage sites.	http://www.phanfare.com/home.aspx
Dailymotion	Dailymotion is a French video-sharing website on which users can upload, watch and share videos. It is one of the biggest video platforms in the world, offering a mix of content from users, independent creators and premium partners. It is available all around the world, in 18 different languages.	Its repository might be hosting videos related to heritage assets. These videos could be extracted and used for documentation uses, studies, analyses and digital reconstructions.	http://www.dailymotion.com/ca-en https://en.wikipedia.org/wiki/Dailymotion
Vimeo	Vimeo is a video-sharing website in which users can upload, share and view videos. It supports high definition playback in 1280×720 (720p), supporting consumer HD.	It is an important online and free accessible database where it is possible to find high definition videos documenting heritage sites before their destruction or damage.	https://en.wikipedia.org/wiki/Vimeo https://vimeo.com/

These analyses are relevant for the research that proposes a flexible documentation-design system able to integrate conventional principles of preservation of tangible heritage and the intangible knowledge embedded in historic structures that is needed for its maintenance in order to respect cultural diversity within the framework of a more comprehensive and inclusive heritage conservation. In addressing this aim, part of the information gathering process is based on bottom-up strategies[7] in order to improve heritage engagement and stimulate active involvement and interest by local actors. This approach is deeply influenced by Mia Ridge's argument who claimed that, *"[...] crowdsourcing in cultural heritage is more than a framework for creating content [...]"* and it is *"[...] a form of engagement with the collections and research of memory institutions, it benefits both audiences and institutions"* (Ridge, 2014), p.2. In line with Mia Ridge's approach, one of the challenges of the research consists in the identification/definition of the "crowd" participants in built heritage crowdsourcing initiatives[8].

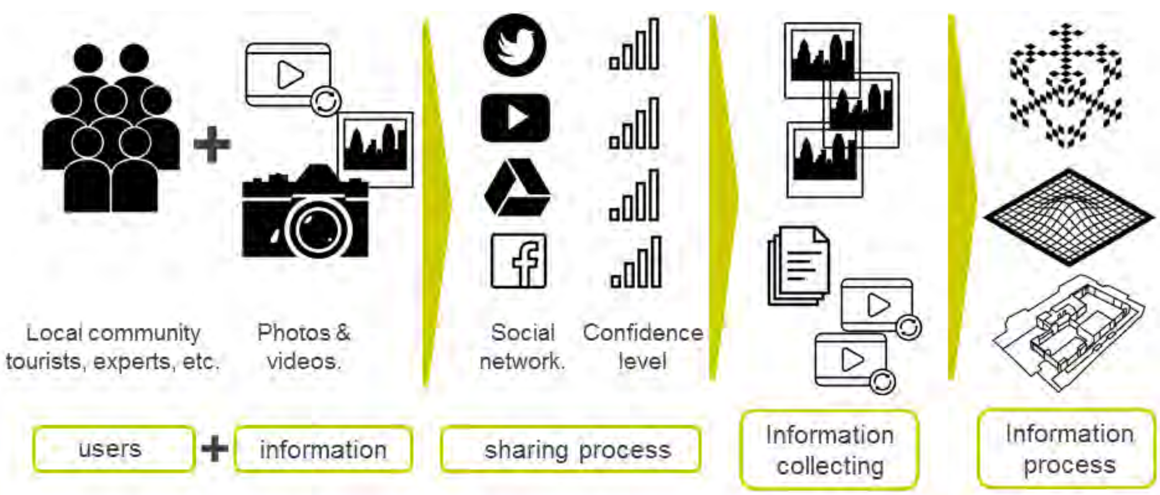

Figure 2 Diagram showing how crowdsourcing and information sharing can support digital heritage documentation. Image source: Author.

[7] As mentioned in Chapter 7, the research carried out on the field analysis in a bottom-up logic. Possible crowdsourcing initiatives and strategies to gain similar information through web supported application is only outlined in Chapter 8.

[8] On this regard Mia Ridge analyses this issue starting from a semantic perspective reflecting on different terms used instead of crowd, defining how "*While 'crowdsourcing' is a useful shorthand, many projects and writers have used other terms for 'crowd' participants, such as 'community-sourcing' [...] 'targeted crowdsourcing' [...], or 'micro-volunteering' acknowledging that often the crowd is neither large nor truly anonymous, but perhaps also reflecting discomfort with the broadness, anonymity or vagueness of 'the crowd'* (Ridge, 2014), p.4.

In this identification process, some challenges should be considered. As Michael Lascarides and Ben Vershbow report, Clay Shirky warn about the increasing difficulties of attracting and sustaining participation obtained through the web network.

Figure 3 Image illustrating the increasing diffusion of social network and sharing web platform. Image source: Author.

Indeed, he claims that due to the decreasing costs of participation networks - let's think about the social networks (Buffer, Hootsuite, Instagram, LinkedIn, Facebook, Blab, Tuenti, Twitter, Google+**,** Meerkat**,** etc.,) and web sharing platforms (Tumblr, YouTube, Vimeo, Flickr, Blogger, XING, MySpace, Vox, Xanga, Ning, etc.,) – there is an increasing *"[...]difficulty of attracting participation (and then sustaining it when you have it) [...]"*(Ridge, 2014) p. 115.

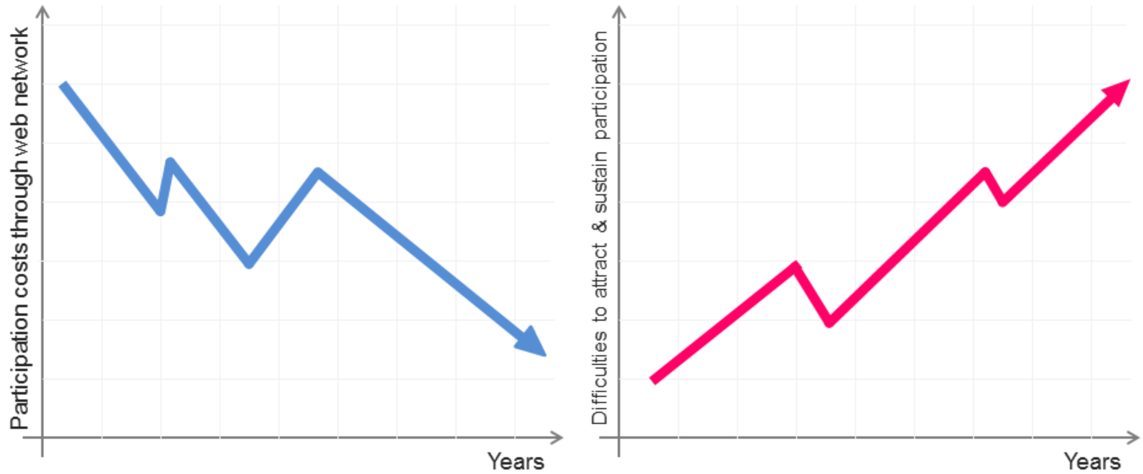

Figure 4 Images illustrating the concept expressed by Clay Shirky, outlining the increasing difficulty of involving and attracting continuous participation through the web, despite the decreasing cost of web networks. Image source: Author.

Hence, in a participative documentation logic, the question: *"How to be creative with user engagement?"* should be addressed.

Consequently, the following questions arise:

How to keep participants/users interested, motivated and rewarded?

What are the factors that determine the success of a crowdsourcing application?

These issues are debated in Chapter 8 *Combined uses of BIM systems and Wiki approaches tocollect and archive quantitative and qualitative information*, paragraph 8.3 *Outlined approach to develop a WikiBIM*, and paragraph 8.3.1 *Design of the Wiki component of a BIM model*.

5.3 Participatory documentation: democratization analysis of the proposed approach

According to the World Bank 2016 World Development report, "*Inclusion, efficiency, innovation [...] are the main mechanisms for digital technologies to promote development". p.2

The pace of innovation and its diffusion in everyday life is rapidly changing the concern on the democratic nature of digital technologies and on the *"ways in which information can be accessed"* (Chong, Gaffney, & Chapman, 2013) p. 358.

On this Chong reports that Goldsmith noticed how the "*developments have meant that digital technologies are much more widely accessible and are increasingly being used by non-digital specialists and the increasing issues about who owns what digitally now permeate the creative sector and implicate governments as they seek to control the Net (Goldsmith et al. 2007)*."(Chong et al., 2013), p.358.

Digital technologies—including but not limited to internet, mobile devices, web platforms and other tools able to collect, store, analyze, and share information digitally—are spreading quickly.

For instance, even in developing countries, the number of owners of mobile communication devices (including smartphones) is increasing. The World Bank reports that nearly *"70% of the bottom fifth of the population in developing countries own a mobile phone"* (World Bank Group, 2016), p.2 despite their lack of other basic infrastructure i.e. no access to clean water or electricity. This trend is confirmed by the evaluation of the number of internet users, that increased from 1 billion in 2005 to an estimated 3.2 billion at the end of 2015, i.e. in less than a decade (World Bank Group, 2016), p.2.

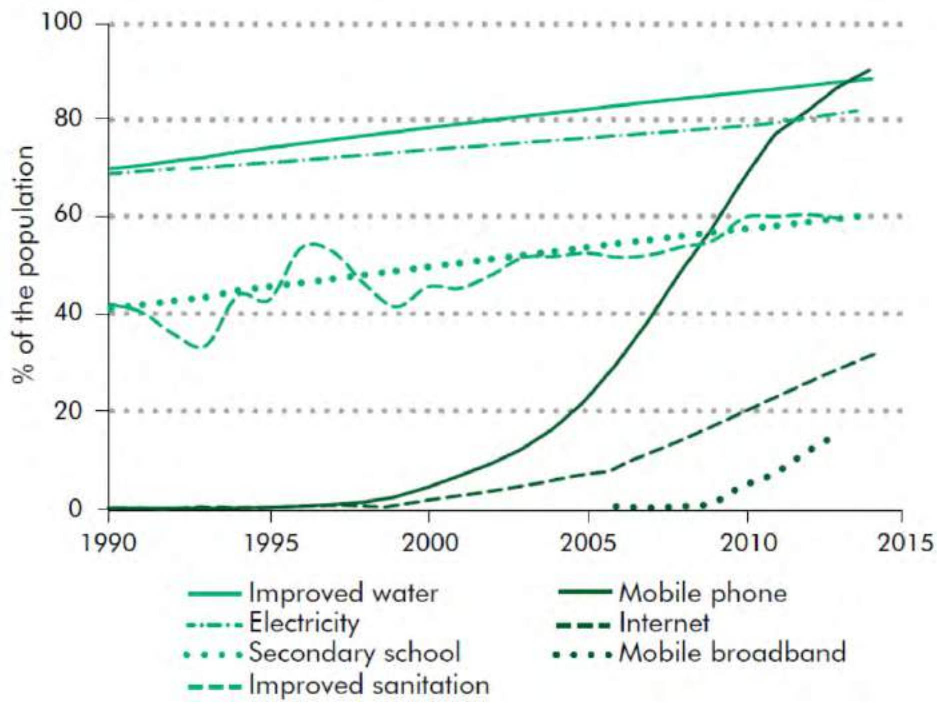

Figure 5 Diagram evidencing the rapid spread of digital technologies in developing countries in comparison with the growth of other basic services such as water supply, education and sanitary services (World Bank Group, 2016), p. 6.

Nevertheless, a significant digital divide remains. Around 60% of the global population is still offline (World Bank Group, 2016), p.2. According to the World Bank statistics, a digital divide persists[9] between and within countries in relation to access infrastructure, devices costs and users' capability. Just to mention the results of some assessments, 6 billion of people are without broadband, 4 billion without internet, 2 billion without mobile phones and 0.4 people are with no digital signal (World Bank Group, 2016).

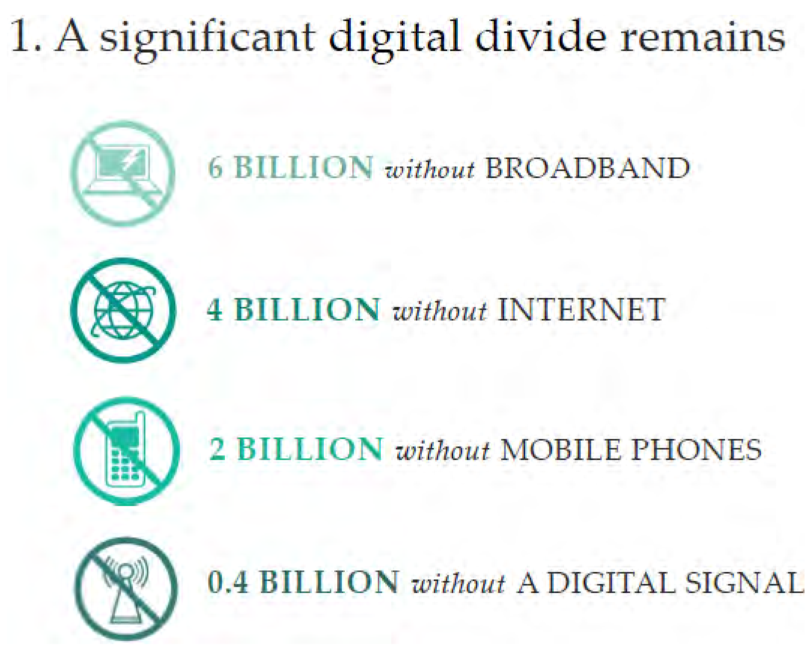

Figure 6 The image reports some of the factors that significantly affect the digital divide (World Bank Group, 2016).

Considering the global population, only 15% can afford access to broadband internet, while mobile phones reach almost 4/5 of the world population, providing the main form of internet access in developing countries. Nevertheless, nearly 2 billion people do not have a mobile phone, and about 60% of the world's population has no access to internet while only 1.1 billion people have high-speed internet broadband[10] (World Bank Group, 2016).

Despite digital technologies have boosted growth and expanded development opportunities, their impact is unevenly distributed and, in some cases, is associated with emerging risks. For example, in advanced economies, technological innovation promotes higher skills while replacing routine jobs, forcing many workers to compete for low-

[10] High-speed internet broadband includes the total number of fixed-line broadband subscriptions, such as DSL (digital subscriber line), cable modems, fiber optics, and the total number of 4G (fourth generation) / LTE (Long Term Evolution) mobile subscriptions, minus a correcting factor to allow for those who have both types of access (World Bank Group, 2016).

paying jobs, thus increasingly contributing to polarized labor markets and rising inequality (World Bank Group, 2016).

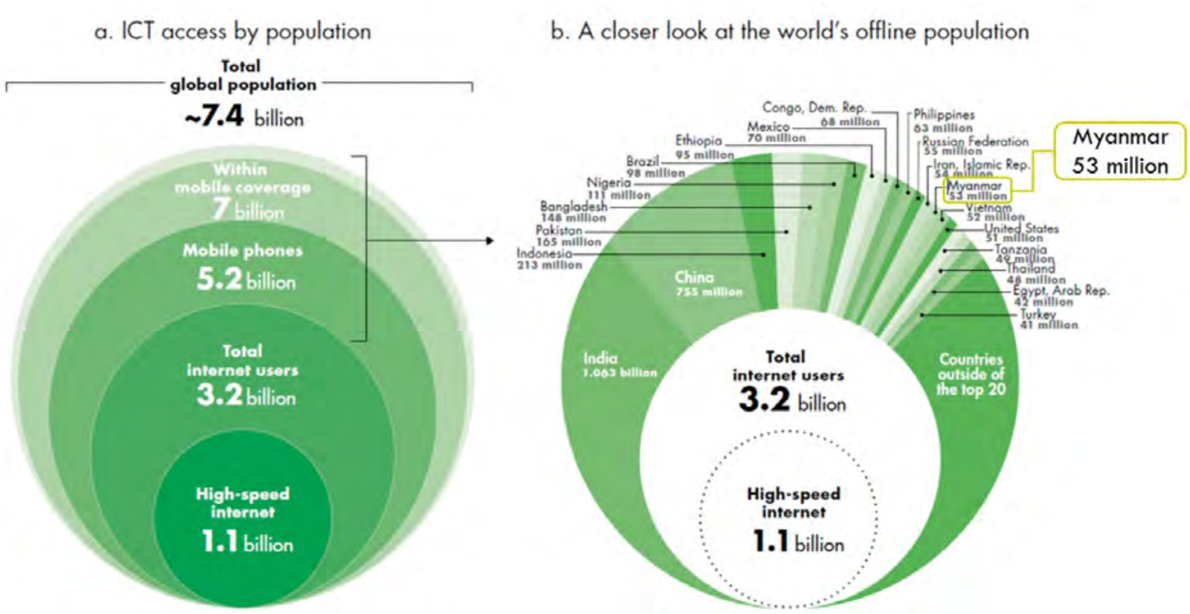

Figure 7 Diagram illustrating the ICT access by the global population. The diagram presents also a focus on the world's offline population that include also Myanmar people. Image source: World Bank (World Bank Group, 2016), p.8.

Further, the World Bank warns how the economics of the internet favors natural monopolies. Indeed the absence of a competitive business environment can result in more concentrated markets where the main benefits are circumscribed to better connected, knowledgeable and more skilled users (intended also as firms) that receive most of the benefits. As a direct consequence, this trend circumscribes democratic advantages from the digital revolution to elite groups (World Bank Group, 2016).

Democracy and participation in Cultural Heritage conservation

The aim of developing democratic approaches in Cultural Heritage actions grounds its legitimacy and inspiration in the Italian Code for the Cultural Heritage assets and

Landscape (Codice dei beni culturali e del paesaggio, D.Lgs. 42, 2004). Article 6 of the Code states that the public use of heritage assets aims *"[…] to promote the knowledge of cultural heritage and to ensure the best conditions of utlization and public fruition of the heritage (promuovere la conoscenza del patrimonio culturale e ad assicurare le migliori condizioni di utilizzazione e fruizione pubblica del patrimonio)."*[11] It also stresses the importance of public participation in conservation and promotion actions, as "*[…] it supports the participation of private stakeholders, both individual and associated actors, for the enhancement of cultural heritage (sostiene la partecipazione dei soggetti privati, singoli o associati, alla valorizzazione del patrimonio culturale)."*[12]

In the international context, the World Development Report, of the World Bank, notes that digital technologies are transforming different fields including business, people's live and government. Nevertheless, there is a significant digital divide depending on multiple aspects such as availability of internet connection, cost and availability of mobile devices, broadband and low or not existing digital signal (World Bank Group, 2016). To fill this gap existing also in the cultural heritage field, digital technologies can play a key role in:

- Inclusive strategies and workflows;
- Innovation in terms of approaches and solutions employed to reduce digital divide for more inclusive conservation actions.

[11] Art. 6 Comma 1. Decreto Legislativo 22 gennaio 2004, n. 42. Codice dei beni culturali e del paesaggio, ai sensi dell'articolo 10 Legge 6 luglio 2002, n. 137

[12] Art. 6 Comma 3. Decreto Legislativo 22 gennaio 2004, n. 42. Codice dei beni culturali e del paesaggio, ai sensi dell'articolo 10 Legge 6 luglio 2002, n. 137

The considerations developed in this paragraph are significant in setting up IT and web supported crowdsourcing initiatives and bottom-up strategies to gather information on historic structures. Considerations and reflections addressed in this paragraph, focusing on the diffusion of IT and web technologies, on their uses and impacts, are preparatory to the paragraphs 8.3 *Outlined approach to develop a WikiBIM* and 8.3.1 *Design of the Wiki component of a BIM model.*

5.4 Challenges of BIM parametric modelling for built structures: LoD, model usability and effectiveness

Limits of the BIM applied to built heritage sites

As evidenced by S. Logothetis, A. Delinasiou and E. Stylianidis, BIM applications in the Cultural Heritage field is an ongoing significant topic *"involving different characteristics including principles, technology, even privacy rights for the cultural heritage objects"* (Logothetis, Delinasiou, & Stylianidis, 2015), p.177.

Experts in the field of Cultural heritage documentation noticed that the employment of BIM systems in cultural heritage field needs to be adapted to the heterogeneity of shapes and irregularities of forms that characterize built heritage structures (Osello & Rinaudo, 2016). According to Anna Osello and Fulvio Rinaudo, BIM systems employed for Built Heritage structures should present additional features than BIM systems applied to new design projects. The authors grouped these required additional features into six main areas:

1. Favoring collaboration and interaction between heritage specialists operators and BIM users;
2. Offering accurate information supporting conservation and maintenance actions;
3. Providing archival standards that can be updated offering a consultation tool that would last over time;
4. Building up data collection;
5. Being easy to use (user-friendly);
6. Being low cost in order to facilitate its application in the cultural heritage field, characterized by a scarcity of economic resources and funds. (Osello & Rinaudo, 2016), p.119

In terms of modelling existing built structure, additional problems arise. The parametric nature of BIM software scarcely works with the irregular shape and complex geometry of existing structures.

As evidenced by Logothetis, Delinasiou and Stylianidis built heritage architectural components are more complex that new ones and their "*geometry and characteristics are not representative for typical software libraries"* (Logothetis et al., 2015), p.179.

To provide possible solutions to this issue, Maurice Murphy[13] proposes a Historic Building Information Modelling (HBIM) with libraries of parametric objects of architectural components (doors, columns, windows, walls, etc.,) developed from direct

[13] Dr. Maurice Murphy, is a lecturer and researcher in built heritage documentation and computer graphics in the new School of Surveying in the College of Engineering and Built Environment at the Dublin Institute of Technology (DIT). At the he DIT, he leads a research group specialized in the application of new technology for digital surveying and modelling of historic buildings and environments in order to support the conservation of these heritage assets. He is currently lead supervisor for Ph.D. and M.Phil. students. In the last three decades he developed a high experienced profile in building surveying and conservation. He also led and participated in several EU programs in the area of Cultural Heritage. He completed his Ph.D. in 2012 at the Department of Civil, Structural & Environmental Engineering, School of Engineering at the Trinity College Dublin. He worked as a consultant to National Monuments (OPW) for a number of years developing new technology based education and training programs for architectural heritage conservation. Murphy has several publications in the areas of heritage documentation (Academia.edu, n.d.).

surveys developed through manual or digital supported techniques, historic manuals, archives drawings, etc.

Consequently, this opens up to several reflections on the Level of Detail (LoD) of BIM libraries and of BIM models in general, to define the parameters of the different level of accuracy and precision of a model depending on its purpose and use.

The LoD can "*be thought of as a combination of the detail (the graphical content) and the information (the non-graphical content)*" (Construction Code, 2013). According to the PAS 1192-2:2013[14], the level of detail (LoD) of a model consists in the "*description of graphical content*"[15]. The same document defines also the Levels of model Information (LoI) associated to a model at different stages alongside the documentation.

The legislation on this topic is still ongoing due to the huge development of BIM in AEC sector and, more recently, also in the built heritage field. Italy is currently developing regulations on the LoD for BIM in existing historic structures.

So far, five main levels of detail have been identified. They include LoD 100, LoD 200, LoD 300, LoD 400, and LoD 500 (Building Design+Construction, n.d.).

According to the American Institute of Architects (AIA), the LoD framework defines the following model element content requirements:

[14] The acronym stands for Public Available Specification, these are the emerging standards rapidly developed for immediate industry needs.. In the specific case of PAS 1192-2:2013 it developed to support BIM adoption in the United Kingdom. It provides a consistent industry wide framework for collaborative working and information management in BIM. PAS 1192-2:2013 focuses on information originated, exchanged or managed in a BIM format. The relevance of this document consists in avoiding confusing, unnecessary, poorly co-ordinated, difficult to find and not structured information (particularly useful considering how this responsible of unnecessary additional capital delivery costs amounting to 20-25%). Information clarity would instead allow projects efficiency wit consequent cost and time savings. Henceforth, the PAS 1192-2:2013 deals with the project delivery phase recognizing information increasing with the project development period it establish a framework to enable users to employ and actively use this information. This approach intend BIM as a process not just as a 3D modelling (B1M, n.d.).

[15] A.77 levels of model detail (LOD)(B1M, n.d.).

- LoD 100: The Model Element may be graphically represented in the Model with a symbol or other generic representation, but does not satisfy the requirements for LOD 200.
- LoD 200: The Model Element is graphically represented within the Model as a generic system, object, or assembly with approximate quantities, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
- LoD 300: The Model Element is graphically represented within the Model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Non-graphic information may also be attached to the Model Element.
- LoD 400: The Model Element is graphically represented within the Model as a specific system, object or assembly in terms of size, shape, location, quantity, and orientation with detailing, fabrication, assembly, and installation information. Non-graphic information may also be attached to the Model Element.
- LoD 500 the Model Element is a field verified representation in terms of size, shape, location, quantity, and orientation. Non-graphic information may also be attached to the Model Elements (Designing Buildings Ltd. 2017, 2016).

The AIA has also published a LOD framework for the AIA G202-2013 Building Information Modelling Protocol Form. Here LOD refers to the 'Level of Development' required for model element content. The term 'level of development' is used rather than 'level of detail' in recognition of the fact that a visually very detailed element might, in fact, be generic and despite appearances might be at a low level of design development.

Steel Framing Columns

100	See B10	
200	See B1010 (00)	
300	Specific element modeling to include: • Specific sizes of main vertical structural members modeled per defined structural grid with correct orientation. • Structural steel materials defined in specification's. • Typical connection details in 2D	
350	Actual element modeling to include but not limited to information needed for cross trade collaboration such as: • Actual elevations and location of member connections • Large elements of typical connections applied to all structural steel connections such as base plates, gusset plates, anchor rods, ect. • Any miscellaneous steel members with correct orientation • Any steel structure reinforcement such as web stiffeners, sleeve penetrations, ect.	
400	Fabrication element modeling to include but not limited to: • Welds • Coping of members • Cap pates • Washers, nuts, etc. • All assembly elements This element level modeling shall include all information needed to fully define the fabrication and installation of the element. Additional non-modeled information may be included into the element.	

Figure 8 Example of LOD for Steel Framing Columns. Image source: BIMForum website (BIM Forum, 2013), (Construction Code, 2013).

The AIA suggests that the LOD framework recognizes that different elements of the project will develop at different rates and "*[…] allows the Project Participants to efficiently communicate to one another the extent to which a Model Element has been developed […]. It also allows the Project Participants to communicate the extent to which a Model element may be used and relied on […]"* (Designing Buildings Ltd. 2017, 2016).

Different standards have been established and adopted by different states. In particular United States, Australia and United Kingdom so far have been the most active in developing norms and standards to regulate the use of BIM in AEC sector. The same standards are currently used also for built structures which present different characteristics and problems.

After this overview of the current debate and state of the art on LOD in BIM modelling, some considerations can be developed. LoDs do not have yet a shared graphical representation associated with each level of detail neither detailed instructions on how to employ LoD according to the final outcome[16] of a project and to the object to be modelled (i.e. new or existing structure) (Building Design+Construction, n.d.). This is particularly relevant in order to effectively manage different requirements, to deal with contractors and subcontractors (Building Design+Construction, n.d.), design firms as well as to work in multidisciplinary teams (i.e. in conservation projects with heritage specialists dealing with fine details as well as structural and architectural aspects).

The definition of these parameters is important in order to enable all the project stakeholders to use and manage the BIM model making it an effectively collaborative tool (Building Design+Construction, n.d.).

This brought about many issues related to the 'best' or more useful level of detail LoD in modelling historic structures in a BIM environment. Since this research is still ongoing, in Chapter 8 approaches and solutions facing the issue of standard LoD in BIM applied to a historic Myanmar temple have been tested and illustrated.

[16] In 2013, AIA published the *AIA G202-2013 Project Building Information Modeling Protocol Form*. Even if the document provides useful information on each level of detail, it does not provide specifications on the information required for each level (Building Design+Construction, n.d.).

As reported in Chapter 8, challenges and limits of the BIM applied to existing historic structures can be grouped as follow:

- Challenges in maintaining the survey accuracy in the 3D modeling;
- Cost and Time of the 3D modeling and semantic characterization;
- BIM model usability and accessibility by different project stakeholders;
- Compatibility issues in terms of files and formats;
- Time and relative costs required to parametrize each peculiar element of a building (i.e. walls structures, doors, stupas, windows, roofs, terraces, etc.).

Nevertheless, the choice of employing a BIM system to support a conservation project from the documentation to the design and dissemination phase, relies on its opportunities in terms of information management.

As noted by the Canada BIM council website, *"BIM is a shared knowledge resource […] forming a reliable basis for decision […]"*(Canada BIM Council, n.d.). Hence, the attention of the epistemic object also focuses on the potentials of BIM as a database of embedded knowledge of built heritage structures.

Reflecting on the parameters of the LoD, some considerations can be developed.

Current recording techniques (laser scanning, photogrammetry, EDM, etc.) enable to reach a level of detail "as built", or almost. Nevertheless, the same level of detail cannot be reached for the inner structure of a recorded building. Investigation of the inner structure can be developed according to the budget of the project due to their expensive and time-consuming nature. These include, among the others, thermography, sonor methods, electromagnetic investigations, Xgraphia, radar, etc. Further, these analyses are usually employed only on selected portion of a building.

Hence, how is it possible to guarantee a consistent LoD among interior and exterior surfaces of a building and its inner core?

These aspects should be considered in order to give to a BIM model, which development is time and cost consuming, effectiveness and usability for the different project phases and for all the project' stakeholders.

Indeed, in the case of brick masonry structures - that can be found from Bagan monuments to the European and Italian context - how can we know the bricks' assembly techniques of a wall? How can we know the stratification (layering), inconsistency and, more generally, constructive techniques (i.e. bricks disposal on the exterior side – materials in the inner core – bricks disposal in the interior side) of a wall structure?

The relevance of an in-depth knowledge of the inner structure of a brick masonry is useful for the following reasons:

1) To plan conservation, repair or maintenance intervention;
2) To the economic management of the (conservation) project.

Indeed, to calculate the cost of an intervention, deploying BIM semantic properties, it is important to have a detailed description also of the inner structure. For instance, information on a wall should include its inner composition, intended as brick assembly and construction components used in the different wall layers. This is useful to reduce errors in the costs estimations of the material to be replaced or of the volumes of a wall to be restored with different techniques (i.e. '*cuci-scuci*' sew up-un-sew up).

These considerations have little influence in the case of a small size building, while their relevance increases exponentially in the case of big size buildings such as basilicas, cathedrals, temples, huge public buildings (i.e. libraries, train stations, postal offices, hospitals, etc.) or palaces and more general architectural-monumental complexes.

Therefore, a theoretical approach recalling the theories of the *bauforschung*, of the *storia operante* (working history) and of the intangible knowledge associated with historic building construction, becomes relevant in the definition of the role of BIM applied to built structures. A BIM model with these characteristics become efficient in the design, planning and management phases of conservation interventions.

Consequently, the previously mentioned rigid standardization of LoD, not considering these aspects in the case of BIM applied to historic structures, appears questionable and inconsistent. This becomes evident in the case of standardized LoD of buildings' shapes not corresponding to the LoD of the interior structures and material conformation.

PART III IMPLEMENTATION OF THE RESEARCH APPROACH

This section introduces the case study of the living religious site of Bagan, explaining the motivations of this choice due to several criteria.

Firstly, the richness of intangible aspects associated with the tangible dimensions of built heritage. The presence and variety of historical monuments in Bagan makes even more meaningful the proposed idea of an open-source approach to built heritage conservation based on the active participation of local actors.

Secondly, the limited availability of recorded archives providing a solid body of analysis and evidence useful for conservation purposes. In the case of Bagan, the lack of, and gaps in, such information and documentation represents a serious challenge to the preservation of built heritage.

Thirdly, the incidence of important macro-level threats that jeopardize the preservation of built heritage, like the impact of globalization and its challenges in terms of sustainability of the social and economic development of the site. Such threats are increasingly affecting Bagan and make the proposed experimental approach particularly relevant in view of the challenges faced by the site, such as its increasing globalization, and extend the scope of the proposed approach from the architectural to the urban scale.

Fourthly, the vulnerability to natural disasters that provide additional challenges to effective conservation strategies. Bagan is located in an area highly vulnerable to earthquakes. In fact, a strong earthquake hit the site during the fieldwork carried out for the completion of this research (the Chauk earthquake that hit Myanmar in August 24, 2016).

Fifthly, the ‘living’ features of built heritage that constitute an important condition for the mobilization of local traditional expertise for conservation activities. The built heritage of Bagan is fully integrated within its historical, cultural and socio-economic context.

All the above criteria are met in the case of Bagan, which is assessed in Chapter 6 and 7. This analysis provides a solid basis for an increased awareness of the multiple aspects of the site and for encouraging the use of local skills and resources.

Additionally, the case study of the research, outside of the Euro-American tradition (Crouch & Johnson, 2001), identified different local perspectives in living, using, building and maintaining historic Bagan architecture. With a specific focus on religious Buddhist architecture, factors shaping the construction and the conservation of Bagan built heritage - such as availability of building materials, traditional skills, construction solutions, social issues, religious aspects, but also climate conditions, natural hazards, and human pressures - are considered.

This approach is in line with a consolidated trend in the architectural field, aiming at broadening the architecture research boundaries[1]. The idea incorporating knowledge and methods from different disciplines is aimed at a comprehensive ‘knowledge project’ to provide a solid basis to understand the sophisticated and intertwined set of values and meanings of layered Bagan architectures. This has the final goal of potentatially orient informed and compatible actions. In this process, the research also stresses the role of intangible aspects that determines the cultural and technical values of historic

[1] For instance, Dora P. Crouch and June G. Johnson reported that “[…] the focus of architectural literature is broadening; a more diversified agenda is now enhancing the former emphasis on formal charactristics.” (Crouch & Johnson, 2001), p. 376.

architectures, essentials for a full understanding of built heritage, its form and its reasons to be conserved.

Figure 1 View of 'living' site of Bagan. Image source: Author.

Different recording strategies are then presented. They capture the key elements of the tangible dimensions of the site, including shape, geometry, color, conditions and character defining elements of the selected temple. In Chapter 7 and 8 different strategies to document its intangible aspects, intended as technical knowledge and skills as well as meanings and values associated with the temple, are illustrated. Methods including conventional direct and indirect research, such as the Rapid Ethnographic Assessment Procedures (REAP), are tested and alternative approaches employing social media and digital platforms are proposed. The collected information is subsequently organized in a geometric-semantic database based on a BIM architecture employing the AutodeskRevit software, by highlighting uses and goals of the designed participative BIM model.

The Conclusion addresses opportunities and challenges of the proposed approach, called WikiBIM, by paying particular attention to its flexibility and replicability, benefits in different scenarios and limits considering several aspects, such as economic constraints, training, software compatibility, usability, data longevity and data exchange.

Finally, concluding remarks focus on the opportunities of integrated digital documentation for inclusive and participatory conservation, by taking into account users' engagement and the key role of IT-supported solutions. Furthermore, the long-term advantages of the proposed approach are explored by considering local development impacts as well as authenticity preservation issues.

6 Chapter: The living religious heritage site of Bagan, Myanmar

The Living Heritage Approach developed by ICCROM stresses the concept of ‘living’ heritage for the conservation and management of heritage sites. This approach highlights the tangible aspects as well as the role played by the local communities that live and work in contact with these sites.

Due to the richness and importance throughout history of its individual monuments, its dynamic social and economic settings and its resident local community, Bagan can categorized as living cultural heritage site. In an area characterized by more than 2,000 monuments, local communities retain religious, social and cultural continuity from the past. The site is perceived and described in most official sources as a harmonious whole. For this reason the living religious heritage site of Bagan has been selected as a representative case study to explain and test the proposed approach.

Another feature of the living site of Bagan, which makes it relevant for the present research, consists in the continued presence of local communities throughout the centuries in spite of the natural and human hazards that affect the region until the present days. The area is vulnerable to earthquakes. The most recent seismic event was the powerful 6.8-magnitude earthquake of August 24, 2016 that hit central Myanmar (Holmes, 2016).

Figure 2 Examples of working activities in the Bagan area. People working in a lacquerware (top left); fishermen boats in the Ayeyarwady river (bottom left); elderly woman cultivating her vegetable garden (right). Image source: Author.

Figure 3 Local boys playing soccer next to historic buildings exemplify the 'living' nature of the site of Bagan. Image source: Author.

Figure 4 Panoramic view of the Bagan plain. Source: Scott Lee.

Indeed, even if after the XIII and XIV century constructions in the site slowed down (due to several historical and political circumstances, such as the Mongols invasions and the shift of the capital from Bagan to Mandalay), albeit at a slower pace, Bagan continued to develop (Stadtner, 2013). As a matter of fact, Stander reports that between the XV and the XX century about 200 monuments were constructed (Stadtner, 2013), p. 54.

6.1 Geographic and territorial framework

Myanmar is one of the most diverse geographical and cultural landscapes in the world. Situated in South-East Asia, the country has a surface of 676 578 sq. km (UNDP, n.d.) and is marked by several geographical regions that range from the snowy mountains in the north to the central desert-like dry zone. It also includes wet areas surrounded by the sea in the southern part. Bagan is located at a latitude of 21° 10’ 44’’ North and a longitude of 94° 52’ 29” East (CyArk, n.d.-b). Its altitude is 174m (570 ft) from the sea level (“Elevation map,” n.d.).

Due to its geographic location, between the Equator (0°) and the tropic of Cancer (23°27’), Bagan presents a typical subequatorial climate with constantly high temperatures all year, marked by hot, dry and sunny winters and springs and heavy rains in the fall and summer. In terms of precipitations, maximum rainfall is usually 135 mm in September and less than 10 mm in other months. Average temperature is 32°C in May and around 25°C in others. The table below shows the average yearly temperatures and rainfall levels in Bagan. This data are relevant to the present study as they allow to understand not only the impact of local weather patterns on vegetation and agriculture, but also their potential threat they pose to Bagan built structures.

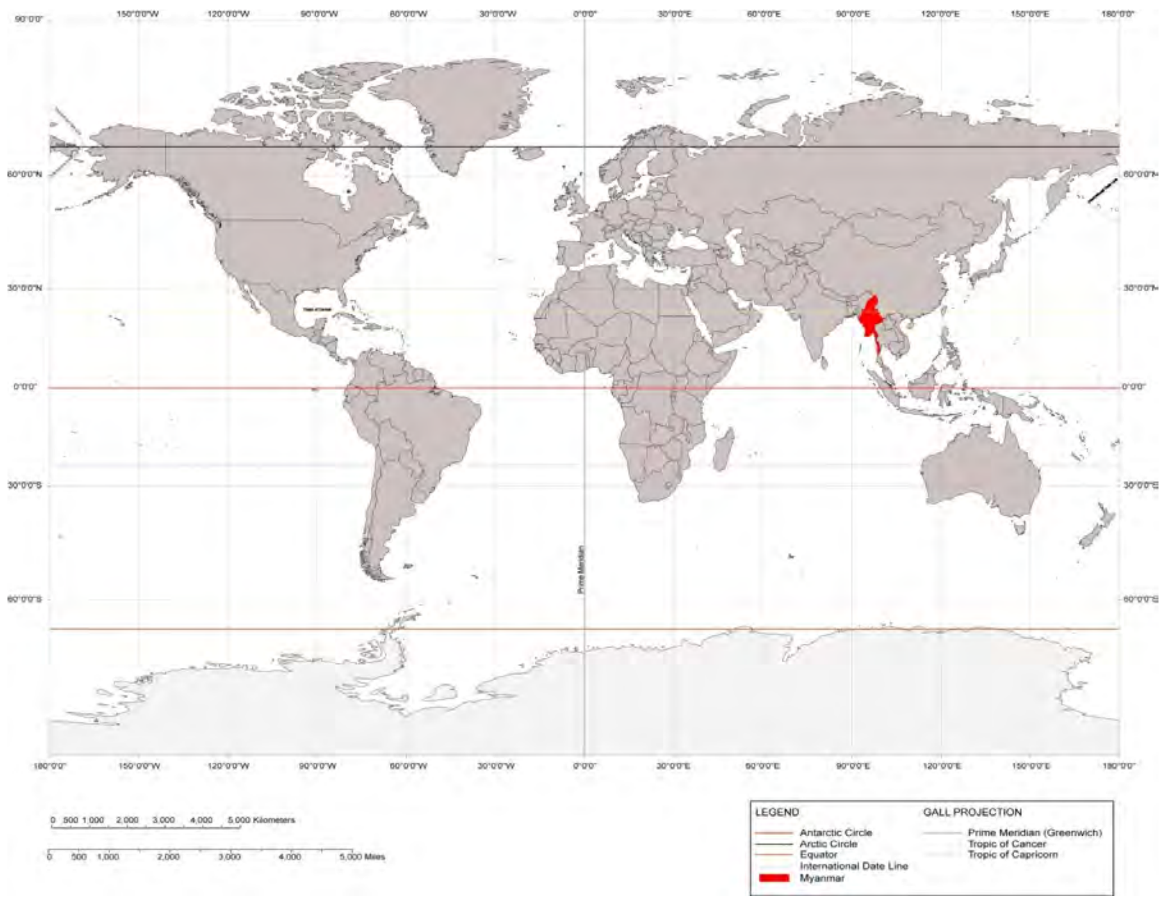

Figure 5 Geographic location of Myanmar. Image source: Author.

These considerations become particularly evident because in the past brick masonry joints were done in mud and coated with plaster. The coating, which played a protective and decorative function, has been in many cases damaged if not totally collapsed. Therefore, the impact of average volumes and patterns of rainfall becomes even more significant, considering the vulnerabilities of Bagan historic structures[2].

Table 1 Annual Temperature and Rainfall Level in Bagan. Adapted from the Urban Planning report for Bagan Nyaung-U, Ministry of Construction, Myanmar (Ministry of Construction Myanmar, 2014).

[2] Evidence of this problem has been first-hand tested by the author, who witnessed the collapse of two monuments (a monastery and a complex of two temples) in November 2016, during the heavy rains that characterize the fall season. In both cases, collapse was caused by the loss of resistance of the mud mortar that weakened the structures. This was confirmed by Vittorio Gallinaro, UNESCO structural engineer met on the site.

YEAR	AVERAGE RAINFALL LEVEL		AVERAGE TEMPERATURE (°C)	
	Days	Total level (inch)	Highest	Lowest
2008	40	26.34	44.5	10.6
2009	38	13.49	44.3	10.2
2010	42	32.66	45.2	10.4
2011	48	40.34	40.8	11.0
2012	34	18.15	44.3	10.6

The Bagan area is featured by dry zone and scrub and deciduous forests. In terms of agriculture, the main production is dry cultivated crops. Agriculture is one of the main economic sectors in Bagan and sesame, cereals, cotton, beans and nuts are usually produced without the use of mechanized techniques. In the dry season, temporary cultivation fields appear on the river bank (Latt, 2016). Bagan vegetation is characterized by bushes and shrubs[3]. Forests count more than eighty species of trees, including but not limited to tamarind, palm, coconut, acacia and neem[4].

One of the prominent geographical features of Myanmar is the seismic zoning of the country with a particular focus on Bagan. The site is indeed situated in an active seismic zone labeled as Zone of high damage.

In fact, Myanmar forms part of the so-called trans-Asiatic seismic zone stretching from Spain, Italy, Turkey and Iran to Asia on the one hand towards the north (Pamir) and on the other towards the south east (Myanmar and Indonesia).

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[3] It is also worth to mention that planting of trees is intended as a religious merit. As reported by Khin Maung Nyunt, several inscriptions record that the planting (mainly of Kokko and banyan trees, mango trees and other fruit-bearing trees for birds and animals) was associated to gain religious merit. Indeed, it is believed that the religious merit gained from planting a tree is equivalent to the merit gained from building a monastery, a temple or a resthouse (Khin Maung Nyunt 1996).

[4] Today's sparse vegetation is the result of anthropic pressure. Indeed, since the late XIX century steamers were introduced to ply along Ayeyarwady River. In the English colonial period, trees on the river banks were cut down for fuel. Furthermore, with the diffusion of steam engine-run boats, deforestation speeded up resulting in the complete clearance of vegetation in the whole dry zone area. Then, population pressure has also been a cause of the deforestation of Bagan area (Khin Maung Nyunt 1996). Timber extraction for the use of fuel wood is still evident, especially around the settlement. Currently, the extraction is regulated and allowed only within the settlement, since timber is the only source of fuel for the local community (Bagan Master Plan Team 1995).

More than four hundred major earthquakes have been recorded in Myanmar between 1904 and 1975, categorized as extremely strong (between 7.7 and 8.5 on Richter scale), strong (13 events between 7 and 7.5 Richter scale) and average (17 events between 6 and 7 on Richter scale).

Figure 6 Map of global seismic activity as of 2014. The map is based on data compiled by the U.S. NOAA National Geophysical Data Center. It includes all earthquakes with a magnitude above or equal to 6.0 on the Richter scale over the past 40 years. Image source: CBC new (CBC news, 2014).

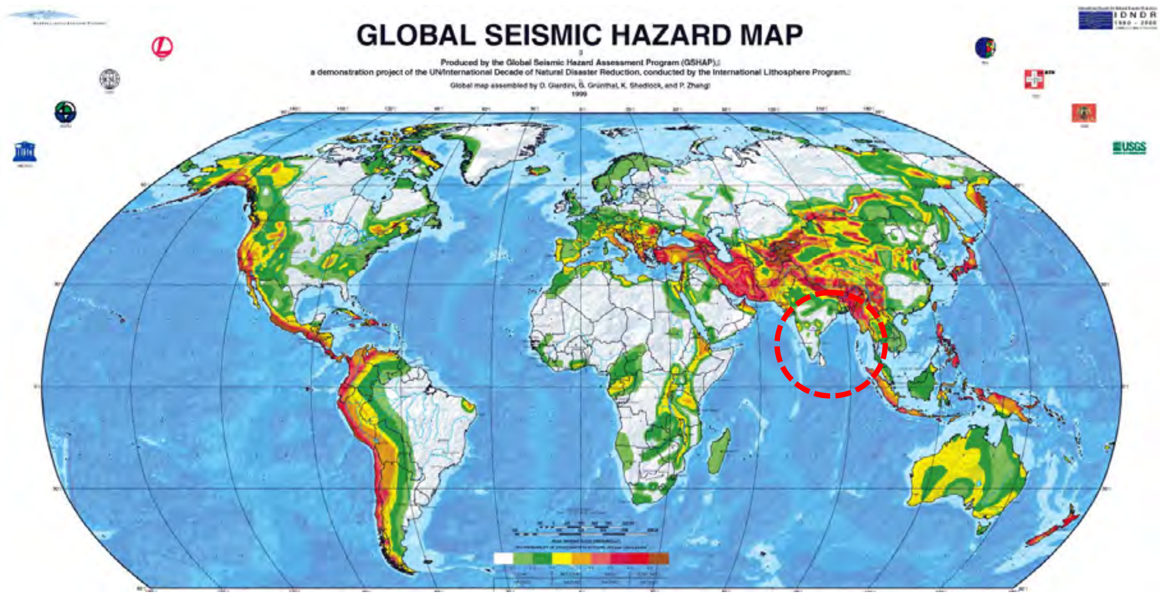

Figure 7 Global seismic hazard map, highlighting the position of Myanmar. Image source: European Space Agency (ESA), Global Seismic Hazard Assessment Program (Global Seismic Hazard Assessment Program, n.d.).

The earthquake with the highest intensity ever recorded in Bagan hit the area on July 8, 1975, with a magnitude of 6.5 according to the Richter Scale. On August 24, 2016, an earthquake with a magnitude of 6.8 stroke the site again causing several damages and destruction to 453 monuments (Weise, 2016) out of the 2,834 monuments recorded by Pierre Pichard (Mezzino & Santana Quintero, 2016).

Myanmar population amounts to an estimated 51.4 milion people, 70% of which is located in rural areas (UNDP, n.d.). The population in Bagan instead counts around 198,000 inhabitants (Kraak, 2015), living either in villages or urban areas.

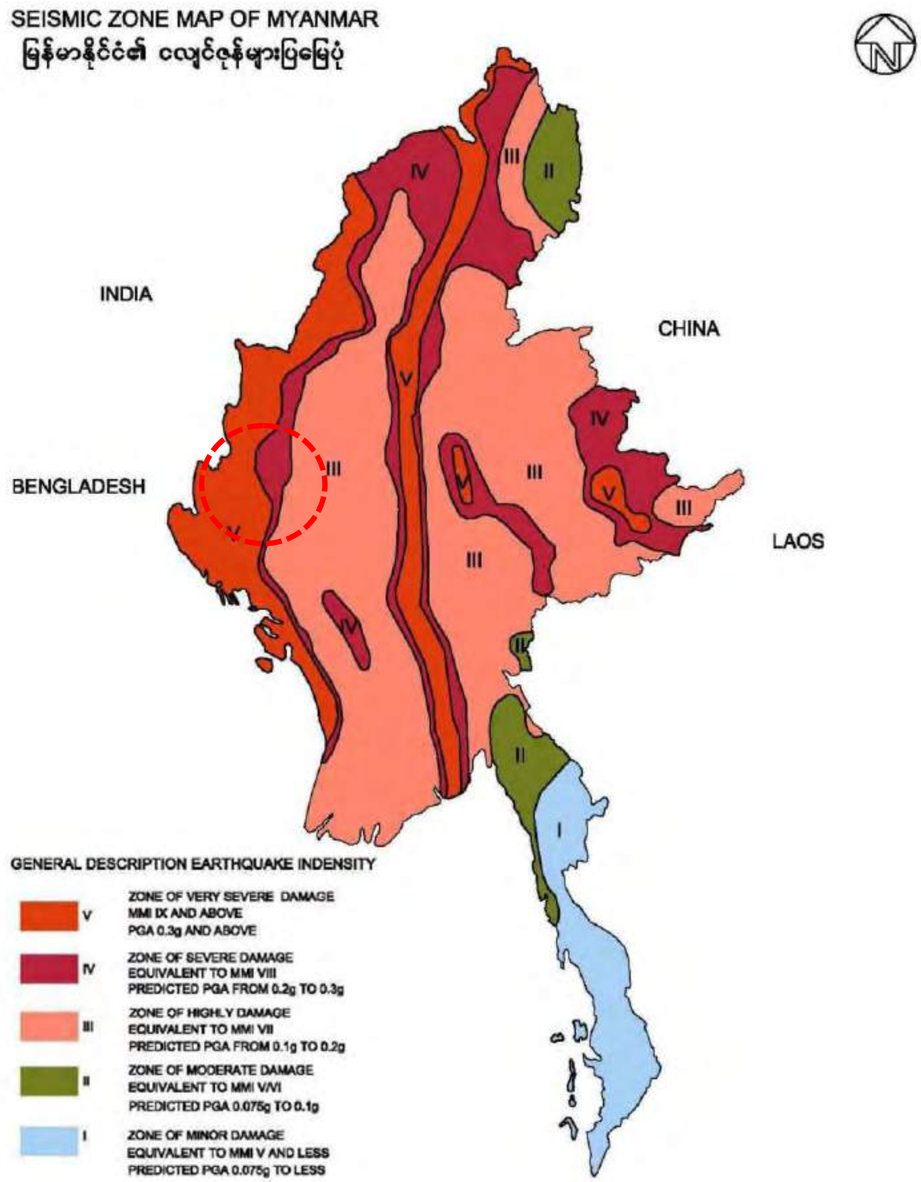

Figure 8 Seismic Zone Map of Myanmar. Adapted from Urban Planning report for Bagan Nyaung-U, Ministry of Construction, Myanmar. (Ministry of Construction Myanmar, 2014).

Communities at the village level have developed strong social and kinship ties for long time. They usually establish strong social bonds only within villages while close relationships among villages are seldom seen in the area. This trend is sligthly changing since the end of the international sanctions and the development of new transport infrastructures that easen people mobility and commercial exchanges. Furthermore, the development of hard infrasturctures (railways, bridges, roads, etc.) has been followed, in the last years, by the diffusion of software communication infrastructures (mainly based on radio signals and internet connection).

Figure 9 Bagan geographic context. Image source: CyArk (CyArk, n.d.-a).

From the ethnolinguistic point of view, the area can be ascribed to the Burman group.

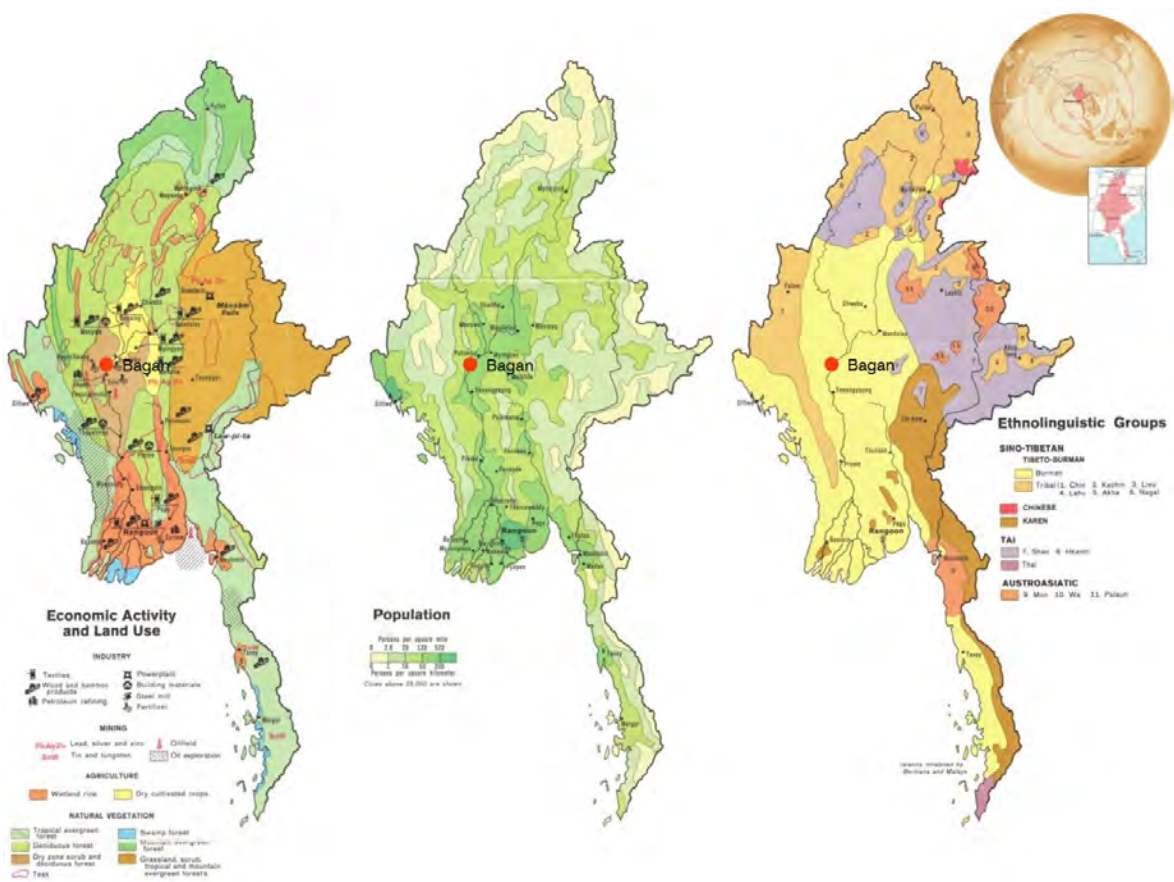

Figure 10 Localization of Bagan within the economic, demographic and cultural territorial context of Myanmar. Image source: (Joshua Project, 2017)

The site of Bagan is located in the center of Myanmar. Its area measures approximately 13 by 7 kilometers, for a total of about 91 square kilometers (Stadtner, 2013), p. 8.

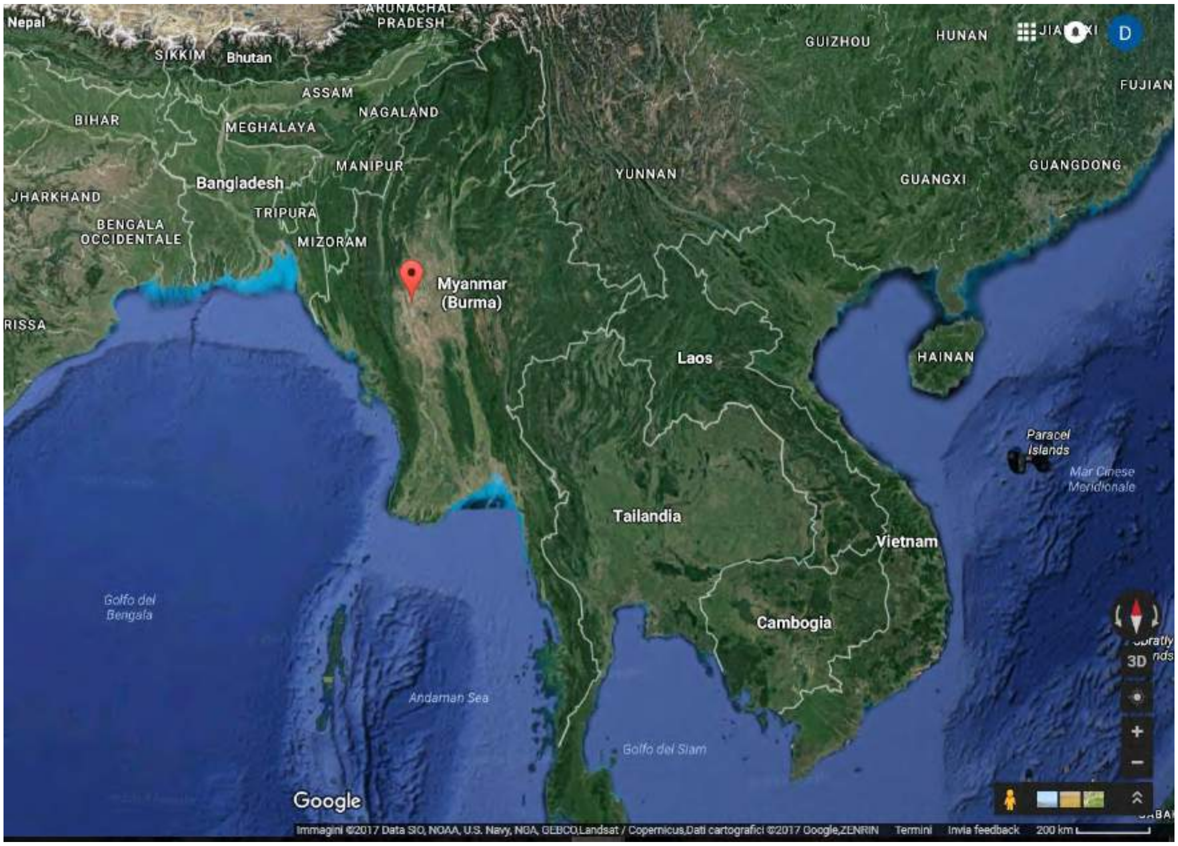

Figure 11 Bagan location in Myanmar geography. Image source: Google map.

Bagan's central location in the dry-zone determined the material type and the development of its temple typology. Due to the arid environment and proximity to the Ayeyarwady river, mud bricks became the favourable construction material. These were made along the banks of the river and then fired in small local kilns. The river also provided resources for mortar making. The central dry climate additionally allowed for the prolonged preservation of brick structures. Low precipitation levels meant less building damage from water penetration and, as a result, many structures have still retained both their structural integrity and their interior art wall paintings.

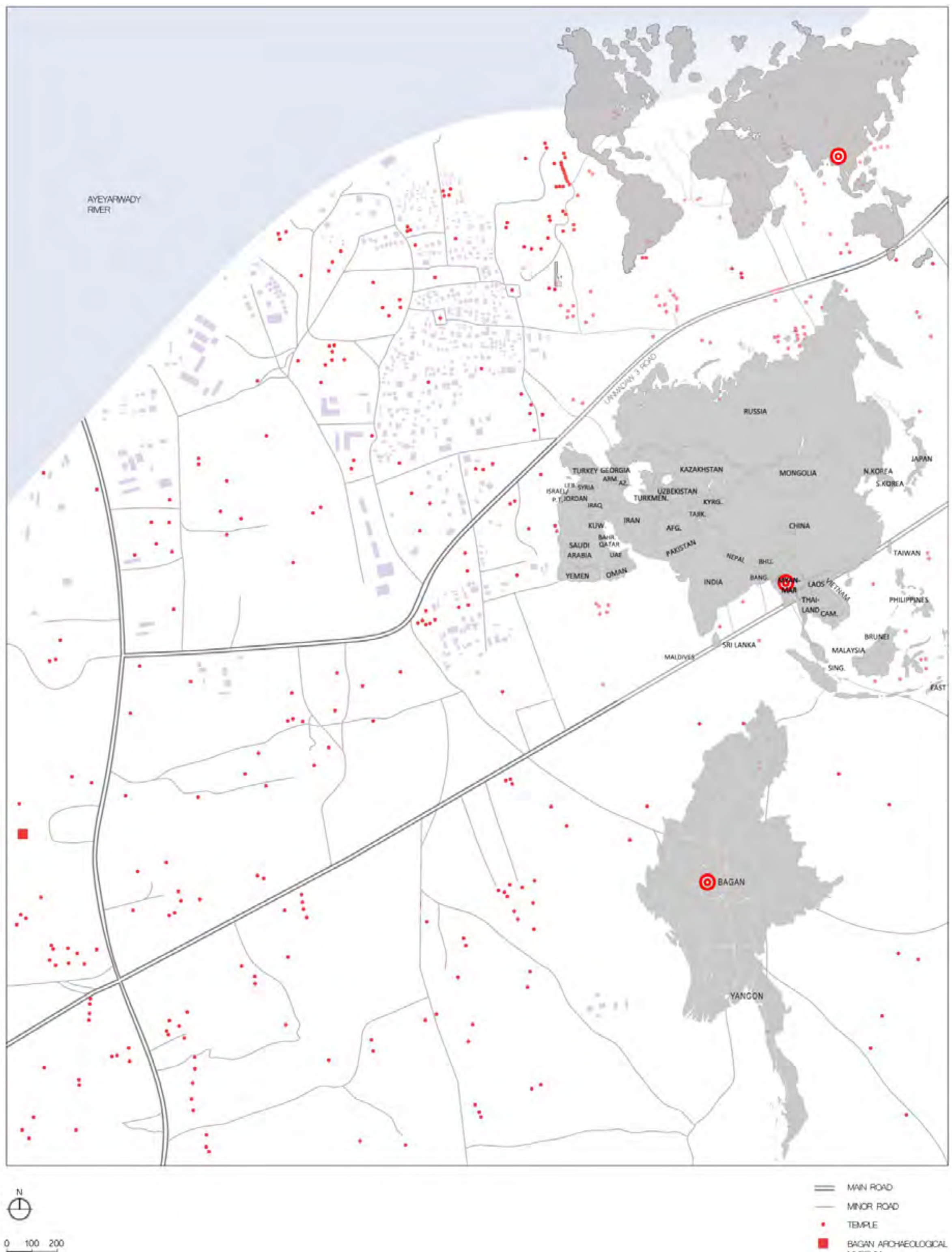

Figure 12 Territorial framework of the site of Bagan. Image source: Author.

According to Pierre Pichard, Bagan (or "Pagan" as it was also called) includes three main areas: the lively town of Nyaung U, the historic walled city of Old Bagan and further to the south the New Bagan (Bagan Myothit).

Among these areas, the site has been articulated in three main zones for a more efficient classification to support the site conservation initiatives. These include the Monument Zone (MZ)[5], the Ancient Zone (AZ)[6] and the Protection Zone (PZ)[7]. There are many estimates of the number of monuments in Bagan but the official assessment, according to the 1993 inventory, the total equals 2,834 monuments (Pichard, 1992).

Figure 13 Bagan monument zone. Image source: Author.

[5] The existing settlements in the monument zone include: Old Bagan, Wet Kyi Inn, West part of New Bagan, Taung Bi, Leya, Myin Ka Pa and Min Nan Thu.
[6] The settlements in the Ancient Zone currently include: Nyaung Oo, East part of New Bagan, Thu Htay Kan, East Pwa Saw, West Pwa Saw and Kontangyi.
[7] Settlements include the Hpyuk Seit Pin area.

From the natural point of view, the area is featured by the Ayeyarwady River that crosses the whole Myanmar flowing into the Andaman Sea. The river is and has always been Myanmar's vital artery. Furthermore, the raw materials of Bagan buildings' constructive elements, such as bricks and mortar, are strictly connected to the river.

Figure 14 Images showing the width of the Ayeyarwady River. Images source: Author.

From the economic point of view, in the Bagan area there are some local industries including lacquerware, bamboo making, cotton weaving, oil making, brick jaggery and cheroots makings. Some factories are located in the villages while cheroots making is carried out in Nyaung-Oo. Lacquerware[8] is the most popular handicraft industry in Bagan, especially in Myinkaba. Cotton weaving is also one of the supplementary

[8] Materials used for lacquerware are mainly bamboo and aloe-resin obtained from lacquer tree (Melanorrfioea usitata) from other regions. Laquerware production needs no energy and generates non-polluted wastes only.

industries, but mostly for its local use. This is due not only to the quality of the local production but also to its insufficient appeal to tourists.

Figure 20 Example of cotton weaving workshop in Bagan. Images source: Author.

Pastoralism is one of the main sources of income of Bagan's rural areas to guarantee the subsistence of the local communities. Indeed, most of the local low-income households combine farming with lacquerware production or other artisanal activities.

Figure 16 Example of farming activities in Bagan area. Image source: Author.

6.2 Historical framework: from the Pyu dynasty until to the National League for Democracy

Prior to the Reign of Aniruddha (200 B.C. – 1044 A.D.) (G. H. Luce, Rhaṅ', & U, 1969), Myanmar comprised many city-states of various ethnic groups, the most prominent groups being the Pyu, the Mon, and the Dvaravati peoples. These different city-states made up the Kingdoms that flourished for over a thousand years. In the centre of Myanmar were areas home to Padaungs, Palaungs, and Shans in the Kayah State – where other states also coexisted, including the Kachin State and the Shan State. Prior to the first Burmese Empire, these states contained their own kingdoms (Lat, 2010a).

Figure 17 Pre-Aniruddha Period (200 B.C. – 1044 A.D.) historical map compared with the current Myanmar territorial divisions among provinces. Image source Author, adapted from Kyaw Lat Art and Architecture of Bagan, (Lat, 2010a), p.13.

The Pyu Kingdoms were dominant between approximately 200 BC and 900 AD and the Mon Kingdom from around the first to second century AD.

The Pyu, from historical records, were located in Upper Burma and settled around the great rivers, whereas the Mon and Dvaravati were located in Lower Burma and present day Thailand (Galloway, 2011), p.70. These groups were highly cultured and at a high point of civilization prior to becoming united. As an important note, there was a line of kings existing before the reign of Aniruddha (200 B.C. – 1044 A.D.). Myanmar kings[9] established their own lineage to the Tagaung Kingdom, a Pyu city-state that was the first kingdom in Myanmar (G. Luce & Pe Maung, 1960), p. 1. It was believed be linked to court of Siddartha, which was a claim to be directly connected to the Buddha. In summary, the Pre-Aniruddha Period was a time of peaceful widespread spiritual beliefs, where Hindu-Buddhist culture first made its way into the land that would become Myanmar.

King Anawrahta (1044-77 A.D.) played a pivotal role in the history of Ancient Myanmar, by uniting the first Burmese Dynasty gathering various ethnic groups together with the Burmese population and opening the gates for Indianization (Stadtner, 2013). These circumstances allowed the highly cultured arts of the ethnic groups to be exposed and shared collectively. In 1057 A.D., Anawrahta (Lat, 2010a) unified Myanmar and set his capital in Bagan. During this time, he highly influenced the building landscape by funding construction and endorsing certain architectural typologies. King Anawrahta, after obtaining the pieces of Theravada scripture from Thaton, began the consolidation of Theravada Buddhism as the national religion (Cocks, 1919), p. 17.

[9] In total, 55 kings were recorded (G. Luce & Pe Maung, 1960), p. ix .

Table 2 Bagan kings in the Transitional and Burmese period (Stadtner, 2013). Table adapted by the Author.

PERIOD	BAGAN KINGS	DATES
Transitional Period	Anawrahta	1044-1077
	Sawlu	1077-1084
	Kyanzittha	1084-1113
	Alaungsithu	1113-1169
	Narathu	1169-1170
	Naratheinhka	1170-1174
Burmese Period	Narapatisithu	1174-1211
	Zeyatheinhka	1211-1235
	Kyaswa	1235-1249
	Uzana	1249-1256
	Narathihapate	1256-1287
	Kyawswa	1288-1298

After King Anawrahta, King Sawlu (1077 – 1084 A.D.), Kyanzittha (1084 – 1113 A.D.) and Alaungsithu (1113-1169 A.D.) succeeded each other (Stadtner, 2013). During this period there were two main types of architectural preferences that are repeatedly mentioned in the past, described as the introverted Mon type against the extroverted Burmese architectural style. While King Anawrahta advocated for a pro-Burmese style, the reign from Kyanzittha to Alaungsithu tended to be pro-Mon due to political affiliations with the Indian dynasties (Wales, 1973), p. 14. Under the Reigns of Sawlu, Kyanzittha, and Alaungsithu (also known as Cansu I), the full canonical Tripitaka texts arrived in Myanmar, a key event that congealed Theravada Buddhism deep into Burmese culture.

The Transitional Period, like the name suggests, oversees the gradual shift from the Old Mon style to the Old Burmese Style (G. Luce & Rhan, 1969), p. 283. This period (1113-74 A.D.) truly ends with a shift to the Burmese style after the ascension of King

Narapatisithu (also known as Cansu II, 1174 - 1211 A.D.) (Stadtner, 2013) and his successors[10].

The Mongol Invasion in the XIII century followed the transitional period (Stadtner, 2013). During the reign of Nara-Thiaha-Pati, the Kublai Khan was rapidly establishing a huge empire dominating most of East and South East Asia. In the great conquer plans of the Kublai Khan, Bagan was one of the neighbouring country to be subjugated (Lat, 2010a). According to Marco Polo, the war between the kingdom of Bagan and Kublai Khan's army started in 1277 A.D. In 1284 the Mongols, coming from Yunnan (Stadtner, 2013), had already conquered most of Bagan (Lat, 2010a).

Due to the political developments, since the end of the XIV century the capital was shifted from Bagan to Pinya and finally to Ava, south of Mandalay.

In 1531, the Portuguese supported the Toungoo dynasty to retake the region under a unitary state. Then, the Alaungpaya founded the Konbaung dynasty in 1755 (BBC News, n.d.-b). In the XIX century, the first Anglo-Burmese war ended with the Treaty of Yandabo, according to which Burma (ancient name of Myanmar) left the Arakan coastal strip, between Chittagong and Cape Negrais, to British India (BBC News, n.d.-b). In 1852, following the second Anglo-Burmese war, the British Empire annexed lower Burma, including Rangoon and then conquered also Mandalay in the following years. After that, Myanmar become a province of British India (BBC News, n.d.-b). In 1937,

[10] As Wales concludes, this is the restoration of the original intent of King Anawrahta, who advocated for a Burmese Style (Wales, 1973).

Britain separated Burma from India and made it a crown colony (BBC News, n.d.-b). During the Second World War the Empire of Japan occupied Burma (1942), but three years later the British army defeated the Japanese, ending their occupation of the country. In this phase a key role was played by General Aung San (father of Aung San Suu Kyi) who led the Anti-Fascist People's Freedom League (AFPFL) against the Japanese occupation. After the independence in 1948, U Nu, foreign minister in Ba Maw's government[11], become prime minister. In the mid '50s he was the co-funder of the Movement of Non-Aligned States together with the Indian Prime Minister Nehru, the Indonesian President Sukarno, the Yugoslav President Tito and the Egyptian President Nasser (BBC News, n.d.-b).

The archaeological site of Bagan has been the capital of the first Myanmar Kingdom from 1044 to 1287 A.D. (Pichard, 1992). In this period Myanmar was organized as a strong union[12] (UNDP, n.d.).

By the end of the XIV century, Bagan ceased its power. Nevertheless, it remained a centre of pilgrimage and religious study (Hudson, 2008). Following the decrease in population and the loss of a central strong political and economic power, many monuments deteriorated due to lack of maintenance, and to natural (flooding, earthquake, weathering,etc.) and anthropic (usage, wars, etc.) pressures.

In the middle of the XVI century, King Bayintnaung established the second Union of Myanmar that used to be one of the mightiest countries in Asia (UNDP, n.d.). In 1752

[11] The Ba Maw's government ruled Burma during the Japanese occupation.
[12] This period is generally referred to as the first Union of Myanmar.

Myanmar was thirdly unified by King Alaungphaya, the founder of the last dynasty of Myanmar. In 1885, the country was occupied by British Empire (UNDP, n.d.).

Only in 1948, it gained independence. Afterwards it was ruled by a military dictatorship for almost fifty years (1962-2011). During this period the generals run the country by abolishing any form of dissent and disapproval[13] (BBC News, n.d.-a). Human rights abuses, denounced by the international community, provoked international condemnation and sanctions.

Since 2010, the country went through a gradual liberalisation process. An example is the ease of the sanctions followed by the re-establishment of normal diplomatic relations and the suspension of a US investment ban under President Obama administration's (The Guardian, 2013), As a matter of fact, in September 2012 US secretary of state, Hillary Clinton, announced that the restrictions would be eased in response to reform efforts in Myanmar (The Guardian, 2013). These events evidenced the changing situation in Myanmar under the presidency of Mr. Thein Sein.

Finally, in 2016, a new government was elected with democratic processes, after decades of military rule. In March 2016 Htin Kyaw, member of the National League for Democracy (NLD)[14], became the first non-military president of Myanmar since 1962.

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[13] This became evident at the international level with the home arrest of the opposition leader Aung San Suu Kyi when she regularly won the national elections in May 1990. Since then, she became the face of the pro-democracy movement pursuing non-violent campaign against the military regime. Her efforts were internationally recognized in 1991 when she was awarded the Nobel Peace Prize (http://www.bbc.com/news/world-asia-pacific-11685977).

[14] The party led by Ms. Aung San Suu Kyi, daughter of Myanmar's independence hero, General Aung San. After the elections that established Htin Kyaw as president, she became state counsellor even if she is widely regarded as the real leader (BBC News, n.d.).

Figure 18 US secretary of state Hillary Clinton working with the Burma's President Thein Sein on the 'normalization' of Burmese-US trade relationship. Photograph: AP/Craig Ruttle (The Guardian, 2013).

Myanmar’s transition to civilian rule started under a new Constitution that came into effect in May 2008. The transition to civilian rule under the new Constitution was the first step in an on-going series of rapid and far-reaching political and economic reforms (The Myanmar Times, 2016).

In October 2016, the US ended the remaining economic sanctions on Myanmar[15].

[15] On September 14, US President Barack Obama signed an executive order terminating the sanctions that would formally end on October 7, 2016 (The Myanmar Times, 2016). The order also reestablished preferential tariffs for Myanmar that were suspended more than two decades ago due to human rights abuses. This would have not been possible without an agreement with the influential Ms. Aung San Suu Kyi (who for long time defended sanctions as a way to keep pressure on the powerful Burmese military) and without a stepping back of the military regime that allowed Myanmar (undemocratic) constitution to be changed (Fisher, 2016).

Figure 19 US President Barack Obama with Ms Aung San Suu Kyi, the main actor in ending the Myanmar sanctions. (Fisher, 2016)

6.3 Socio-cultural and economic context

The legendary origin of Bagan dates back to the II century but its development is mainly documented from the dominance of King Anawratha (XI century) and continued throughout the XVI and XX century as reported by some mural paintings (Falconer et al., 1998), P.27. The site counts more than three thousand monuments even if documentary sources report that in the past between XI and XIII century counted more than 13,000 stupas and temples (Falconer et al., 1998), P.27. Currently, it is still one of Asia's most important centers of Theravada Buddhism.

Many of the temples are still being venerated by the local population as well as by national and international pilgrims. Most of the about 3,000 recorded Buddhist monuments[16], ranging from small stupas and temples to monastic complexes and several enormous stucco-covered structures, were built during the XI to XIII centuries[17] when Bagan was flourishing as the capital of the first Myanmar kingdom. The site is enclosed by a city wall, which dates back to the IX century, however, many temples were built outside the city wall. From the XIII century several developments are recorded in the villages surrounding Bagan (mainly around the Western Pwasaw and Minnanthu) were new activities were set up (Stadtner, 2013).

In the same century the number of monuments grew exponentially. This phenomenon was also favored by the reduced dimension of the new temples compared to those of the XI and XII centuries. This 'construction boom' also affected the southern area of Bagan where new villages – including Sale, Hsale, Myingun and Kyuntaw – were developed (Stadtner, 2013).

Bagan's larger structures were funded by successive kings as well as by high-ranking members of society and the smaller ones by the local population (Pichard, 2013). The ancient capital was originally designed to reflect Buddhist cosmology. At the same time, the royal patronage of monuments served as a means to legitimize the power of the Bagan kings as mediators between the religious and secular worlds (Frasch, 1996).

Apart from a central authoritarian power, the reasons for Bagan development were also of socio-cultural nature. Donald M. Stadtner reports that the motivation of the construction of Bagan monuments can be found in the votive tablets and stone inscriptions explaining the votive nature of these religious structures: *"Donating temples, stupas, or monasteries*

[16] The UNESCO inventory, published in 1992, recorded 2834 monuments. Nevertheless, according to the local department of archeology in Bagan, the Department of Archaeology, National Museum and Library Department of Archaeology, National Museum and Library, the number of the monuments is greater.

[17] The archeologic site of Bagan was the capital of the first Myanmar kingdom from 1044 to 1287 A.D. (Pichard, 1992).

were considered good works that accumulated merit for specific religious aims that hinged on the concept of future rebirths"[18]. (Stadtner, 2013), p. 38.

Furthermore, the construction of Bagan religious monuments can also be found in the donor tradition. Donors were intended to acquire merit for specific religious aims and to legitimize donors' social position. Hence, donations for the construction of monasteries, stupas and temples, provided merit and enachanced social and political status of the donors (Stadtner, 2013).

From the demographic point of view, the site is currently registering a population growth as the whole country. Indeed, the census data collected from the Myanmar Information Management Unit (MIMU) show that the population of Myanmar has been steadily increasing. The 2014 census provisional results report that:

"The population of Myanmar has steadily grown since the beginning of census taking in 1872, rising from 2.7 million persons, to 10.5 million in 1901, to 13.2 million in 1921, then to 28.9 in 1973, 35.3 million persons in 1983 and 51.4 million persons in 2014 [...]. The steady increase in population size over the period has policy implications for all sectors of the economy, particularly those of education, health, employment and housing." (Population, 2014), p. 7.

[18] Indeed according to the Theravada Buddhism there were two main goals. The first one consisted in achieving the nirvana or Buddhahood or, alternatively the end of the cycle of rebirths. The second goal consisted instead in witnessing the rebirth of the Buddha of the Future (Metteyya), which according to the Buddhism religions is supposed to appear 5000 years after Buddha's death (Stadtner, 2013).

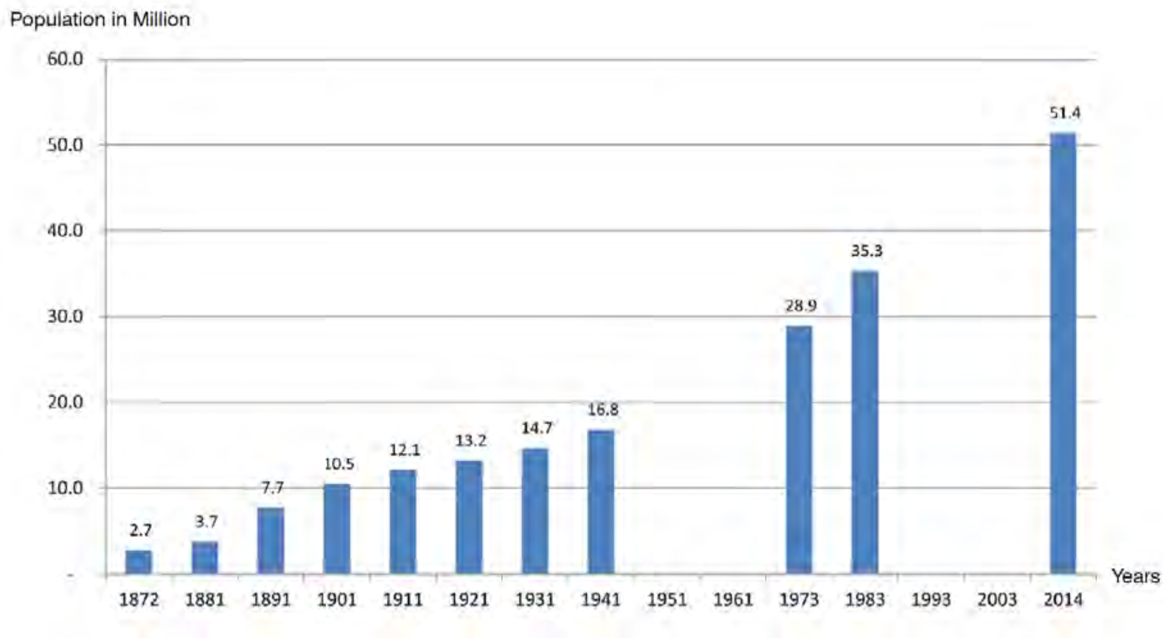


Figure 21 Diagram presenting the population growth in Myanmar. Those with no data displayed were years during which censuses were not conducted. Image source Population and Housing census of Myanmar (Population, 2014).

In the report, it is shown that the country counts a population of approximately 51,419,420[19].

One of the potential concerns of heritage conservation arises from the urbanization in Myanmar, particularly in the Mandalay province where Bagan is situated. The increases of population are most pronounced in areas of greater urbanization (Population, 2014), p.12. The map outlined below shows the population densities of each state, the greatest ones being registered in Yangon and Mandalay.

In conjunction with the rise in population is the increase of tourists. Tourism is an expanding industry in Myanmar, which has led to interest in the conservation work of Bagan’s Archaeological Zone. Myanmar Tourism statistics show that the number of

[19] The data are updated as of March 29, 2014 (Population, 2014), p. 6.

people visiting Myanmar has increased almost six times from 219,864 people in 2008 to 1,201,583 people in 2015 (Population, 2014).

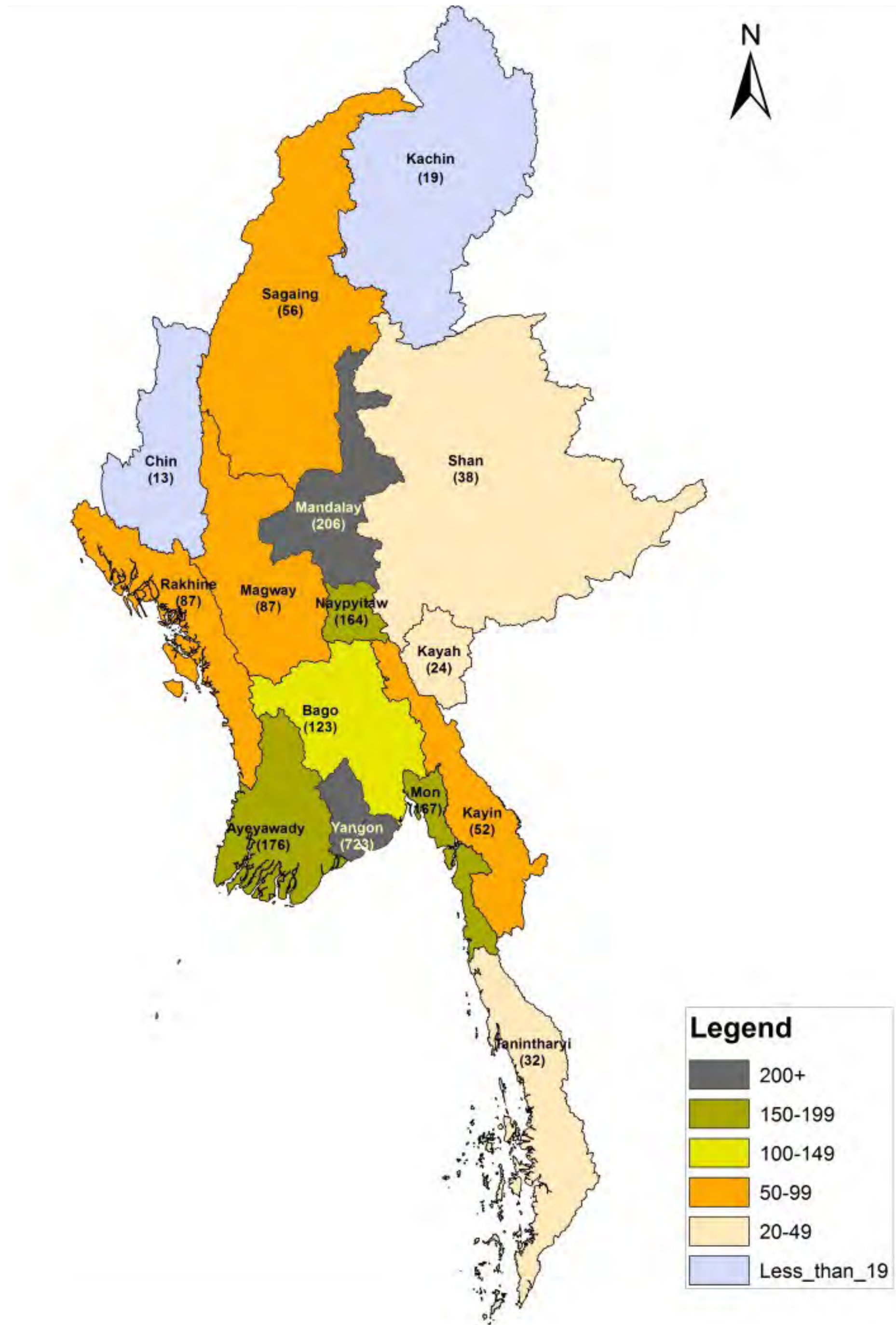


Figure 22 Map of Myanmar by Population Density in persons per square kilometer. Regardless the average Myanmar population density (76 persons per square kilometer), the most densely populated

State/Region is Yangon (723), followed by Mandalay (206) where Bagan is located. Image source: Population and Housing Census of Myanmar, 2014 (Population, 2014).

The increasing tourism pressures are evidenced by the huge number of visitors mainly registered from 2012. This phenomena can be explained by the eased of the restrictions in the same year[20], starting to open up Myanmar to the rest of the globalized countries. The diagram below illustrates the trend of the Tourist arrivals.

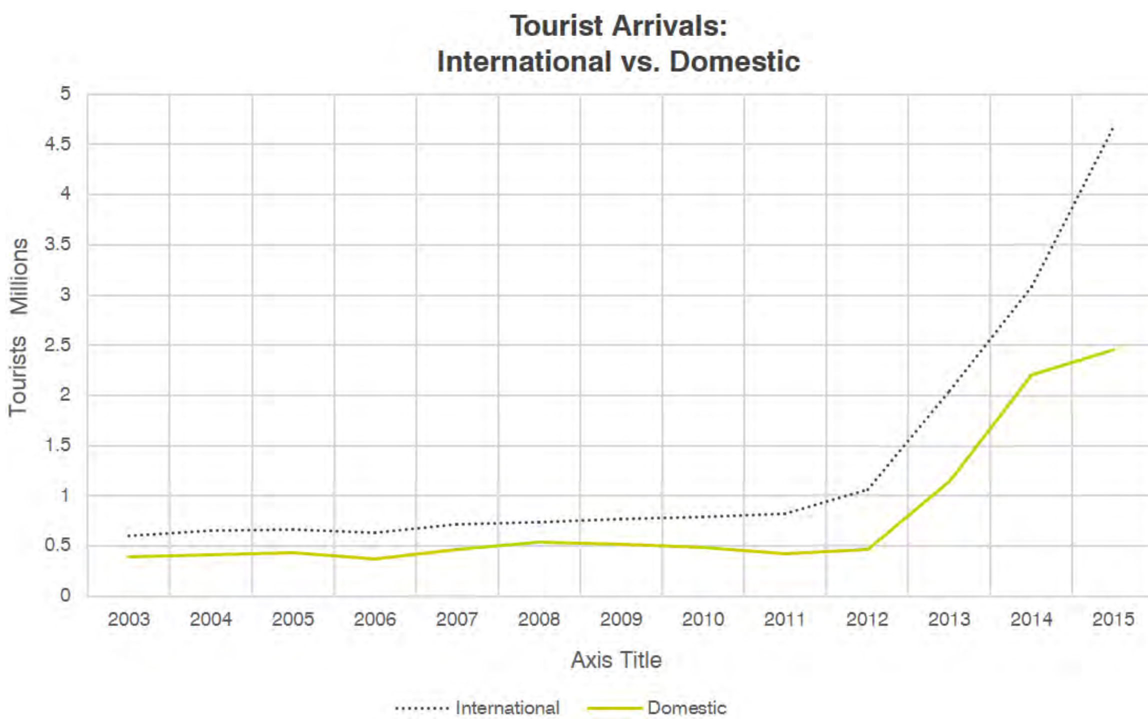


Figure 23 Diagram illustrating the tourist arrivals in Myanmar from 2003 and 2015. The diagram has been developed by the author from the Tourism Statistics published by the Ministry of Hotels and Tourism (Ministry of Hotels and Tourism, n.d.).

[20] Indeed, in the September of same year the State Secretary Hilary Clinton under the Presidency of Barack Obama announced the soften of some sanctions imposed on Myanmar in 1988. This decision was justified by the recognition of the fledgling democratic transition of the country. Therefore, the ban on U.S. companies investing in or offering financial services to the country was resized. Further, as reported by Paul Eckert and Arshad Mohammed the *"Secretary of State also said that the United States was also ready to allow private U.S. aid groups to pursue non-profit activities on projects such as democracy building, health and education and to give select Myanmar officials and lawmakers permission to visit the United States, relaxing long-standing visa bans"* (Eckert & Mohammed, 2012).

These increases of numbers are quite significant, indicating a need to properly develop a conservation management plan for the protection of Bagan’s monuments - both in terms of urbanization of the land from population growth and tourist activity (Eckert & Mohammed, 2012).

To the increasing number of visitors corresponds also an overall increase of hotels and rooms. The diagrams below focuses on the data of the annual increase of hotels and rooms in Mandalay and Bagan from 2008 and 2015. The slight increase of Bagan hotels is fairly stable while rooms have been gradually increasing since 2008. This can be justified by the regulations and restrictions on building new hotels in the Bagan historic areas. It is possible to hypotize that to bypass these restrictions, new rooms have been constructed in the same areas where already existing hotels are located.

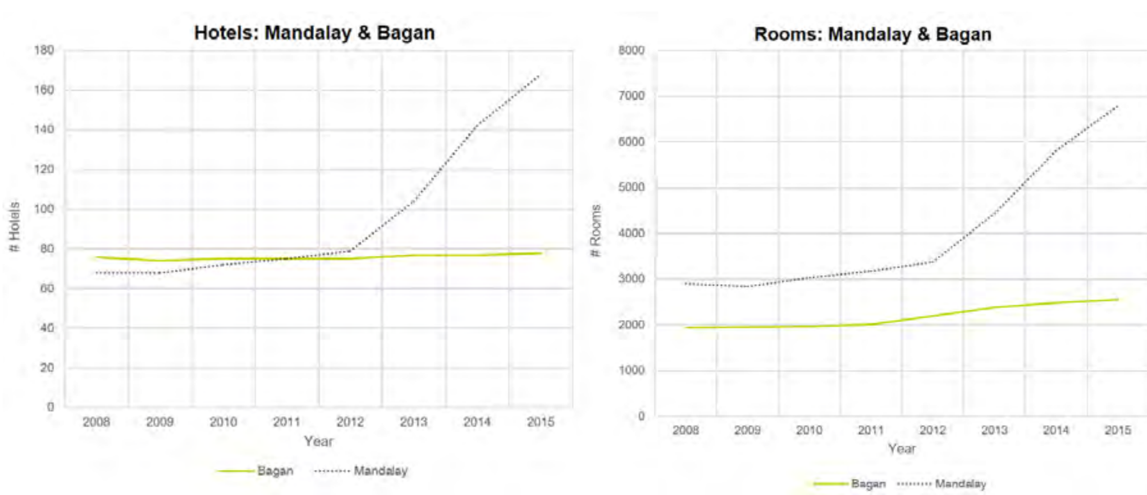


Figure 24 Annual increase of hotels and rooms in Mandalay and Bagan from 2008 and 2015. Diagrams developed by the author using the data of the Tourism Statistics published by the Ministry of Hotels and Tourism (Ministry of Hotels and Tourism, n.d.).

No.	Country	2007-2008	%
	ASIA	139666	63.52
1.	THAILAND	33377	15.18
2.	CHINA	31122	14.16
3.	KOREA	13448	6.12
4.	TAIWAN	12712	5.78
5.	JAPAN	12627	5.74
6.	SINGAPORE	8795	4.00
7.	MALAYSIA	8394	3.82
8.	INDIA	7652	3.48
9.	HONG KONG	2856	1.30
10.	BANGLADESH	1000	0.45
11.	OTHERS	7683	3.49
	WEST EUROPE	49925	22.70
1.	GERMANY	11116	5.06
2.	FRANCE	10889	4.95
3.	SPAIN	5930	2.70
4.	U.K	5578	2.54
5.	ITALY	5460	2.48
6.	SWITZERLAND	3130	1.42
7.	BELGIUM	1808	0.82
8.	AUSTRIA	1611	0.73
9.	OTHERS	4403	2.00
	NORTH AMERICA	16310	7.42
1.	AMERICA	13825	6.29
2.	CANADA	2485	1.13
	OCEANIA	6937	3.16
1.	AUSTRALIA	6063	2.76
2.	NEWZEALAND	847	0.39
3.	OTHERS	27	0.01
	EAST EUROPE	3822	1.74
1.	RUSSIA	1849	0.84
2.	OTHERS	1973	0.90
	MIDDLE EAST	1522	0.69
	OTHER AMERICAS	1277	0.58
	AFRICA	405	0.18
	TOTAL	219864	100

Visitors by Nationality

No.	Country	2012	%
	ASIA	[illegible]	[illegible]
1	THAILAND	[illegible]	[illegible]
2	CHINA	[illegible]	[illegible]
3	JAPAN	[illegible]	[illegible]
4	KOREA	[illegible]	[illegible]
5	MALAYSIA	[illegible]	[illegible]
6	SINGAPORE	[illegible]	[illegible]
7	TAIWAN	[illegible]	[illegible]
8	INDIA	[illegible]	[illegible]
9	HONGKONG	[illegible]	[illegible]
10	BANGLADESH	1737	[illegible]
11	OTHERS	[illegible]	[illegible]
	WEST EUROPE	[illegible]	[illegible]
1	FRANCE	[illegible]	[illegible]
2	U.K	[illegible]	[illegible]
3	GERMANY	[illegible]	[illegible]
4	ITALY	[illegible]	[illegible]
5	SWITZERLAND	[illegible]	[illegible]
6	SPAIN	[illegible]	[illegible]
7	BELGIUM	[illegible]	[illegible]
8	AUSTRIA	[illegible]	[illegible]
9	OTHERS	[illegible]	[illegible]
	NORTH AMERICA	[illegible]	[illegible]
1	AMERICA	[illegible]	[illegible]
2	CANADA	[illegible]	[illegible]
	OCEANIA	[illegible]	[illegible]
1	AUSTRALIA	[illegible]	[illegible]
2	NEWZEALAND	[illegible]	[illegible]
3	OTHERS	47	0.01
	EAST EUROPE	[illegible]	[illegible]
1	RUSSIA	[illegible]	[illegible]
2	OTHERS	[illegible]	[illegible]
	MIDDLE EAST	[illegible]	[illegible]
	OTHER AMERICAS	[illegible]	[illegible]
	AFRICA	[illegible]	[illegible]
	TOTAL	[illegible]	[illegible]

Visitors by Nationality

No.	Country	2015	%
	ASIA	938487	72.10
1	THAILAND	204539	15.71
2	CHINA	147977	11.37
3	JAPAN	90312	6.94
4	KOREA	63715	4.90
5	SINGAPORE	45125	3.47
6	MALAYSIA	40852	3.14
7	TAIWAN	31735	2.44
8	INDIA	34628	2.66
9	HONGKONG	4237	0.33
10	BANGLADESH	2913	0.22
11	OTHERS	272454	20.93
	WEST EUROPE	209300	16.08
1	FRANCE	47435	3.64
2	U.K	45120	3.47
3	GERMANY	35727	2.74
4	ITALY	14841	1.14
5	SWITZERLAND	12293	0.94
6	SPAIN	9158	0.70
7	BELGIUM	6666	0.51
8	AUSTRIA	4398	0.34
9	OTHERS	33662	2.59
	NORTH AMERICA	83866	6.44
1	AMERICA	69815	5.36
2	CANADA	14051	1.08
	OCEANIA	35566	2.73
1	AUSTRALIA	30820	2.37
2	NEWZEALAND	4547	0.34
3	OTHERS	199	0.02
	EAST EUROPE	15433	1.19
1	RUSSIA	4138	0.32
2	OTHERS	11295	0.87
	OTHER AMERICAS	9575	0.74
	MIDDLE EAST	5527	0.42
	AFRICA	3829	0.29
	TOTAL	1301583	100.00

Figure 25 Statistics of the increased visitors to Myanmar from 2008 to 2015. Image source: Population and Housing Census of Myanmar, 2014, Provisional Results, (Population, 2014).

The increase of tourism surely influenced Myanmar economic growth that has averaged 5% in recent years with a per capita income of USD$702 (UNDP, n.d.).

Evidence of the economic growth and tourism development with potential consequent pressures to develop new services, infrastructures and accommodations can be found in the increase of foreign investments in Myanmar. As reported in the diagram below, since 2008, the trend of the foreign investments was fairly uniform and stable up until 2012. Immediately following 2012, there was a big spike in ongoing projects. As already mentioned the reasons of this shift can be found in the relax of some sanctions from the United States.

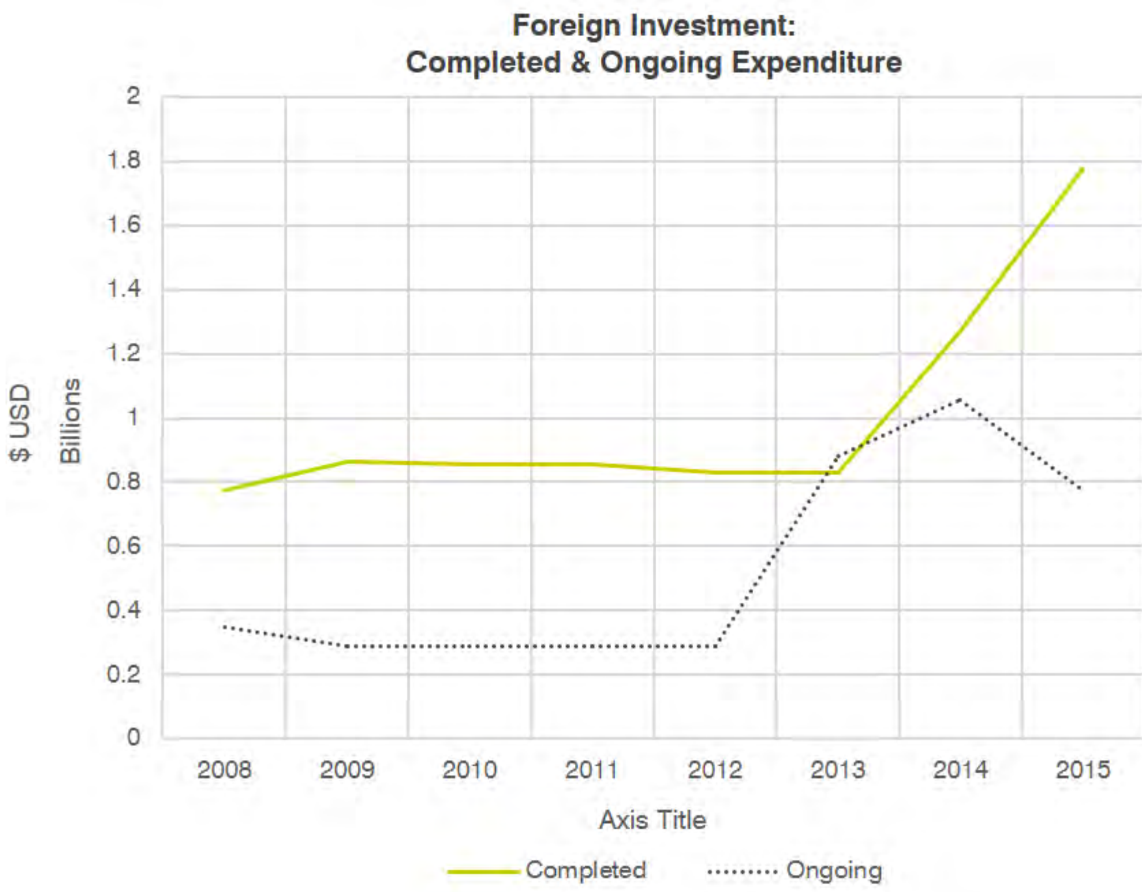


Figure 25 Diagram illustrating the trend of the foreing investmens including completed and ongoing expenditure from 2008 to 2015. The diagram has been developed from the Tourism Statistics data published by the Ministry of Hotels and Tourism (Ministry of Hotels and Tourism, n.d.).

6.3.1 Heritage conservation in Bagan

Along the centuries, Bagan built heritage has been affected by damages caused by both natural and human causes. From the flooding in 1331, to looting in the XV, XVI and XVIII century (particularly during the Ava-Hanthawaddy wars of 1742-1754) and to the several seismic events[21] that affected the site (Hudson, 2008).

[21] From the 1174 to the 1975, sixteen earthquakes have been recorded (Hudson, 2008).

To contrast these damages and destructions caused by catastrophic events, particularly earthquakes, several repairs occurred. Than Tun reports *"seventy instances of 'making new' at Bagan between 1212 and 1965, a practice he calls 'a sad story of antiquities being ruined through repair"* (Hudson, 2008), p.555. Particularly after the 1975 earthquake several repairs and reconstructions have been recorded.

Figure 26 View of Bagan plain depicting the state of degrade affecting many of its historic built structures. Image source: Author.

Since 1988, about 150 monuments were repaired. These actions were sponsored and coordinated by the Burmese government and by international agencies such as the United Nations. As reported by Hudson, the United Nation Development Programme provided about one million dollars to support conservation projects and monument recovery. International commitments to Bagan conservation came from several countries worldwide. For instance, training activities, equipment and expertise came from Japan, Yugoslavia and France, while Italy mainly supported the preservation of temples' wall paintings.

Trustee committees promoted the conservation and repairs of additional monuments also maintaining, in many cases, their worship functions (Hudson, 2008).

In terms of restoration and recovering, from the end of the '80s until the first years of 2000, *"[…] reinforced concrete belts and jacketing, strengthening with steel-tied bars and […] injections of concrete were introduced"* (Hudson, 2008), *p. 556.* In this time period, the archeologist Pierre Pichard started the development of the Bagan inventory, mapping, measuring, characterizing and documenting Bagan monuments.

In 1994, Myanmar ratified the World Heritage Convention and interests in Bagan heritage conservation rose again. In 1995, the DoA was looking for sponsors to repair the monuments suffering from rain damage and other deterioration radically increased after the 1975 earthquake (Hudson, 2008). The 'Secretary One' of the regime, Khin Nyunt, promoted a media campaign on TV, radio and press to stimulate private and public donations. This fundraising campaign was also successful because donation practice for religious purposes was something rooted in the Myanmar culture since the foundation of Bagan. Indeed, in Theravada Buddhism merit is believed to be gained through donations for future lives (concept based on the reincarnation concept). Donation amounts allowed to extend beyond repairs, rebuilding and reconstructing from ruins and rubbles. In this process, donors could select the monuments they wanted to sponsor. In terms of costs, just to have an overall idea, private companies contributed for over US $ 1,000,000

(Hudson, 2008), p.558. Sponsors included local, national and international donors. They ranged from military and police officers, government departments, international religious groups, individuals and families, and services organizations (Hudson, 2008), p.558. Indications of their names and roles are reported on the marble plaques in front of any repaired or reconstructed structure.

The images in figure 26 illustrate marble plaques placed in front of most Bagan monuments indicating the name of promoters of the reconstruction or repair works.

In 1996, the *Bagan Archaeological Area and Monuments* (the official name of the site on Myanmar's national Tentative List for World Heritage) was nominated for World Heritage listing. However, in December 1997, the World Heritage Committee decided to refer the nominated site back to the State Party, since the nomination did not fulfill the requirement of adequate protection and management (UNESCO WHC-27/CONF.207/3). As a reaction to the Committee's decision, the government of Myanmar withdrew almost completely from the international cooperation related to Bagan's protection[22].

As a consequence, at the end of the '90s support to the conservation and management of Bagan built heritage decreased[23]. An international symposium, held in 1988, discussed

[22] Instead, Myanmar's military government decided to start a campaign to collect public donations for 'conservation and renovation' at Bagan. Donors were mainly government officials, military leaders, and Burmese expatriates living abroad, but they also included individuals, families and Westerners [Hudson 2008]. Up until 2001, more than 1.4 million US$ had been collected and the money was used to partially restore or substantially renovate more than 1000 monuments [Moore/Nyunt Han, 2000]. Unlike the original brick structures that used to be plastered, the reconstructions were built as bare brick structures, most likely with the objective to blend in or complete the archaeological landscape. Undeterred by the criticism from international experts on the quality of restoration and reconstruction work, the Myanmar Ministry of Culture even published a series of six books documenting the reconstruction work with 'before and after' photographs. In some cases, where only the footprint of a structure could be identified and data about the original form of the monument was lacking, the part to be reconstructed was built in a completely new design.

[23] Nevertheless, in 1994 the UNESCO-Japan Fund in Trust provided US$ 283,400 for a two-years project to develop guidelines for cultural heritage protection in relation to the new development in the area (Hudson, 2008).

the preservation and the development of the site, and evidenced the poor quality of the restoration work carried out in the previous years[24] (Hudson, 2008).

Figure 27 Marble plaques in front of Bagan temples indicating the name of the donors. Temples in the left (from top to bottom) are the Phya-sa-shwe-gu temple and Eim-ya-kyaun-myet-hna temple; on the right, the Khe-min-ga-zedi temple. Image source: Author.

[24] Hudson reports how the symposium highlighted that *"industrial bricks and cement had been used [...] and work had been done too hastily"*(Hudson, 2008), p. 558.

Figure 28 Temple no. 820 before (1985) and after (2001) reconstruction. Source: P.Pichard, 2013.

The reasons of the refusal of the nomination relies on political facts. Indeed, in 1995, under the military regime repairs were developed in the form of heavy reconstruction of the site. As reported by Campton, *"a Disney-style fantasy version"* (Hudson, 2008) was carried out employing incompatible materials and design of the parts added to the existing monuments.

According to Bob Hudson, the reconstruction of Bagan has been among the most extensive and radical ones of the last decades. Hudson estimated that 1299 monuments including stupas, monasteries and temples have been totally rebuilt while 688 monuments have been repaired with major interventions (Hudson, 2008).Since 1995 until first decade of this century, the reconstruction of Bagan monuments has been promoted by donors who wished to gain not only religious merits, as in the past, but also political ones, by showing devotion and consent to the military regime (Hudson, 2008). Donations ranged from the more modest to the more substantial ones.

Currently, excavation, clearing of ruined buildings and mound of existing temples are the responsibility of the DoA.

The only existing organic inventory of Bagan monuments, used to coordinate all the actions, dates back to the '80s. It was developed between the 1982 and 1991 under the coordination and supervision of the archaeologist Pierre Pichard within the framework of a UNDP project[25]. This is the only written and graphic archive to develop future actions and to detect the past ones. The inventory analysis is the starting point for the development of any conservation action.

In terms of authenticity of the conservation actions, the structures maintained by the DoA or by trustees, usually supported by international agents such as UNESCO, can be considered authentic from the structural point of view[26].

However, buildings maintained by trustees were usually whitewashed while the structures conserved and repaired by the DoA are usually deliberately left in bare brick on the exterior. This choice is very questionable since it is "historically inauthentic" (Hudson, 2008), p.567. Indeed, traditionally Bagan monuments were all coated in stucco and whitewashed (sometimes gilded and decorated with glazed terracotta panels). Apart from a decorative aim, the stucco coating played also the function to protect the brick masonry structure from water penetration, particularly during the rainy season.

[25] The inventory was published in eight volumes between 1992 and 1995. The information provided by the inventory for each monument contains: Inventory Number; Name of the Monument; Broad location referenced to a prominent monument, landmark or village (indeed in Bagan there are no street names or street numbers that can be used as a reference); Coordinates; Short Description. The short description of each monument is then articulated into ten main items. They include: 1) A general description indicating the type of monument (stupa, temple, monastery, etc.), number of storeys and size; 2) Measured floor plan in scale 1:100, 1:200, 1:400, 1:500 or 1:1000 depending on the monument size. In some cases elevation(s) and a cross section(s) are also provided; 3) Upper parts, providing indications about roofs, terraces, towers, shrines, domes, spires, stupas, etc. 4) Construction information including materials and construction techniques; 5) Present conditions and date of eventual previous interventions (when known); 6) Images illustrating the monument conditions as well as the character defining elements such as: contextual views, details, and decorative apparatus; 7) Information about the decorative apparatus including elements such as: stucco mouldings, mural paintings, glazed terracotta tiles, etc. This section indicates also the estimated percentage of the original decoration; 8) Epigraphy, documenting eventual stone inscriptions, ink captions, or graffiti; 9) References to previous works and publications; 10) Estimated construction period (This section extensively refer to: Pichard, P., Inventory of monuments at Pagan. UNESCO, Paris, 1992).

[26] Regardless "additions or modification such as interior whitewashing or the addition of the *hti* or metal umbrella"(Hudson, 2008), p.563.

Nevertheless, 89% of Bagan built structures have undergone major reconstruction or complete rebuilds (Hudson, 2008).

Usually, surviving parts of Bagan period are evident after reconstructions. This is evident in many temples that were rebuilt from ruins. The dimension of the reconstruction of several Bagan monuments provides an idea of the huge economic resources employed.

Even less authentic is the reconstruction of sites from rubble; an example, in most of the cases, of fanciful reconstructions.

Figure 29 Example of stupa coated in stucco and whitewashed, Sandar Muni Pagoda, Amarapura (Mandalay region). Image source: Author.

6.3.2 The risk of the globalization processes

The current socio-political situation shows the growing risk of possible negative impacts of globalization processes that could affect Myanmar and the delicate balance of its cultural heritage resources.

Indeed, the victory at the 2015 election of the National League for Democracy led by the nation’s pro-democracy leader, Ms. Daw Aung San Suu Kyi, against the former military regime led by the former president U Thein Sein, brought about the lift of the sanctions on the country which had lasted for nearly seven years (Ramzy, 2015). This event, which eventually contributed to the country’s democratic transition, could have indirect consequences on the development and management of cultural heritage sites. The end of the sanctions has been also strongly supported by US businesses, arguing that they damaged wider US trade and investment beyond targeted companies and individuals (The Myanmar Times, 2016). Despite the democratic transition will open up Myanmar to the rest of the world, it will surely expose it to a rapid globalization process that will affect different fields including the Cultural Heritage one.

Figure 30 Image depicting how the masthead of the main newspaper at the international level reported the news of the end of the Myanmar sanctions and of the new democratic political system of the country, questioning their possible socio-economic implications. Image elaborated by the Author.

Current changes and globalization risks are already confirmed by many evidences. Let's think for example of the telecommunication sector quoting Megha Bahree, "*Until a couple of years ago, it was practically impossible for someone not connected to military rulers to get service […]. But the situation has started to change […]* Incoming calls are free, and outgoing calls cost about five cents a minute. To help expand access to sim cards — and, surely, as a publicity stunt — the government has started a raffle where the winner gets a sim card for only two dollars (Bahree, 2014).

Figure 31 Young monks playing with an iPhone. Source: (Bahree, 2014).

From November 2010, under the presidency of Thein Sein Myanmar opened up to the outside world, inviting tourists and investments in a variety of sectors, such as telecom and tourism. For example, Megha Bahree reports that in the telecom field in Myanmar the two existing cell-phone operators have been challenged by *"new fifteen-year telecom licenses to Telenor, of Norway, and Ooredoo, of Qatar*" (Bahree, 2014). Further reflections emerge when the authors note that "*With these companies preparing to beef up the country's telecom infrastructure, it's now only a matter of time before cell phones become as ubiquitous in the country as bicycles once were. (Those who can afford motorcycles and cars have left their bikes behind.)"* (Bahree, 2014).

Henceforth, in light of the trends in the telecom sector, what could happen in the architectural and urban field? What could the consequences of the growing numbers of tourists be? How is the development of new services and infrastructures being organized? Are there any regulatory frameworks? How can the design of effective tools and policies manage new anthropic pressures in Myanmar heritage sites such as Bagan?

The risks related to the growth of tourist flows has to be considered in relation to the inadequate infrastructural system of the site, not conceived for car and motorized traffic. The subsequent increase of environmental as well as acoustic pollution in the site, due to motorized traffic, has also to be considered. All these aspects are particularly relevant if we take into account the specificity of the site, as a place of worship, meditation and prayer associated with Theravada Buddhism.

Another consequence of the reforms and social transformations brought about by such changes is an increasing engagement with the international community and its standards. Myanmar has been re-engaging with the World Heritage system. In 2014, the Pyu Ancient Cities became Myanmar's first site on the World Heritage list. This successful listing encouraged the government of Myanmar to re-launch the preparation of a nomination for Bagan. In the past years, following the failed attempt of nominating Bagan for the World Heritage List in the 1990s, Myanmar's military government invested in an extensive reconstruction programme of religious monuments at Bagan. Between 1995 and 2012, more than 1000 pagodas and temples were reconstructed and about 600 were partially rebuilt.

International media as well as the international expert community have repeatedly scolded the Myanmar government for their anachronistic construction and unprofessional reconstruction work at the historic site. However, the military government's objective when publicly campaigning for the reconstruction of Bagan was most likely not first and foremost the compliance with international conservation standards, but rather pursuing political power ambitions by appropriating a historical site of national importance.

Pressure and challenges to Bagan built heritage continued despite the end of the dictatorship ratified with the election of president Htin Kyaw associated with the National League for Democracy (NLD) party.

As Anna Laura Kraak reports, the township of Bagan is a poor rural area characterized by unpaved streets, a prevalence of cars pulled by donkeys and mules on motorized traffic, dwellings in most of the cases without running water and electricity, open air markets and local restaurants.

All these features are likely to change drastically as a consequence of the reforms and social transformations on-going in the country. Recent years have been crucial for the history of Myanmar. The main most changes included the development of the country as well as its economic transition *"from a centrally directed economy to a market-oriented economy*" (Kraak, 2015), p.3, following the end of the international embargo and isolation from the global markets. The more recent political transition from an authoritarian military government to a democratic system[27] will likely bring about an exponential increase of tourism and related needs in terms accommodations, services, transports, service facilities, etc. The anthropic pressures on the sites, linked to the recent developments, are underlined by the researches recently conducted by Anna Laura Kraak, who reports that: *"[...] In September 2014, the government ordered a temporary suspension on further hotel development while potential World Heritage zoning is*

[27] Further, since 2011 the country is emerging from 60 years of conflicts in the border areas (Kraak, 2015), p.3.

negotiated. International business people and hotel chains are not the only stakeholders affected by the suspension. Local people who put all their savings in the extension of their guesthouse are the ones who end up disadvantaged by such policies. Meanwhile, around twenty luxury hotels continued developing despite the suspension, which most of my interviewees believe is the result of corruption. […]. Further challenges related to land and development rights are related to ambiguity of land ownership Technically, all land is government owned. It is divided . into urban, agricultural and religious zones. However, the zones on the official records only loosely reflect the situation on the ground. For example, many locals have informal agreements with pagoda trustees or local government officials to have their dwellings and businesses on religious land. These people are usually poor and live in precarious and uncertain situations, particularly in this time of transformation. Depending on its implementation, a World Heritage designation could have a direct impact on the livelihoods of many. Furthermore, religious and cultural rights are stake in Bagan when the conservation and protection of monuments excludes people from their cultural heritage and spiritual practices. […]"[28] (Kraak, 2015), p.3.

[28] Anna Laura Kraak reported these data according to the 2014 census that indicates the population of Nyaung U (township of Bagan).

Figure 32 Example of the proposed new Green Hotel along the Ayeyarwady river in the site of Bagan. Source Ta3 Architecture Asia ("GREEN 4* HOTEL in Bagan – MYANMAR," n.d.).

These considerations are particularly relevant in relation to the development of tourism and the new investments in the country in terms of new services and accommodations. If on one hand this could be seen as a positive element for the country and its economic growth, on the other hand it has demographic as well as development implication that may hamper the delicate balance of Myanmar cultural sites. In the case of Bagan, for instance, this risk is easy to identify. The images above present the projects – currently suspended - for the construction of new hotels and accommodations in the middle of what could be defined as the core zone of the site.

These issues underline the complexity of the current situation and only some of the threats posed by the touristic development of the site to its safeguarding as cultural religious living heritage.

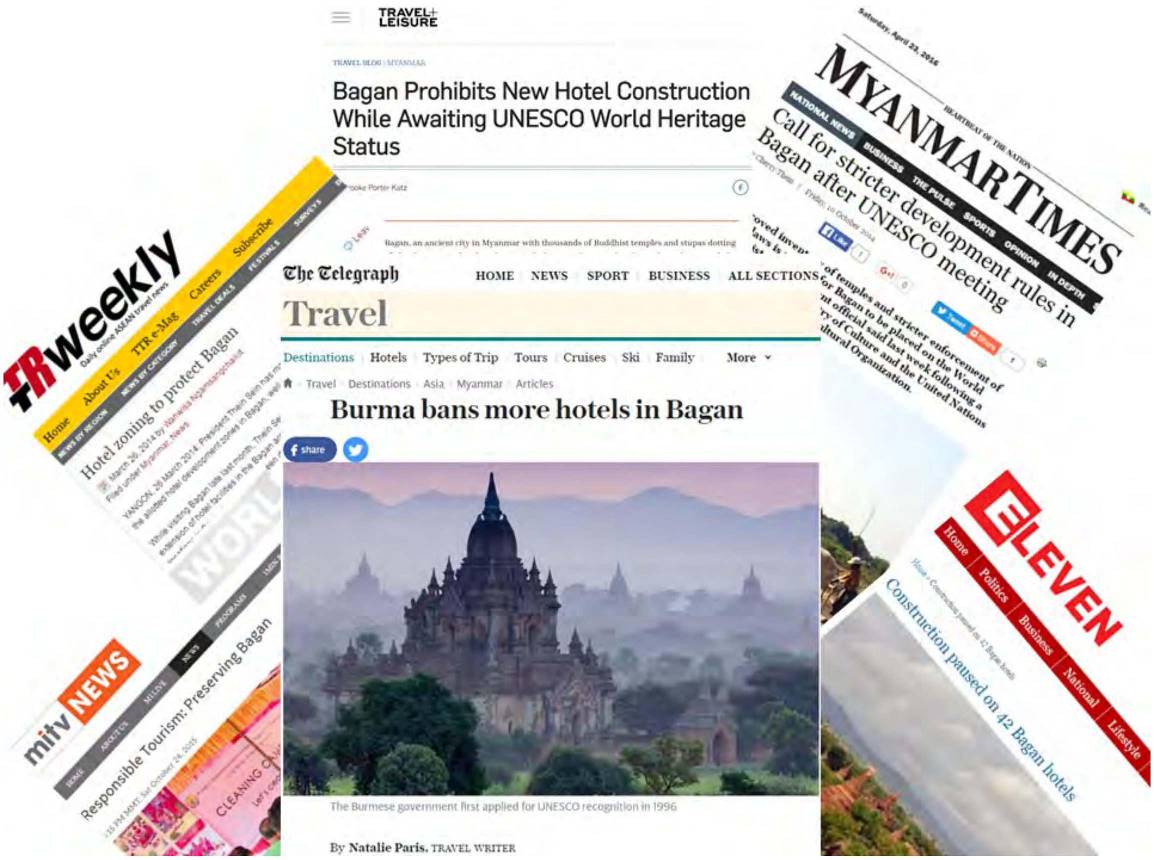


Figure 33 Local news reports denouncing the pressures imposed on Bagan for new developments on the site. Different printed and digital media reported the request to stop the construction of 42 new hotels planned to respond to the needs broguht about by tourism boom. Source: Eleven Myanmar (Eleven Myanmar, n.d.).

Therefore, conservation processes in Bagan need to address the *"right to culture"* (Kraak, 2015), p.4, intended as conservation of ancient monuments and right to popular religious practices. Indeed, Bagan is *"a pilgrimage site and thriving with popular religious practices. These practices range from paying obeisance to Buddha images, to re-gilding ancient monuments and attending pagoda festivals"* (Kraak, 2015), p.4.

Beside anthropic pressures, socio-economic processes expose Bagan to several threats. These can be grouped into six categories: 1) Development Pressure; 2) Tourism Pressure; 3) Road network and Transportation Pressure; 4) Vandalism; 5) Improper Conservation Techniques and 6) Weakness of knowledge and community involvement.

Figure 26 Example of vandalism on the wall paintings of a Myanmar temple. Image source: Author.

As already anticipated, development impacts in Bagan are mainly associated with the construction of new buildings (mainly hotels, tourist facilities and private residences) due to the growing tourist flows. This implies, as a consequence, changes in building design and style with contemporary and poor quality architecture which is usually unrelated to the context. This also brings about the loss of the traditional architecture style and building techniques and the erosion of Bagan character. Furthermore, these pressures directly impact on Bagan monuments and the surrounding environment by increasing the number of shops in and around them, thus destroying the quite atmosphere that characterizes these places of worship and pilgrimage. Uncoordinated developments and lack of planning also contributed to dysfunctional waste disposal management, with subsequent pollution problems and degradation of the environmental quality of the site.

New developments also imply new telecommunications that require hardware support such as telecommunication towers whose visual impacts jeopardize the harmony of the cultural heritage landscape.

Figure 35 Example of waste management problems in the site of Bagan caused by lack of coordination and planning of the development of the site. Image source: Author.

Tourism pressures, as already reported, include the need of accommodations, services and facilities for visitors. Further, tourists' behaviour represents a threat to the conservation of the temples since the climbing is not controlled and there are many cases of congestion, particularly at sunset (the time of the day in which temples are more crowded).

Beside, tourism development is also associated with the enlargement of road networks and transportation services. In order to avoid traffic jams, the main roads have been upgraded and enlarged to the detriment of the monuments.

Figure 36 Example of enlargement of historic roads in Bagan. Image source: Ma Wint Tin Htut Latt.

6.4 Bagan Cultural Built Heritage

Architecture does not exist in a vacuum, but is always strongly tied with the social, historical, cultural, and political changes of its surrounding context. Bagan is no exception: its religious and secular architecture is influenced by its surroundings. Hence, a brief summary of Bagan’s geographical and architectural context will increase the understanding of the Loka-hteik-pan temple, selected as case study of this research, and of the site where it is located.

Religious structures such as stupas, pagodas, and temples as well as secular buildings, have been constructed throughout the country, but the greatest concentration of its religious architecture is found in the heart of Myanmar, Bagan. The archaeological site of Bagan was the capital of the first Myanmar Kingdom from 1044 to 1287 A.D. (Pichard, 1992). It continued to be the site where a large number of religious constructions were made in the following dynasties, with some scholars estimating the costruction of about ten thousand monuments in that period.

Secular architecture played its own significant role in ancient Myanmar, despite being far outnumbered by the number of religious buildings and monuments. Secular architecture tended to be made of ephemeral construction material, such as wood, leading to the present survival of very few examples. Kyanzittha's palace, for instance, was constructed of wood and has completely deteriorated (Lat, 2010b), p.70.

Bagan built heritage presents a complex variety of architectural types: monasteries, underground structures, royal palace (mostly ruined), local housing (for different social classes), stupas, and temples[29].

However, the three main building types, still existing, are temples, stupas and monasteries. Apart from this schematic categorization, Bagan built heritage presents both secular and religious architecture.

External Architectural Influences

For a full understanding of the site it is interesting to identify the two main external influences that have greatly impacted Bagan's architecture. One is the introduction of Buddhism into Myanmar, and the other one is Indian culture – which is also largely tied to the depiction of Buddhism and its expression of art and architecture.

[29] In the site there are two main architectural typologies: the stupa and the temple. The main differences between the two types of buildings concern their accessibility and use. Indeed, the stupa is a monumental structure that commemorates the Buddha or his memorable deeds. Stupas may have many different contours but a bell-shape is most common for the larger stupas. Temples instead are places of worship, devotion, and meditation totally accessible to the public (although in the past their accessibility was ruled by a complex hierarchy distinguishing between monks and common people, currently anyone can access them).

Indianization

Throughout the span of the Burmese kingdoms and first empire (200 B.C. – 1287 AD) (Becka, 1995), p. xiv, India's constant influence shaped art and architecture in Myanmar. According to Wales, the Indians were the most important people group who played into the formation of Burma's historic culture (Wales, 1973), p.10. He uses the term "Indianization" to describe the process of Myanmar acceding itself to Indian culture. For reasons that are not quite clear, Myanmar was not as strongly influenced by other bordering countries or by the Southeast Asian Kingdoms during its Golden Age.

From India came trade exchanges, cultural ideas, artisanal techniques, and naturally, religious teachings. Wales suggests that commercial trade was perhaps not the most effective means of Indianization; he deems that the spread of culture was expedited by Indian Buddhist missionaries and Indian specialists (such as astrologers), (Wales, 1973), p.10. These people were often welcomed into the country due to the underlying belief of superior Indian knowledge. Buddhism, as it will be explained in the next section, was one of the most important external influences from India.

In addition, Indian migratory flows into Myanmar, which included a number of refugees fleeing persecution from Indian Brahmins (Baig, n.d.), aided with Indianization.

It is important to note that Buddhism was not the only religion originatjng from India that penetrated the country; Hinduism and its different denominations occupied the land of Myanmar prior to its unification. Aniruddha's capture of the Mon Kingdom of Thaton[30]

[30] The Thaton Kingdom or Thuwunnabumi was a Mon kingdom that lasted from the IV century B.C. to the mid XI century A.D. It essentially consisted in a city-state centered on the city of Thaton. The Kingdom located in between current lower Myanmar and

in 1057 led to the attainment of the first Tripitaka texts and equally opened the door for a full surge of Indian influence as Thaton was primarily an Indian civilization.

Indianization was also a means for Burmese kings to establish their own political platform. Myanmar Kings frequently sought to consolidate their power by maintaining good relations with the nearby empires, and in several circumstances owed their position of power to the surrounding Indian Kingdoms.[31] Anawratha (1044-1077) himself kept close relations with King Vijayabahu of Ceylon, who helped him solidify Buddhism into his court (G. Luce & Pe Maung, 1960), (Facts and Details, n.d.). His son, Kyanzittha (1084-113), married a Bengali wife and allowed her to construct a Mahayanist temple.[32] Indian craftsmen were brought over for the construction of her temple, and they shared and spread their artistic styles. This pattern of international marriage continued with every ruler to ensure their own position of power; the exchange of artisanal techniques resulted as a by-product of this trend.

In terms of religious infuences, Theravada Buddhism originated from India but has arguably found its widest expression in Myanmar (Lat, 2010b), p. 46. Theravada Buddhism, in particular, has permeated deeply into the cultural and religious way of life for the Burmese nation for nearly more than one and half millennia. Unlike India, Theravada Buddhism remained the country's national religion and its place was never

Thailand. It traded directly with South India and Sri Lanka, and became a primary center of Theravada Buddhism in South-East Asia. Thaton, like other Mon kingdoms, faced the gradual invasion of the Khmer Empire. Nevertheless, the Pagan Kingdom from the north eventually conquered it in 1057 (Www.revolvy.com, n.d.).

[31] For instance, Cansu II became King only thanks to the support of the Sinhalese Dynasty (Cocks, 1919), p, 20.

[32] As expected, the craftsmen she brought over and employed would have been trained under the Pala style of art at the time (Wales, 1973), p. 12.

truly challenged.[33] Myanmar today continues to be dominated by Theravada Buddhism as its main religion, giving its temples a distinct heritage by the retaining of their original function.

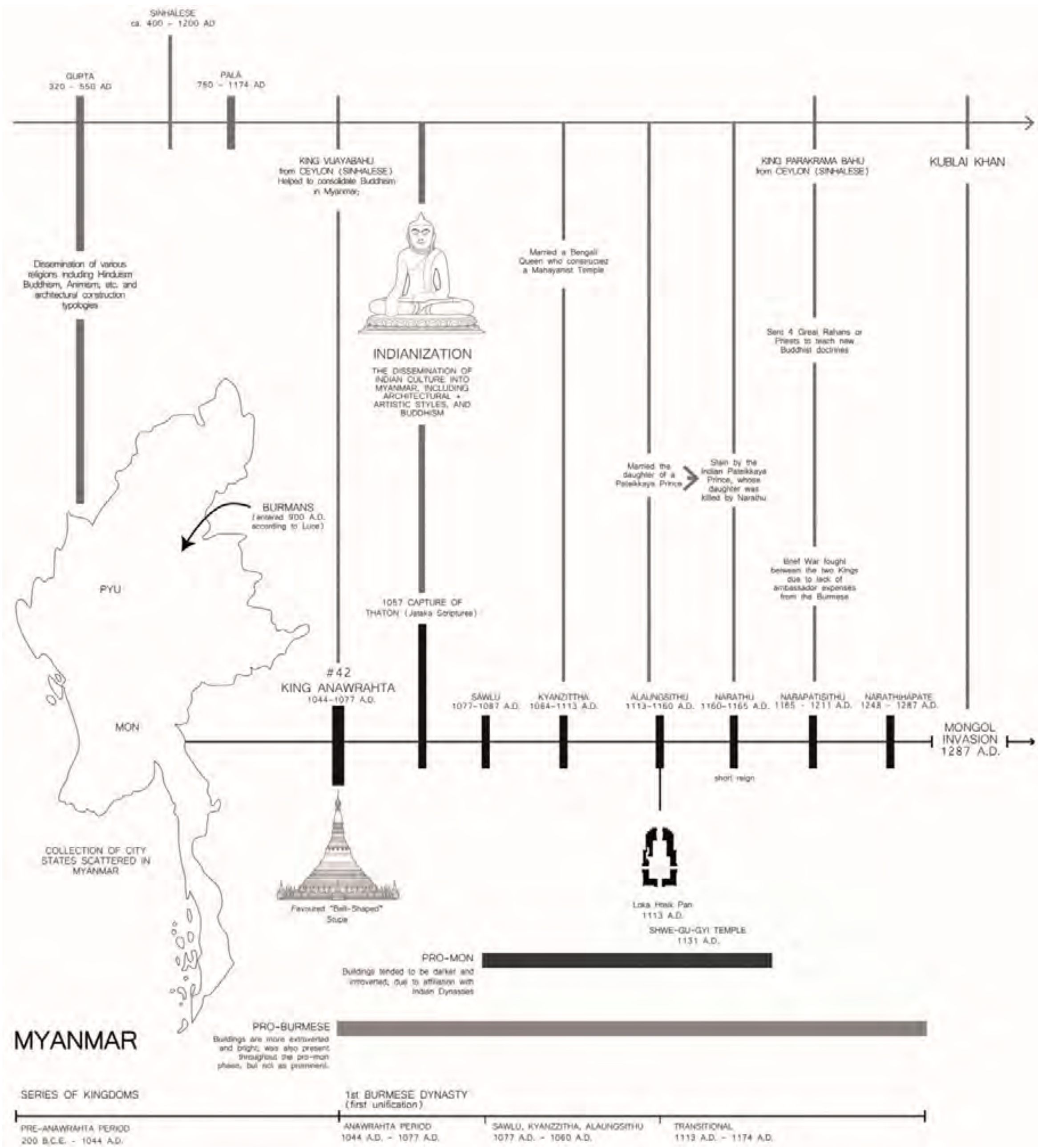


Figure 37 Myanmar history timeline and influences. Image source: Author.

[33] There were of course religious influences to consider; keeping good relations with the Pala Kingdom meant respecting Mahayanist Buddhism. After the Mongol invasions of 1287 A.D., the country was plummeted into anarchy and saw a decline in Buddhist worship. However, it never adopted another religion. Buddhism was revived in the XV century by a Mon Dynasty in Pegu (Lat, 2010b), p. 85.

6.4.1 Architectural typologies and urban shapes

The main architectural influences, typologies and styles permeating its architecture ought to be addressed in order to better understand Bagan.

Mon and the Pyu influences

Bagan presents two main types of architectural preferences that are repeatedly mentioned in the past, described as the introverted Mon type against the extroverted Burmese architectural style.

The architectural features of the Mon reflect their preference for a meditative interior. The Mon Style was characteristically known to be dark, mystical, and heavily influenced by India. Wales indicated that the Old Mon temple is a Post-Gupta style from Pala India, consisting of three main parts: the dark central Shrine, the four-sided corridor, and the Hall with the main entrance (Wales, 1973), p.20. Other stylistic elements include perforated brick windows (Shin, 1962), p. 228, the Makara pediments (Wales, 1973), p.37, and intricately decorated interiors that are richly carved and covered with paintings. Due to the darkness of these temples, it was common for bats or other animals to nest in them. The Late Mon temple is a little different, featuring a perfect Greek cross plan, with four hallways and two corridors (G. Luce & Rhan, 1969)p.3. The most robust example of this plan is the Ananda Temple.

Similarly, the Pyu preferred dark temple interiors as well. They have many similarities to the Mon, and in some cases, it is unclear whether they originated from one or the other.

One area of Pyu influence was their architectural forms. Many examples of Early Bagan temples are Pyu in their plan and structure, but are Mon in their architectural features (Shin, 1962), p. 3. Like the other city-states in the area, the Pyu underwent Indianization and learned the arch and vault construction techniques from Gupta India (Wales, 1973), p.18. The stupas that king Anawrahta (1044-1077 A.D.) (Stadtner, 2013) favoured so much are a testimony to their influence in architectural forms, and can be found throughout the Bagan landscape. These are a Pyu type featuring a high cylindrical body, tapering parasol wings, and a series of terraces (Wales, 1973), p.15. In comparison, the Mon received patronage for their bell-shaped stupa (Wales, 1973), p.16.

Burmese Style

It was widely believed that the Burmans (or a group known as the Bamars) first entered Myanmar around the X century; this was established as a hypothesis by G.H. Luce, however there are other theories as regards their date of origin (G. Luce & Pe Maung, 1960), p.26.[34] It is unclear whether this group of people had developed their own indigenous style, however, they were a culture that assimilated and challenged the Mon and Pyu artistic styles. Instead of assenting with romantic and dark Indian-like temples, the Burmese preferred light and air. Under their rule, a double-storied temple typology was developed, which was particularly challenging from the structural point of view. The Burmese style often used materials of stone, smaller bricks, and voussoir arches in order to improve the strength and stability of buildings. Although it was a slow progression, Burmese architectural preferences began to clearly show by the rule of Cansu I (1113-1160 A.D.), (G. H. Luce et al., 1969).

[34] There are two other hypothesis, one according to the book Glass Palace Chronicles and another book called Jatapum.

The Burmese Style saw temples grow taller in proportion with two or more stories, masterly construction of vaulting and joinery, and the emphasis of vertical lines (Shin, 1962), p. 229. The interior features were changed to bring light and air inside, by the enlargement of windows, heightening of doorways, and even the elimination of the central shrine (Shin, 1962), p. 228. In some cases, windows were transformed into doors for better illumination (Stadtner, 2013), p. 54. Bats were removed from the temples, and the temple became more hygienic and clean. While the exterior of the temple was lavishly decorated with Makara pediments over the entrances, its interior were austere and simple. This choice of adornment greatly contrasts the highly-decorated interior of the Mon temples, reflecting the clean aesthetic.

Bagan architectural features

In terms of architectural elements with a structural function, Bagan built environment mainly presents brick masonry vaults, load bearing walls and pillars.

Concerning vaulting techniques, as reported by Pierre Pichard, vault systems in Bagan have been probably influenced by eastern India Buddhist centers (Pichard, 1992). It is likely that the initial vaulting technique was borrowed from India, due to little evidence of development and the mature technique of early vaults (Stadtner, 2013), p. 56. Ancient Burmese builders adapted the vaults to suit their own temples, reaching an exceptional level of mastery.

The interior spans of Burmese temples were very wide, making them significantly different from Indian vaulting. The technique, described by Stadtner, differs from European vaulting because "*the bricks were set vertically, with their broad side* *perpendicular to the length of the vault. The fired brick voussoirs were cut on one side to form an irregular trapezium*" (Stadtner, 2013), p. 57. This ultimately eliminated the need for scaffolding, and reduced the dependency on strong mortar to hold the bricks together. Due to this technique, Myanmar temples could adopt large entrances and spanned large areas, such as encircling inner corridors (Lat, 2010b), p. 86.

Different types of vaults were employed in Bagan. These have been identified by Kyaw Lat (Lat, 2010b), p.84, as:

1. Corbelled Vault;
2. Barrel Vault;
3. Cross Vault (groin vault);
4. Lean-to Vault;
5. Multi-layer vault;
6. Flat Arch;
7. Cupola Vault.

The corbelled vault was a technique borrowed from India, present in many examples of South East Asian architecture. In Myanmar, this was used as a minor vault type for small spaces such as doorways or windows (Stadtner, 2013), p.57. Barrel vaults were frequently employed in entrance hallways, or for inner corridors of the hollow-core or solid-core temple. Lean-to vaults were equivalent of the European buttress, acting as a wall stabilizer.

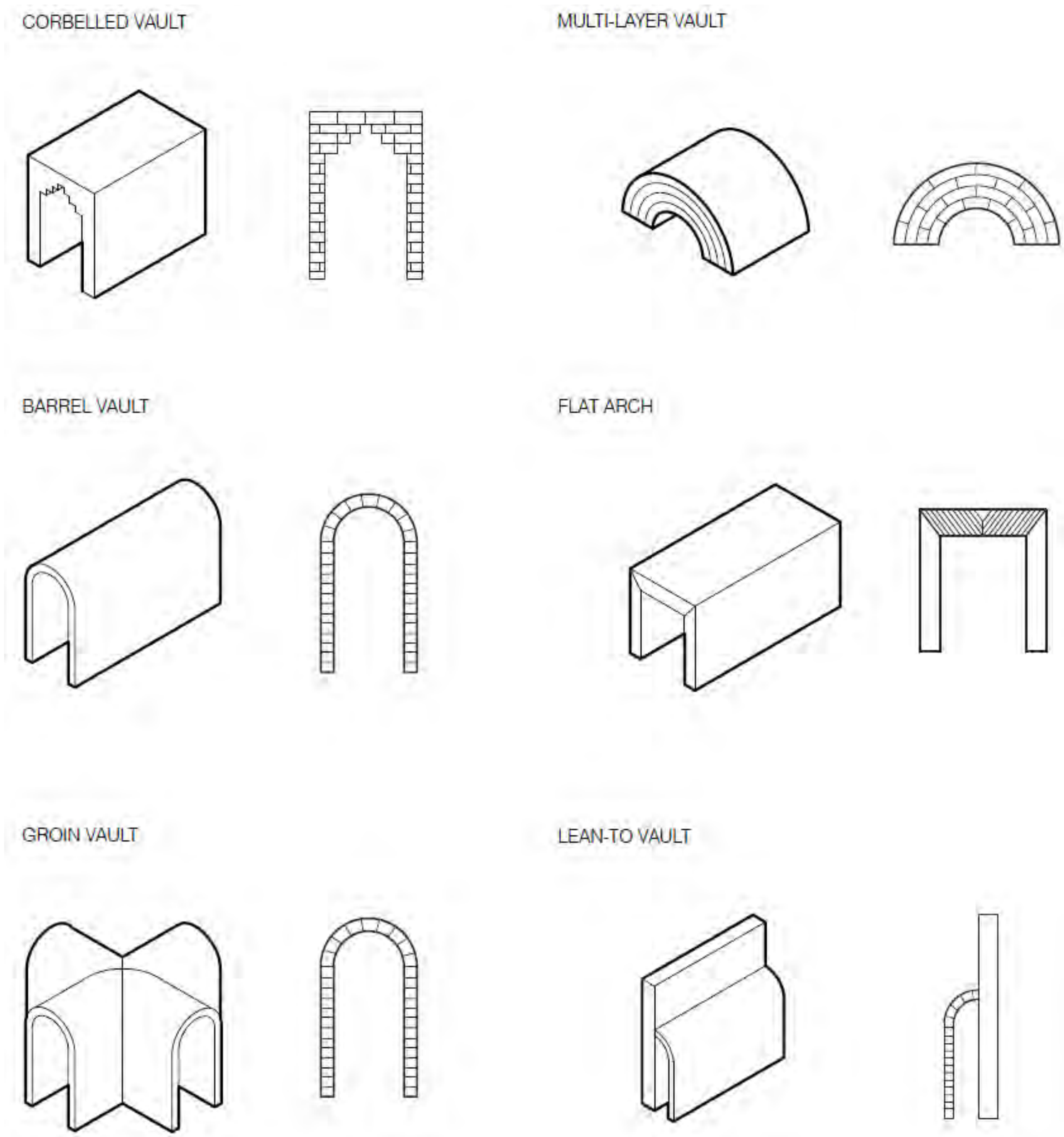


Figure 38 Example of vaults types used in Bagan historic structures. Image source: Author.

The multi-layer vault was created to achieve two different goals:

- High height was required on the outside in order to accentuate the effect of ascension;
- An intimate worship space, obtained with a lower high of the vault, needed to be preserved on the inside.

Figure 27 Example of double vault in Bagan. Pya tha gyi temple (inventory number 893). Image source: Author.

Hence, a double-vault construction system was developed in order to maintain lower interior spaces and higher exterior heights. For the same reason, the temple's roof was designed with a lower level than the temple itself, stressing the sense of progression (Lat, 2010b), p. 87.

The selection of the different types of vaults depended on their structural function. Usually, cloister vaults were used on square or rectangular support such as temples' shrine. Barrel vaults (full, half or three quarters) were instead employed to cover long spaces such as entrance hall, porch and corridors (Stadtner, 2013).

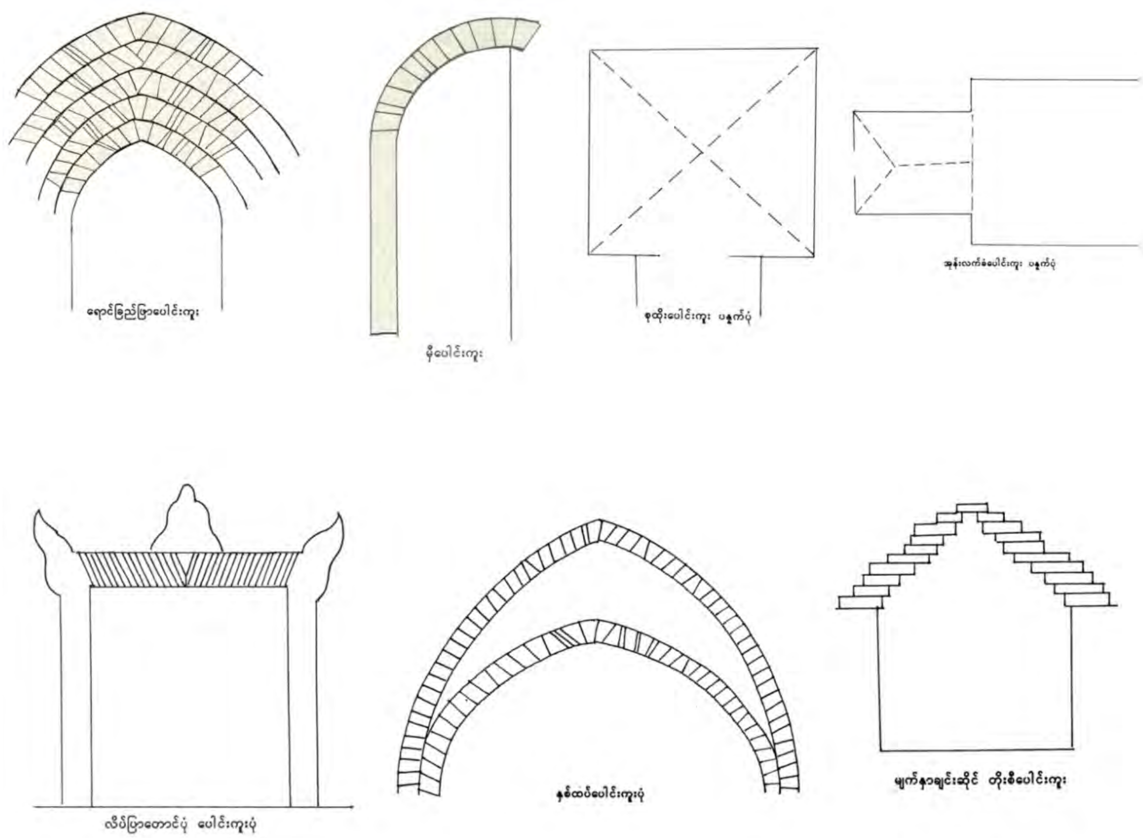


Figure 40 Sketches of different vaults types. Image source Kyaw Lat, *Art and Architecture of Bagan and Historical Background* (Lat, 2010b).

Distinctive construction features of Bagan built heritage are not only limited to structural aspects but include also functional and aesthetic features. For instance, as temple development progressed to the location of deeper shrines, there was the problem of allowing light to reach the interior. The shrines were meant to be dim, but not fully dark to the point where the Buddha's face was not visible. One solution implemented was the use of light-wells and skylights, which would allow enough light to pass through to the interior shrine (Shin, 1962), p. 228. This technique was used at the Ananda Temple.

According to Kyaw Lat, Bagan's builders were master engineers of soil mechanics. The solid-core of the temples would, "distribute [loads] equally to the soil to avoid the concentrated pressure directly to the soil at certain points, since the vertical loads, especially under the Sikhara tower, are very high."(Lat, 2010b), p. 88. This was a clever way to reduce point loads and spread it evenly over a wider surface. With the development of multiple shrines, there was a need for better structural soundness as temples increased in size and shrines. There were several engineering adaptations for this, which additionally looked to withstand seismic stresses. Bagan lies along the Indian tectonic plates, making it a zone highly susceptible to earthquake activity. The builders of Bagan employed extremely thick walls to allow for the rigidity and strength to withstand earthquakes (Lat, 2010b), p. 89. At the same time, the walls of the inner shrines performed the structural function of the central pillar (Lat, 2010b), p. 63. On a small temple, the average thickness of a wall could range from 1.5 to 2 metres.

Another feature that was prominent in Bagan's architecture was the translation of symbology into its architectural features or decoration. Symbols from Buddhist literature were frequently depicted, the majority of which consisted of natural elements. The lotus flower is an example whose patterns could be found in many elements, such as the Buddha's throne.

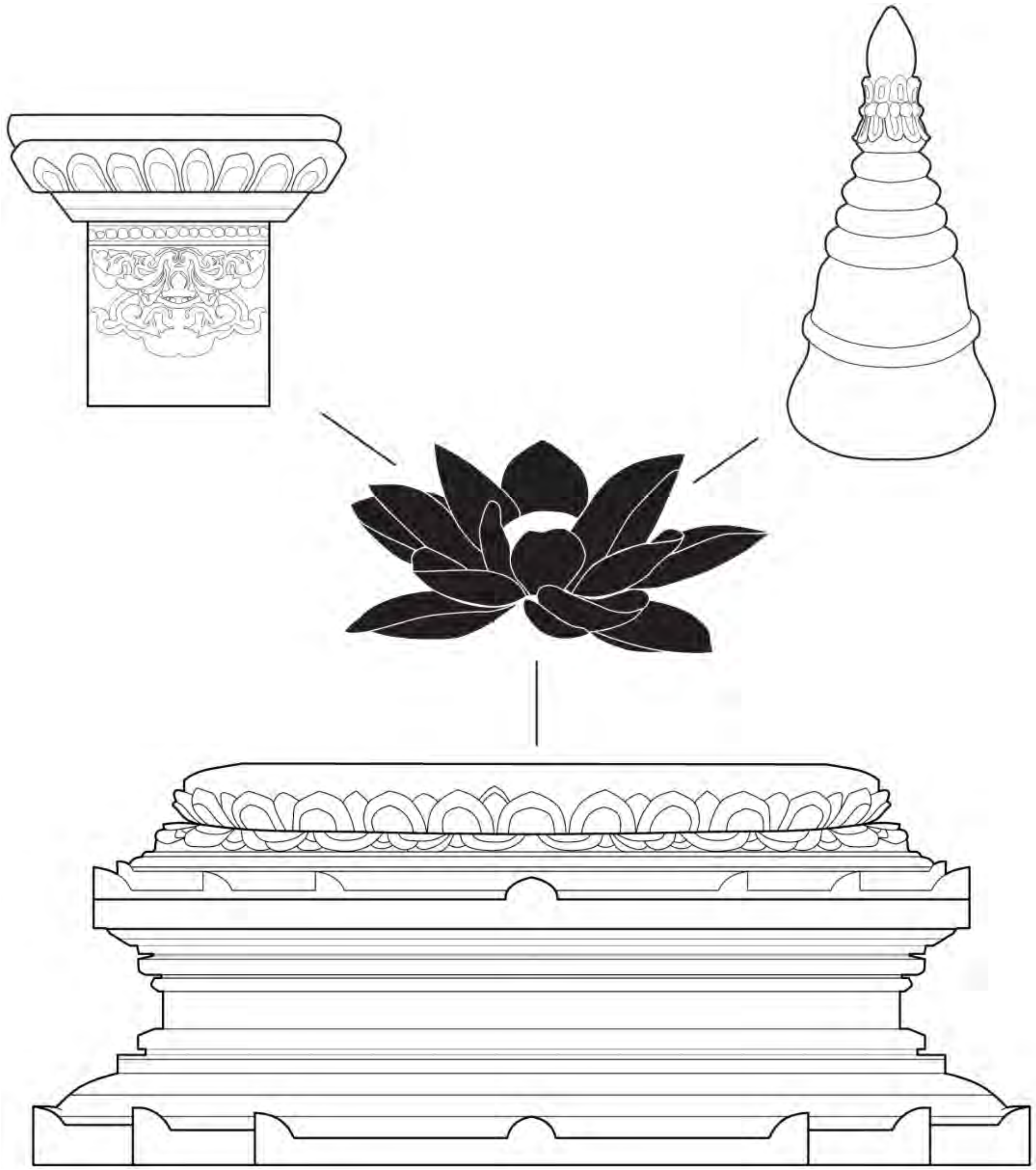


Figure 41 Example of the translation of symbology into its architectural decorations and shapes. Image source: Author.

Religious Architecture

According to Bob Hudson, Bagan urban development should be interpreted as a physical manifestation of the desire of salvation through merit (Hudson, 2008). The abundance and variety of religious architecture in Bagan, and more generally in Myanmar, reflects the persistence of Buddhism over the last 2000 years (Falconer et al., 1998), p. 21. It is impossible to analyze this kind of architecture without considering its social attributes and the involvement of local communities. Indeed, to build a pagoda was for Buddhists (individuals and communities alike) proof of high prestige and goodwill. The labor for pagoda constructions was mostly volunteer-based, also because of its strong religious connotations[35]. As Ma Thanegi noted, "*the most prestigious merit a Buddhist could aspire to achieve is to become a paya d'agar 'donor of a pagoda'*" (Thanegi, 2005), p. 100.

Religious observance was very much embedded into the everyday life of the Burmese people, explaining its inseparable presence in art and architecture. Buddhism has manifested itself into Bagan's religious architecture, whose function was designed to be a place of worship and as a sacred representation of scripture. Religious architecture became an all-embracing art form, where Buddhist subject matter is depicted in architectural motifs, art wall paintings, statues and woodcarvings.

Therefore, religious architecture can be intended as the product of communities that play an active role to promote and support (physically and financially) the development of religious buildings. Religious donations were and are the main system that guaranteed the

[35] The construction and maintenance processes had very strong meanings; for instance, contributions to the renovation or maintenance costs were considered a great merit. Another example is provided by the act of carrying bricks, which was done in company of the people with whom one wished to be reunited in the next lives (Thanegi, 2005), p. 96.

construction and maintenance of religious structures. As John Falconer, Elizabeth Moore, Daniel Kahrs, Alfred Birnbaum, Virginia McKeen Di Crocco and Joe Cummings noted, "*[…] Bagan was a […] clear demonstration of pious donation and merit making*" (Falconer et al., 1998), p. 96. These donations promoted the architectural "*embellishments*" (Falconer et al., 1998), p. 21, and decoration as well as innovation in terms of shape, forms and structural solutions. Furthermore, as Falconer et. al. reported, *"eclecticism and variation mark all of Myanmar's religious architecture. The variation in temple form encouraged an equally broad repertoire of interior donations.*" (Falconer et al., 1998), p. 24. Relations between donation and construction or maintenance of Myanmar religious architecture are also addressed by another researcher, Anna Laura Kraak, who analyzed the relationship among making process in religious heritage architecture and the concept of merit making[36].

Religious architecture in Bagan usually presents masonry structures, mainly in clay bricks, even if there are some monuments in stone (such as Nanpaya in sandstone).

Meanings and values related to religious architecture range from the significance of the constructive materials (like the devotional meaning of some constructive and decorative elements, such as the bricks) to the meaning of the design, inscriptions, decorations (stucco and plaster works, wall paintings[37], etc.) and shape of the religious structures. In

[36] She stressed "*the belief that the construction of Buddhist buildings is a good work that accumulates merit and ensures a good rebirth or even nirvana for the donor. Hundreds of stone inscriptions and votive tablets testify to this motivation*" (Kraak, 2015).

[37] Paintings were applied to dry plaster walls. Colours came from available natural sources such as lime, ochres and charcoal mixed with other material – of animal and vegetal origins – mixed with the pigments for a better cohesion to the wall. Mural paintings in Bagan mainly present scenes from the life of the Buddha. Often there are eight events – Buddha's birth, his enlightenment, the first sermon, the twin miracles, the descent from Tavatimsa heaven, the Parileyyaka retreat when the Buddha is honoured by an elephant and a monkey, the taming of the Nalagiri elephant and finally Buddha's death and ascent – that surround the temple's main image. Usually the Jatakas – the stories that tell about the previous lives of the Buddha, in both human and animal form – are also depicted. The Jatakas consist in the story of the 550 previous lives of Buddha, usually represented in framed squares with a schematic illustration of the story elements. The Jatakas can also be presented in continuous narrative strips. According to Buddhism, Buddhas existed in previous eras. Myamar Theravada Buddhism counts 28 previous Buddhas, usually depicted in a row at the topo of a wall (Falconer et al., 1998), p. 32.

the Nanpaya temple, for instance, bricks were donated by the surroundings villages as showed by the stamps on the sandstone bricks reporting the name of the donor village (Falconer et al., 1998). Apart from the specific case of Nanpaya temple, this was common to many other temples in Bagan as evidenced by several ancient found bricks indicating the name of the village where they were fabricated or of their donors.

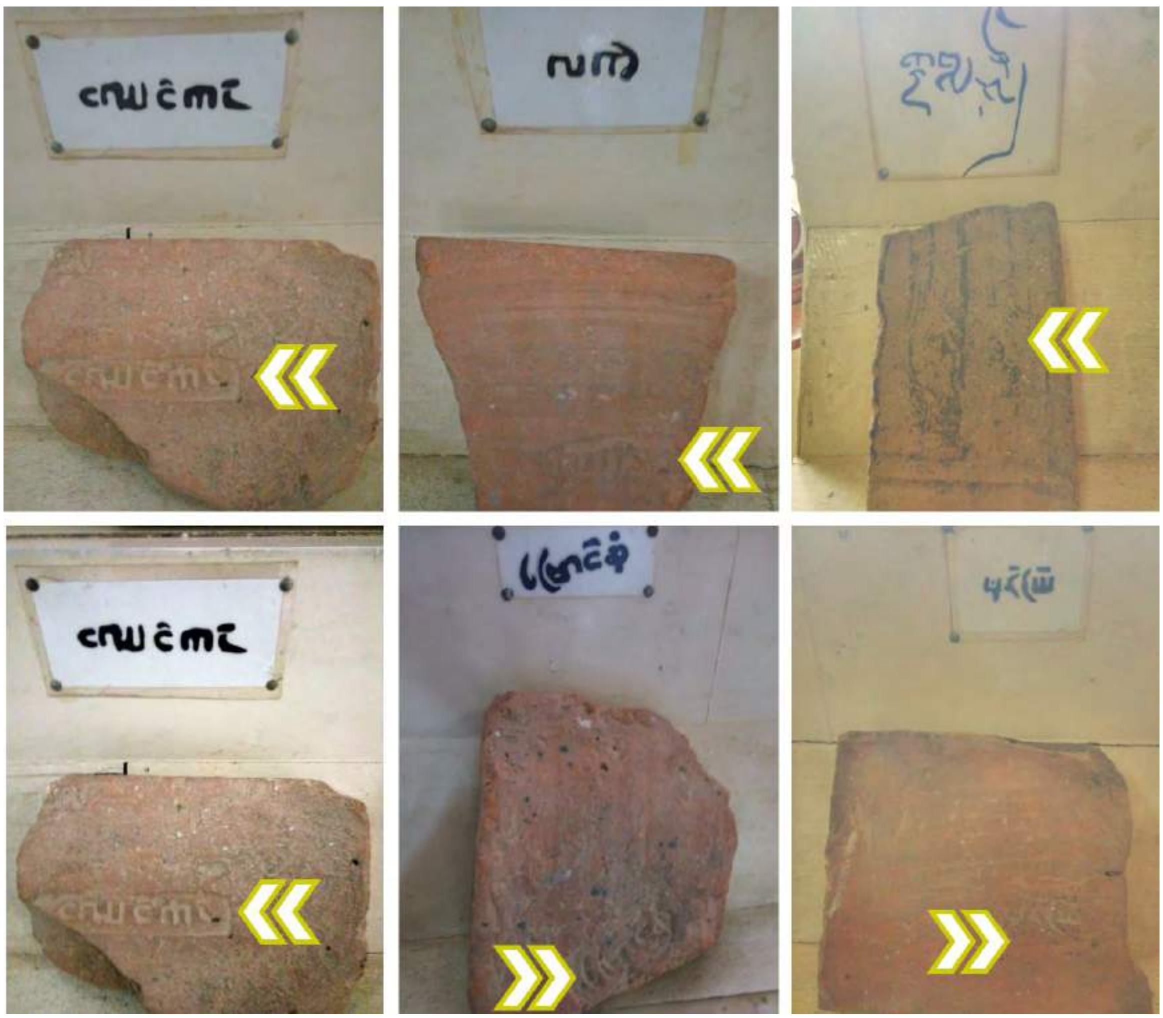


Figure 42 Examples of different ancient bricks indicating the name of the village where they have been manufactured. Bricks conserved at the Archaeology, Bagan. Image source: Author.

As already anticipated, most of Bagan’s stupa and temples are constructed in bricks and then coated by combining glazing, stuccowork, and painting. In many cases, stupas were decorated with terracotta plaques and temples decorated with plaster, stucco works and wall paintings inside. Influences in term of architecture typologies and decorative apparatus derived mainly from the Ayarwaddy River, water infrastructure for trades and exchanges, as well as the interaction with Bengal in Northeast India, Tibet and traders from the Silk Route. Apart from these influences, architectural shapes, forms and decorative motives are the consequence of each donor *"[...] wishing to outdo his or her predecessor in order to accumulate ever-greater merit, or they may be a result of religious preferences"* (Falconer et al., 1998), p.32.

As already mentioned, religious architectures in Bagan include three typologies:

1. Stupas;
2. Temples[38];
3. Monasteries.

The main difference between stupas and temples concerns the accessibility and use of the building. Indeed, the stupa is a monumental structure meant to commemorate the Buddha or his memorable deeds. Stupas may have many different contours, but, bell-shaped stupas are most common for the larger stupas. Temples instead are places of worship, devotion and meditation totally accessible to the public[39]. Generally, these buildings house Buddha images or contain sacred relics.

[38] Bagan temples present different typologies: central-shrine temples, temples with a solid core, with a central shrine and corridor, two-storY, three-storY and four-story temples.
[39] Even if in the past their accessibility was ruled by a complex hierarchy distinguishing between monks and common people, currently they are accessible by everyone.

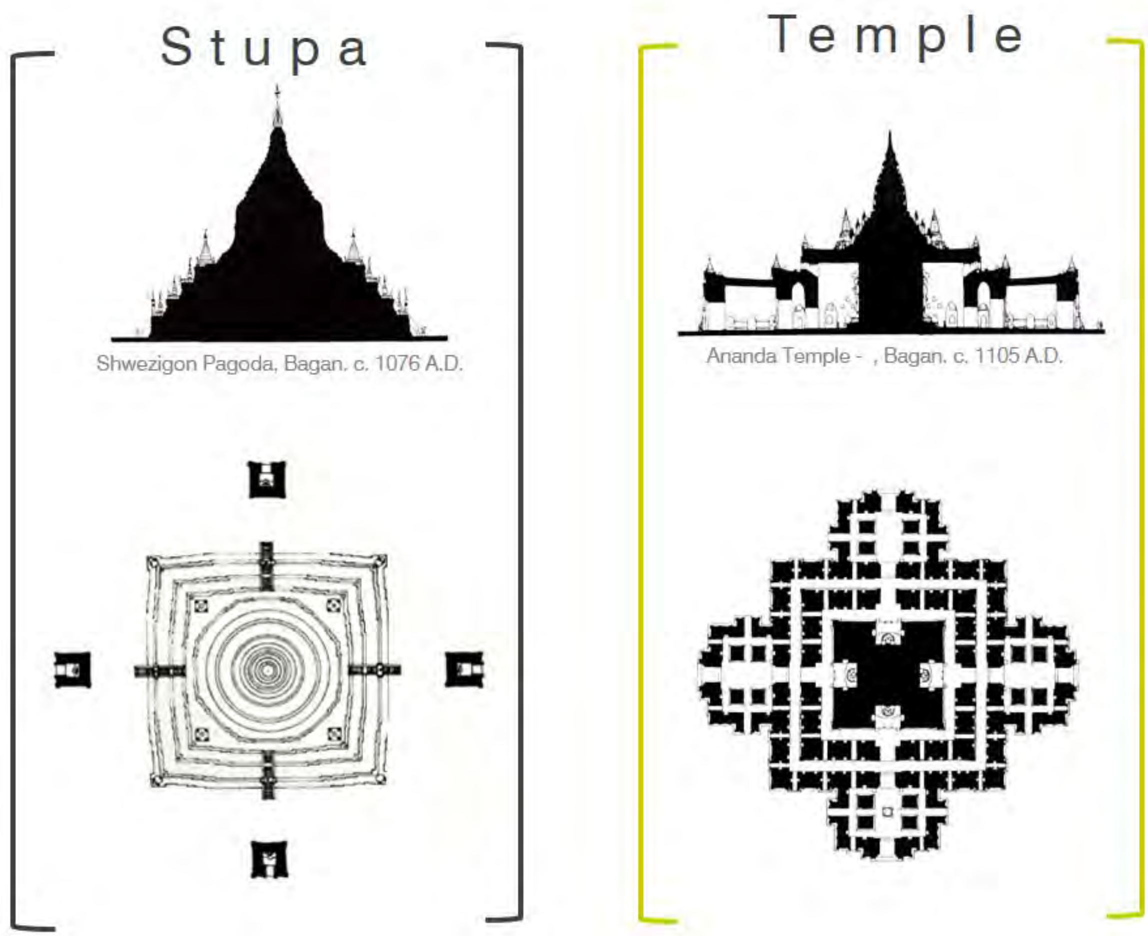


Figure 43 Image illustrating the main difference, in terms of accessibility, design and spatial distribution, between stupas and temples (Mezzino, Quintero, Pwint, Latt, & Rellensmann, 2016).

6.4.2 Temples, Stupa, Palaces and Monasteries

Temples

There is no precise architectural evolution of the Burmese temples, as their influence was drawn from numerous sources throughout their construction. However, there were certain characteristics of construction techniques found to be more prevalent among certain peoples or during certain timeframes.

An analysis of the historical development of the area is useful for understanding the evolution of Bagan's architecture. The first Burmese kingdom underwent a construction frenzy that would never again be equaled in the following periods (Cocks, 1919), p. 22. Gordon Luce, in his book *Old Burma-Early Pagan*, has divided Bagan temple architecture into four main periods (G. Luce & Rhan, 1969), p. 283:

1. Pre-Aniruddha Period
2. Reign of Aniruddha (c.1044-77 A.D.; also known as Anawrahta)
3. Reigns of Sawlu, Kyanzittha (1084 – 1113 A.D.), and Cansu I
4. Transitional Period (1113 -74 A.D.)

Temples in Bagan were built as places of worship and devotion, and often they contained relics and sacred objects. In Myanmar, they are meant more specifically for the worship of Buddha images. Both stupas and temples were influenced by eastern Indian architecture.[40] According to Ma Thanegi, "*the earliest temples of Bagan were evidently styled after the Bebe and Lemyethna temples of Thayekjittaya. They have a basic square shape with the Buddha image set against the far wall opposite the main entrance. The interior of darkness is relieved only by a few perforated windows"* (Thanegi, 2005), p. 36. As already mentioned in Paragraph *6.4.1 Architectural typologies and urban features*, the desire for a dim praying space was likely from Indian influence (who would have influenced the Mon and Pyu) (Stadtner, 2013), p. 64. The Burmese would later intervene and introduce bright temples as their preference; the Shwe-gu-gyi under king Cansu I is considered the first significant temple of Burmese architectural style.

[40] (Stadtner, 2013), p. 63. An example is the design of the curvilinear tower – shikhara – that, as a matter of fact, can be found in the ancient Sanskrit Indian architectural manuals. Another example are the architectural motifs, such as frieze of *kirtimukhas*, which can be found in Orissa at Lalitgiri. Then, from a spatial point of view, the basic floor plan disposal is also an Indian legacy. Indeed, sanctum preceded by a covered porch was a standard plan disposal for Indian temples.

The so called Burmese style, whose name's origin is probably related to the simultaneous development of the Burmese language, has as main features arched doorways and windows that supplied air and light. This style includes also the architectural typology of the double-storied temple particularly challenging from the structural point of view[41]. The Burmese style fosters the use of stone, smaller bricks and voussoir arches in order to improve buildings strength.

In terms of plan disposal there are two main typologies. The first one is based on a solid-core encircled by a vaulted corridor and the second kind is a hollow-core temple, with an open-vaulted shrine often surrounded by a vaulted corridor too (Stadtner, 2013), p. 62. Temples of these type are rectangular or square-shaped in their ground plan. This is a broad classification, and variations of these two ground plans can occur. As an example, the famed Ananda temple is based on a solid brick core, whereas Loka-Hteik-Pan contrasts by featuring an open-vaulted shrine. Loka-Hteik-Pan, as illustrated in the next section (Chapter 7 - *The Zètema of the Loka-hteik-pan temple*) is a variation of the hollow-core temple. Its builders decided not to include a vaulted corridor around its hollow-core.

Temple development began with one shrine, and then expanded into multiple shrines. To accomplish this, inner load bearing elements had to be developed, such as the addition of columns (Lat, 2010b), p. 64. Typically, a single shrine would have one Buddha situated in the centre, and the ones with multiple shrines would have four Buddhas facing each cardinal direction. As a distinct separation from Indian architectural practices, Myanmar developed peculiar vaulting techniques that allowed for wide spans of the interior.

[41] To reduce the load and quantity of building material the vaults were staggered.

Other types, such as the pentagonal or octagonal-type, are present in Myanmar but are very uncommon. These temples, in comparison, would have 5 or 8 Buddhas seated at the main shrine. Five-sided Buddhist temples are unique to Myanmar, and found nowhere else in the world (Stadtner, 2013), p. 262.

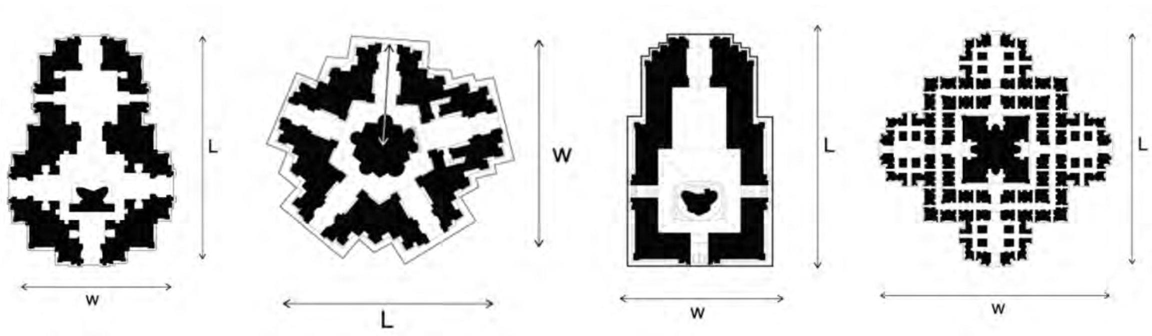


Figure 44 Examples of different Bagan temples typologies. Image source: Author.

In term of design, as previously mentioned, temples needed to purse a double goal. In order to have ascension effects, high heights were required on the outside; at the same, the worship function in the inside had to be preserved.

Figure 45 Upper terraces of the Eim-ya-Kyaung-nga-myet-hna temple. The design of the roof and the stupa disposal was aimed at evocating ascension effects. Image source: Author.

Hence, a proper construction system was developed in order to have double vaults having lower spaces inside and higher heights outside (Stadtner, 2013). For the same reason temple's roof were designed with a lower quote than the temple itself stressing the sense of progression (Stadtner, 2013).

Figure 46 Khe-min-ga-zedi temple. The photo, taken with a drone, illustrates the dramatic effect of the upper part that looks higher thanks to the contrast with the lower roofs. Author: Scott Lee, CyArk.

From the decorative point of view, entrance halls and corridors were usually decorated with wall paintings. The main purpose of these artworks was educational. Indeed, books were extremely expensive and wall painting decoration was an efficient way to disseminate stories about Buddha, thus increasing people awareness (Thanegi, 2005).

Figure 47 Example of interior mural painting, Loka-hteik-pan. Source: Author.

Sculpture as decorative art was also used to fill the numerous niches in the indoor and sometimes also outdoors of the temples.

Most of the temples present, both in the interior and exterior, large areas of plain wall surfaces with juxtaposed stucco ornament. The most decorated parts with this technique were the top and the basement of the walls. The top parts of the wall were usually decorated with a frieze of *kirtimikhas*, made of stucco. The uniqueness of this frieze consists in its figures that represent a monster face (*kirtimikhas* can be translated with the term ‘ogre’) with bands of foliage or pearls descending from their open mouths (Stadtner, 2013).

Figure 48 Examples of indoor and outdoor niches in Bagan temples. Source: Author.

Figure 49 Example of frieze with ogre face with bands of foliage or pearls descending from their open mouths in the Phya-sa-shwe-gu temple. Image source: Author.

Temples decorative apparatus

Bagan art wall paintings display not only the excellent artisanal skill of the Ancient Burmese, but also their avid devotion to the Buddhist religion[42]. Bagan is one of the most important devotional sites to Buddhism, holding Southeast Asia's largest collection of murals from the XXI to XIV centuries (Falconer et al., 1998), p. 155. The majority of the paintings are narrative pieces, meant to be stories depicting Buddha's life. For many years up until the XVIII century, art wall paintings were almost entirely religious in subject.[43]

Ancient Bagan's pious observance to Buddhism prompted their art wall paintings to be didactic in nature, often encouraging the community to lead a faithful life. To aid with comprehension, bands of writing – also called *glosses* - are commonly found underneath *Jatakas* paintings– the 547 lives of Buddha before he was born as Prince Siddartha Gautama (Falconer et al., 1998) p.72. An additional purpose for these paintings was for an individual to build internal merit by devotion, making the paintings serve an iconic function (Stadtner, 2013) p. 76.

In addition to the *Jatakas*, there are several recurring themes that are frequently illustrated within the Bagan temples, each one related to the Buddhist faith. These include

[42] The historical development of Myanmar strongly impacted the development of Bagan art wall paintings. King Anawrahta royal patronage provided a strong foundation for the development of devotional buildings, allowing paintings and early art-forms of Bagan to take root. Although art wall paintings were not very prevalent, Luce writes that this was the best period for unglazed Jataka terracotta, which carried Buddhist thematic material often found in art wall paintings (G. H. Luce et al., 1969), p. 283. However, without a proper doctrine, the thematic material was limited.
The arrival of the full Tripitaka texts, the sacred canon of Theravada Buddhism, written in the Pali language (Oxford living dictionary, 2017), introduced a wider variety of topics that resulted in artists painting more themes in wide-wall spaces of temples. This period saw the Mon fine arts at their best, and many paintings can be found with rich, deep, warm colouring – characteristics of Mon style painting (Shin, 1962), p. 4. Paintings with Mon characteristics have been found as early as the Reign of Anawrahta and have extended well into the Transitional Period.

[43] `*In the 18th century, scenes of both court life and daily life of ordinary people began to appear, especially in the Konbaung Dynasty (1752-1855). After the takeover of British Rule in Burma in 1824, Bagan artists began to incorporate Western influences such as the use of linear and aerial perspective*` (Falconer et al., 1998), p. 160.

the *28 Buddhas* who have appeared in this present universal cycle, the *Eight Grand Events* of Siddartha Gautama, and the *Life of Buddha* (Falconer et al., 1998), p. 126. Whereas the stylistic presentation of these paintings may have changed, the thematic matter has remained relatively the same throughout the centuries.

Hand in hand with the frequently painted religious themes are the appearances of symbolic images related to Buddhism, usually used as temple adornment. These symbols hold greater significance than as simple ‘decoration’ by carrying deeper emblematic meanings, including:

Table 3 Table outlining main symbolic Buddhist images used to decorate Bagan temples. Source: Author.

Footprints of Buddha	Footprints were meant to symbolize Buddha's presence or his legendary visits, and are often found impressed upon rocks (Hasan, 1993) p.336.
Lotus Flower	Often used as the Buddha's throne; the lotus flower signifies the soul's ascension to enlightenment, beginning from the mud, river, to the light (Patry Leidy, 2009), p .30.
Bodhisattva	Bodhisattvas are beings who reached enlightenment but chose to return to earth to help others find enlightenment; they are typically portrayed wearing earthly riches such as jewels and crowns (Patry Leidy, 2009), p. 39.
Bodhi Tree	The Bodhi Tree is a symbol of Buddha's presence and an object of worship; it was believed to be the tree which the Buddha sat underneath on the night he attained enlightenment (Shin, 1962), p. 401. The Banyan Leaf comes from the Bodhi Tree.

Bagan wall painting as a tangible example of multiculturalism and cultural exchange: the Indian influences

Bagan’s art wall paintings were stylistically affected by art of the surrounding regions, and were also subject to Indianization. It is widely acknowledged from multiple sources that these influences originate from a variety of regions in India, including (but not limited to) the V-VI century Gupta Dynasty from northern and eastern India, XXI century Pala Dynasty of West India and present-day Bangladesh, and even from the Sinhalese people of northern India (Galloway, 2011), p.72. In particular, these influences brought stylistic depictions and methods of making sculpture, decorations, and art. Despite different methods of portrayal, Bagan art wall paintings still carry similar stylistic elements. Figures were generally presented in a two-dimensional manner without the use of shading. The forms of these figures were outlined with a clear black line and then filled in with a solid color. Perspective, in terms of the Western vanishing point, was not present. However, there was an attempt to create depth and perspective by the relative positioning and overlapping of figures (Falconer et al., 1998), p. 155.

Since the V-VI centuries, both the Pyu and the Mon were in constant contact with South India by the sea, allowing for a variety of cultural exchanges. Evidence of their contact is shown by the Pyu's acquaintance with Sanskrit Buddhist texts and by the Mon's adoption of the south Indian alphabet and its adaption to suit their own language and literature (Shin, 1962), p. 21.

Apart from sea trade, Indian influence was brought over by the flows of immigrants during the Reign of Kyanzittha (1084-1113 A.D.). While the Burmese had been perfecting their Buddhist religion and art under the support of royal patronage, the Hindus had begun a rigorous campaign of driving out Buddhism from India (Shin, 1962), p. 22. Fearing religious persecution, many Indian immigrants took refuge in Burma, bringing with them a wide knowledge of language and literature, architecture, and of course, their artwork[44].

[44] Examples can be found in the portrayal of images in Bagan. The portrayal of Buddha himself was often varied. The Pyu, who were active during the V century, would depict Gupta-style images of Buddha, and in the VII century, these images would change to look more like the Pallava and Pandya styles of southern India (Falconer & Invernizzi, 1998), p.133.

As an example, the origins of Loka Hteik Pan's interior south wall can be traced directly back to Pala Buddhist Art (Shin, 1962), p. 12. The artist has arranged the *Eight Grand Events* of the Buddha in the same manner as Pala Buddhist Art, with seven scenes framing the central eighth scene of the Buddha. In the West Wall, the last ten *Jatakas* appear to follow the Sinhalese order (Shin, 1962), p. 12.

In terms of materials, Bagan art paintings used five colours, consisting of red, white, black, blue/green, and yellow. Most of these colour pigments were made from natural ingredients, such as soot as black colour and lime for white colour. The red colour was made from iron, yellow derived from clay stone, and blue was an imported material from India. Walls were coated with plaster before the paint was applied on it. During the XIII-XVIII centuries, the brick was further chipped for better adhesion of the plaster (Falconer et al., 1998), p. 155.

Furthermore, many temples present also glazed ceramic tiles mainly employed to decorate the high base moldings.

These aspects allow to appreciate the significance of the selected case study for the collection, organization and management of information relevant to built heritage conservation, as explained in chapter 7 - *The Zètema of the Loka-hteik-pan temple* and in chapter 8 - *Combined uses of BIM systems and Wiki approaches to collect and archive quantitative and qualitative information.*

Figure 50 Ananda temple. Example of glazed ceramic tiles that decorate the high base moldings. Source: Author.

Stupas

The term stupa derives for the Pali, Snaskirit term cetiya (Stadtner, 2013), and denotes a Buddhist structure that, in Myanmar as in other countries, enshrined relics[45]. Myanmar builders have blurred the usage distinction between temples and stupas, where temples often also carry relics and feature a stupa-like dome. Stupas, although accessible by public, are more iconic in nature and serve the purpose of acting as a landmark in terms of the city's urban design (Stadtner, 2013), p. 58.

These structures change, in term of shape, geometry and spatial configuration, depending on the period in which they were built and on the geographical context. India stupas[46] for example *"were semi-hemispherical in shape and crowned with multiple stone umbrellas*[47]*"* (Stadtner, 2013) p. 59. As mentioned, different types of stupas were adopted by the Mon and Pyu peoples, namely the bell-shaped stupa, prevalent among the

[45] As Stadtner reports, relics include meaningful and auspicious objects, such as body remains of Buddha or other objects used by him (from the alms bowls to his tooth-brush) (Stadtner, 2013).

[46] According with D. P. Crouch and J.G. Johnson, when after the II century B.C., Buddhism religion spread in north, south and east Asia, stupa's shapes were modified according to regional modifications depending on the religion change as, for instance, the Theravada Buddhism in Myanmar. (Crouch & Johnson, 2001).

[47] As noted by Stadtner, the umbrella stands for veneration of Buddha, sacred object or more generally royalty (in Indian contexts).

Mon (Wales, 1973), p. 16[48] and a high-cylindrical body with a terraced base, widespread among the Pyu (Wales, 1973), p. 15. The bell-shaped stupa remains the most commonly found stupa in Bagan.

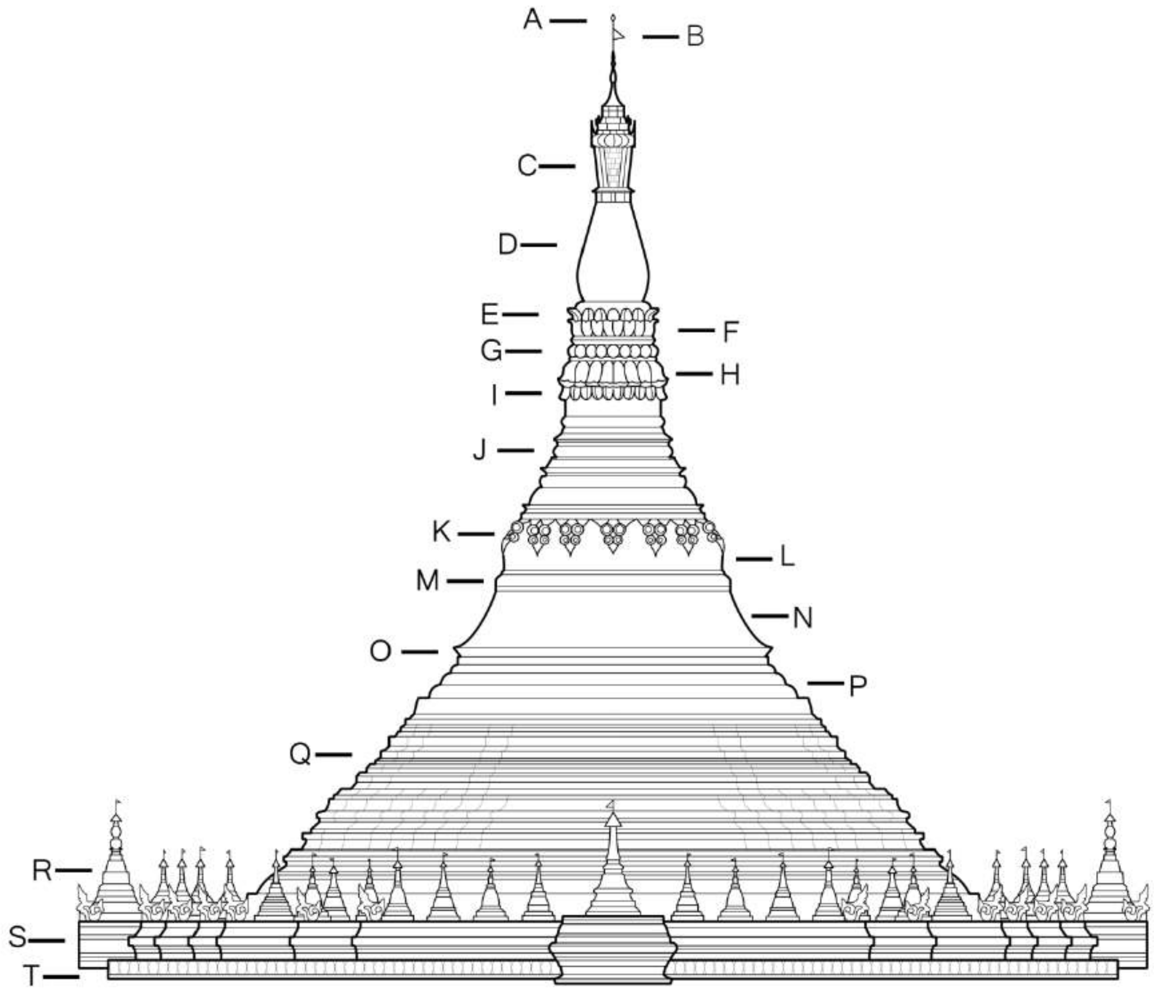
In the case of Bagan, stupas usually stand on octagonal and squared terraces or podium; above these terraces there is a bell surmounted by different shapes, whose order is, from down to top: rings, petals of the lotus flower, banana bud shape[49] (also known as hngetpyawbu), the umbrella (hti), the flag like vane and finally the orb that symbolizes the Nirvana (Falconer et al., 1998), p. 21.

Most of the original crowning above the umbrellas, indicated by closely spaced brick rings within the spire of the stupa (Stadtner, 2013), have fallen in the years due to earthquakes and other deterioration agents. According to Stadtner, this crowning might have consisted in a *"tapered bud-shaped object resting upon a single or double layer of lotus petals"* (Stadtner, 2013), p. 59. One of the symbolic meanings associated with shrines, stupas, and temples is their verticality that represents Mount Meru, considered as the centre of Buddhist cosmos.

As another important consideration, stupas can be difficult to accurately date due to the Buddhist practice of rebuilding upon broken stupas (Lat, 2010b), p.59. Buddhists at that time believed that religious structures cannot be fully cleared away even after its collapse because the site in itself is still sacred.

[48] An example of this is the West Hpetleik temple

[49] The shape of the banana could recall the position of two hands held in prayer.



A DIAMOND ORB
B GOLD BANNER
C UMBRELLA
D BANANA BUD
E TENDER LOTUS
F UPTURNED LOTUS
G GLASS BAUBLES
H INVERTED LOTUS
I TENDER LOTUS
J EMBOSSED WRAP
K Flower Sprigs
L Inverted Alms Bowl
M Bosom Wrap
N Bell
O Rim of the Bell
P Brass Coils
Q Octagonal Ridges
R Small Stupas
S Flower Platform
T Royal Footwear

Figure 51 Image illustrating the different components of a stupa. Image source: Ma Thanegi, Myanmar Architecture cities of gold, (Thanegi, 2005), p. 100.

Despite the challenge of determining the time period, one positive outcome of such practice is a beautiful patina accumulation on some of the stupas in Bagan[50] (Lat, 2010b), p.59.

Although the shape of stupas may vary, the so called bell-shape is the most common in Bagan, even if some examples of hemispherical shape can be found.

Monasteries

Monasteries were simply built according to Buddhism precepts. They served both as dwellings and meditation places for the monks (Falconer et al., 1998), p. 59.

Ma Thanegi reports that the monasteries were built in "*alignment with the east-west axis […]*" (Thanegi, 2005), p. 96 and raised on a "*platform with an open patio around it […] where monks can walk up and down while meditating"* (Thanegi, 2005) p. 96. Usually, monasteries were designed to guarantee good air circulation and adequate shade using for example protruding eaves. This kind of building type was built for religious purposes as well as for educational ones. Many of them were in fact also used as schools run by the monks. Further, monasteries were also a refuge for orphans and homeless.

Due to their purpose, monasteries were and are often built adjacent to, if not connected to, an existing temple and or stupa. They come in a variety of shapes and sizes, and *"range from large complexes with numerous secondary structures to small, single-cell buildings standing alone*" (Stadtner, 2013), p. 66. Bagan monasteries were typically in a rectangular-shaped plan, and later monasteries were developed with more spatial requirements. According to Kyaw Lat, more sophisticated monasteries included four spatial zones (Lat, 2010b), p. 68:

[50] One stupa found at Tagaung, the Shwezigon, revealed the styles of three periods, Pyu period from VI century AD, Bagan period from XI century, and from the Pinya period in the XIV century.

1. Public Zone (typically an open hall with timber roof);
2. Common Areas (within the main structure);
3. Zone for shrine and Buddha image (within the main structure, usually in a central location);
4. Zone for individual cells (sleeping quarters).

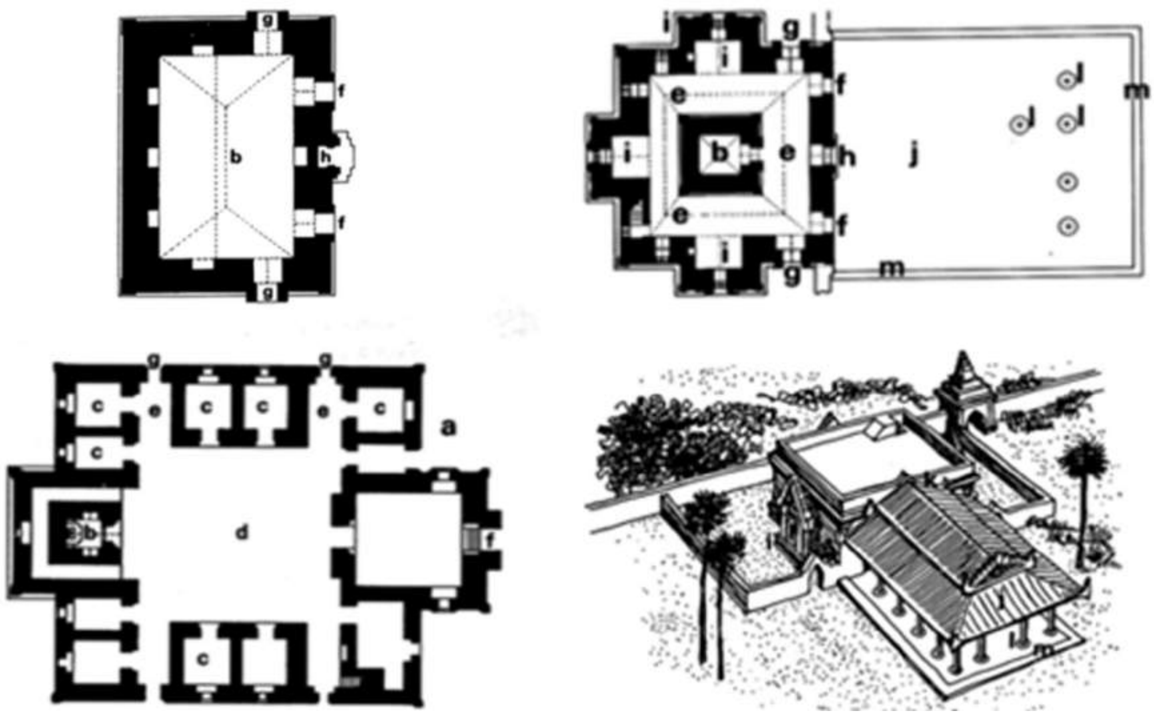


Figure 52 Example of monasteries in Bagan temples. Source: Pichard, P. Inventory of monuments at Pagan. (Pichard, 1992).

The exterior of monasteries were often also adorned with stucco, similar to their temple counterpart. It was, however, unusual for the interior walls to be decorated since they were often left bare or decorated simply (Stadtner, 2013), p.67.

Figure 53 Ananda-oke-Kyaung monastery built next to the Ananda temple (from the image it is possible to appreciate the whitewashed wall fencing Ananda temple). Image source: Author.

Figure 54 Example of wooden monastery in Bagan. I Image source: Author.

Secular Architecture

Secular architecture in Bagan is strictly related to the presence of kings, their royal courts and a large community of monks that induced the development of new buildings and infrastructures such as palaces and dwellings. Nevertheless, secular architecture was also partially affected by the Buddhist religion. Common motifs and symbols of prestige were depicted in the royal court[51].

Secular buildings were constructed completely in teak wood widely available and resistant. Despite the use of the same material, the design and ornamentation of the homes of court members were ruled by strict laws differentiating these buildings from the non-royal structures. Usually, these wooden buildings were normally raised above the ground level to protect dwellers from flooding during the monsoon period, and they had an under floor ventilation making interior environments cooler and the building resistant to extensive damp biological and botanical agent such as insects and fungi. Furthermore, building materials like teak, bamboo wood and thatch are largely available, adapt to the form and function of the buildings and possess good insulation properties, avoiding the transmission of heat into the inside of the living areas (Falconer et al., 1998), p. 62. Because of climatic causes, natural factors such as floods, wild fires, earthquakes, biological and botanical agents (insects, fungi and bacteria) and man-made threats (mainly fires, wars, theft, and purposeful alteration and relocations), most of the wooden structures decayed.

[51] In the Mandalay Palace, for example, wooden thrones of the king were carved to resemble the basis of a Buddha statue as a sign of power and wisdom (Falconer et al., 1998), p.59. Additionally, the architectural motifs of the Mandalay Palace often included mythical creatures depicted in Buddhist literature and floral patterns found in temples (Wales, 1973), p. 93. Above the throne of the Mandalay were arches decorated with sixteen Buddhist *deva* figures.

Figure 55 Example of dwellings in the Bagan area. Image source: Author.

Materials

The main constructive materials employed in Bagan were fired bricks.

The knowledge of fired brick which started in China in 2000 BC (Plumridge & Meulenkamp, 1993), p. 13, and it was diffused from India to South Asia through the Buddhism culture.

In the case of Bagan, the adoption of bricks as main constructive material was also supported by the proximity of the Ayarwaddy river which provided the perfect natural environment for clay extraction for bricks production. Therefore, easy availability, cost, cultural influences, natural resources easy and fast production were the main factors that brought to an extensive use of clay-bricks in the construction of Bagan built heritage.

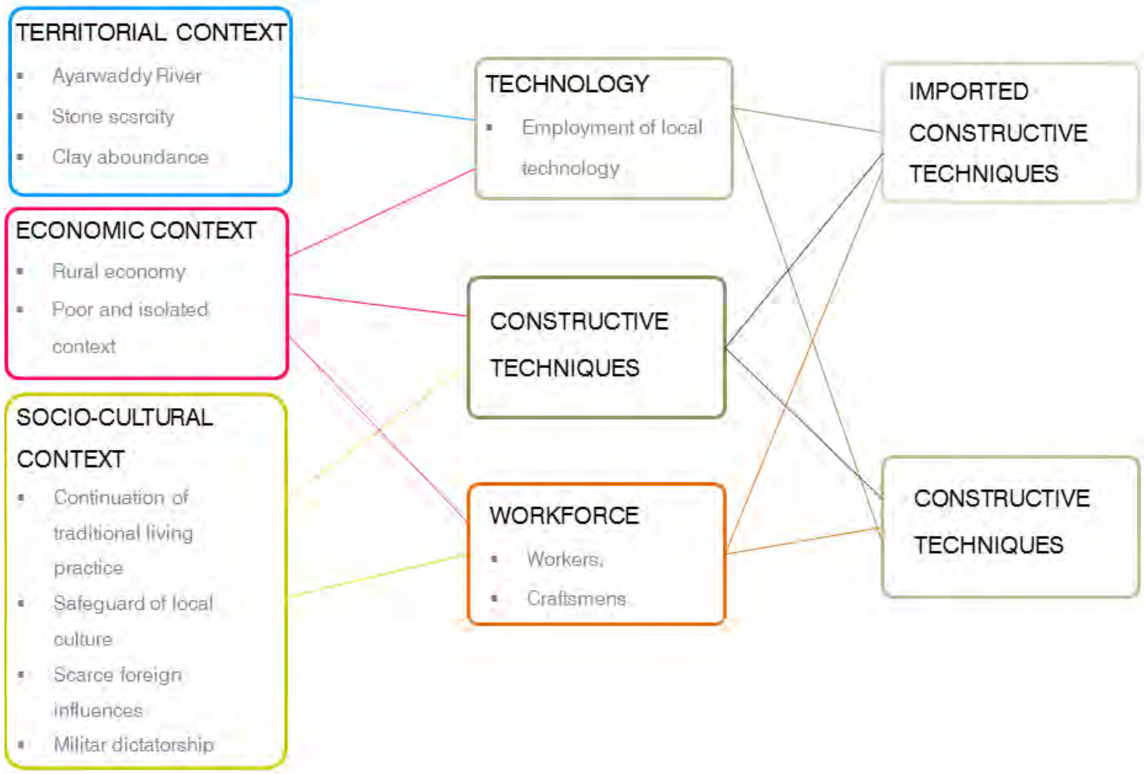


Figure 56 Factors that influenced the adoption of bricks as main construction elements. The same factors are also relevant in justifying their use in maintenance and repair actions. Image source: Author.

In Bagan bricks manufacture processes are not recorded and only orally transmitted. Meanings and values of these constructive elements, such as bricks, range from the significance of the building materials, including the religious meanings[52], to constructive solutions and mechanical properties (i.e. bricks cooking procedures and temperatures of the original bricks compared to current ones).

Bagan's structures, predominantly constructed in brick masonry, used to be coated and decorated with stucco. Today, much of the stucco coating and exterior decorative carvings are gone. However, the interiors of many of the temples still contain mural

[52] Bricks were donated by the neighboring villages as form of devotional practice(Falconer et al., 1998).

paintings and contemporary stone inscriptions documenting the social and political history at the time of their construction. Mud bricks were a versatile medium used to construct the majority of religious structures in Bagan. The Ayeyarwaddy River provided material to make the brick, and also allowed for bricks from elsewhere to be shipped into Bagan by bamboo rafts (Lat, 2010b), p. 85. Brick was a common material dominating South East Asia, and has remained the main construction material for religious architecture in Myanmar (Stadtner, 2013), p. 46.

In terms of production, one could imagine the vast number of bricks needed to construct a single monument. The Dhammayazika required an estimated 6 million bricks, and it was not uncommon for monasteries to consume half a million bricks (Stadtner, 2013), p. 46.

Figure 57 Dhammayazika pagoda, southern part of Bagan. It is one of the largest stupas in Bagan, according to estimations on its volume, approximately six million bricks were employed for its construction completed in only two years (1197-1198). Source: (Mapio, n.d.) and (Stadtner, 2013).

Hundreds of workers were employed for the production of bricks, whose process required several steps. Clay was stomped into the right consistency, pressed into moulds, and then fired in local kilns (G. Luce & Rhan, 1969), p. 232. Presently, bricks continue to be made in the same fashion in Myanmar.

The size of ancient bricks was larger than the one of modern bricks. The measurements taken from an ancient brick on the site was 35 x 17.4 x 4.2 cm. This is close to the recorded average size of 36 x 18 x 6 cm in Stadtner's book (Stadtner, 2013), p. 47. In comparison, the size of bricks for recent temples is recorded at a much smaller size, with a larger depth, of approximately 21.5 x 10 x 5.4 cm.

Figure 58 Comparison of the different dimensions of Bagan bricks. Image source: Author.

Figure 59 Materials used in building construction and repair. Image source: Author.

Concerning the mortar binding the brick together, it was comprised of similar compatible materials, and was applied as a very thin layer. Stadtner explains that *"binding the brick facing to the inner wall was of little concern in most cases*", causing weakness in the walls. Mortar could be composed of 9 different local ingredients including (but not limited to): clay, plant material, Kywal Kaw (plant sap), and Oat Shik Thee (Bael fruit)[53].

The built environment in Bagan did not frequently use stone as a common construction material. Stone was either used as a substitute for bricks, or in places with practical advantages from their strength, such as for cornerstones (G. Luce & Rhan, 1969), p. 231. The Ananda temple itself took advantage of the physical strength of stone by alternating it with brick in the formation of large arches. Other areas that used stone were floor

[53] Sugar presence in the mortar mixture attracted insects that partially caused its deterioration over time.

paving, doorway thresholds, and lintels and jambs (Stadtner, 2013), p. 47. There were exceptions to stone as a minor building material, such as monument 1239, NanPhaya Temple. This is a unique temple with intricate stone carvings on its interior, a rare example in Bagan whose interior has not employed carved stucco or art wall painting decorations.

The exteriors of all Bagan masonry monuments were covered with a layer of decorative plaster. In the ancient times, regardless of brick or stone, the physical structure of the monument would not be visible. Paster would be applied over the finished masonry structure, and molded into a variety of architectural and sculptural reliefs. A part for its protective function the white stucco had a symbolic meaning. It evocates the "*snow-clad Himalayan holy mountains visible on pilgrimages from Pagan to Buddha's birthplace*" (Crouch & Johnson, 2001), p. 22.

The interiors of the temples were usually decorated with art-wall paintings. Paintings[54] were applied to dry plaster walls. Colors came from available natural sources such as lime, ochres and charcoal mixed with other material - of animal and vegetal origins – mixed with the pigments for a better cohesion to the wall.

In both the interior and exterior, temples have large areas of plain wall surfaces juxtaposed to stucco ornament. The most decorated parts with this technique were the top

[54] Mural paintings in Bagan mainly present scenes from the life of the Buddha. Often there are eight events - Buddha's birth, his enlightenment, the first sermon, the twin miracles, the descent from Tavatimsa heaven, the Parileyyaka retreat when the Buddha is honoured by an elephant and a monkey, the taming of the Nalagiri elephant and finally Buddha's death and ascent - that surrounds the temple's main image. Usually the Jatakas - the stories that tell about the previous lives of the Buddha, in both human and animal form – are also depicted. The Jatakas consist in the story of the 550 previous lives of Buddha usually represented in framed squares with a schematic illustration of the story elements. Sometimes instead the Jatakas can be presented in continuous narrative strips. According to Buddhism, Buddhas existed in previous eras. Myanmar Theravada Buddhism counts 28 previous Buddhas usually depicted in a row at the top of a wall (Falconer et al., 1998), p.32.

and the basement of the walls. The top parts of the wall were usually decorated with a frieze of *kirtimikhas*, made of stucco.

Many of these motifs depicted floral or geometric patterns, a direct influence from Pala India (Stadtner, 2013), p. 49. They would cover areas like the pilasters, wall surface, friezes, mouldings, and windows[55].

According to Stadtner, the composition of Bagan's stucco is likely to be comprised of lime, water, and sand mixed together to form a thick paste (Stadtner, 2013), p.49.

Glazing was an art form that extended from the pre-unification of the first Burmese empire. It is likely that the Pyu and Mon were well-crafted in this technique. They then transferred the knowledge to the Burmese. These glazed tiles would often be colored and decorate monuments, placed as alternating dentils along the bottom of high-base wall mouldings or on the terraced rooftops. These tiles would often have stucco patterns or images on it, with a glaze applied to its surface (Stadtner, 2013), p. 50. Glazed ceramic decorations, usually in form of plaques, were made of silica, white clay, calcium, lead oxide, copper oxide, chrome oxide, vanadium oxide and feldspar (Thanegi, 2005), p. 53.

[55] Some of the themes were religious in nature as well, representing the Bodhi tree leaves.

Figure 60 Example of stucco decorations on the Loka-hteik pan temple. Images source: Author.

Makers

Bagan society developed professional groups of builders, craftsmen and masons that elaborated and perfectioned building construction and restoration tecniques. Among these professionals information and knowledge were transferred person-to-person (Crouch & Johnson, 2001) by oral instructions and by working together, in a 'learning by doing' approach. The aesthetic sense, architectural skills and construction materials used in Bagan is the result of a person-to-person interaction among professionals.

The figure of the architect is never mentioned in Bagan. Stadtner reports that architects are just sporadically referenced in some inscriptions. Recalling the definition of Bernard Rudofsky in this *Architecture without Architects* (Rudofsky, 1965), Bagan was developed by local craftsmen, a heterogeneous group of workers (including masons, stucco workers, artists, etc.) and more generally by the ‘genius loci’.

Figure 61 Brick maker at work, Bagan area. Images source: Author.

7 Chapter: The Zètema of the Loka-hteik-pan temple

As the title suggests, this chapter proposes an approach to the Zètema of the selected temple. This transliteration of the Greek term Ζήτεμα indicates the personification of Research, in the sense of rigorous and personal research of any aspect and value, in this case, associated with a historic built structure.

As a general introduction, it is worth to clarify the reasons of the adopted choices in the documentation project and of the proposed workflow.

In line with the purposes of the research, the documentation of the Loka-hteik-pan temple has been developed according to two main principles:

1) Cost-effectiveness in heritage conservation. The proposed approach takes into account budgetary limitations that characterize the cultural heritage field.

In order to provide an ethic [1] approach to document built heritage structures, budgetary constraints have been considered.

2) Awareness of the importance of the human factor. The limited availability of human resources in the heritage field, as well as the implications in terms of time and costs of training activities to adopt new approaches, technologies, and tools for the documentation, management and design of built heritage sites, have been also considered.

Hence, user-friendly software and techniques that require a low- or medium-level theoretical background and skills have been preferred, when possible. In line with these considerations, user-friendly software such as AgisoftPhotoscan was employed

[1] The term is here intended as compatible with the aims and goals of heritage conservation.

to process data gathered with structure from motion (SMF) photogrammetry. Despite its cost, the software has been selected for its user-friendly interface and for the high automation level of the software that decreases the required training time in the data processing phase. This choice was made in the awareness of other existing photogrammetric software that presents a better control of the data processing with minor automation levels and higher control of the processing phase[2]. About the processing of the scans coming from the terrestrial laser scanning the SCENE software was selected because of its schematic workflow and its graphic and user-friendly interface, as well as its availability in the CIMS laboratory[3]. Similar considerations oriented the choice of the BIM application AutodeskRevit 2016 for the 3D modelling of the documented temple, as explained in the paragraph *8.2.1 Information processing in a BIM environment: challenges, constraints and opportunities.*

Despite these considerations, during the data capturing as well as data processing phase, different workflows and tools were tested in order to provide an overview of possible alternative solutions.

The same two principles – the awareness of budgetary constraints and the implications of limited human resources - were followed in the documentation of the social, cultural and innovative technological aspects of the temple, carried out through the Rapid Ethnographic Assessment Procedure (REAP). This method, even if

[2] Other existing open source photogrammetric software include, but are not limited, to: Autodesk ReMake (https://remake.autodesk.com/about), MicMac (http://micmac.ensg.eu/index.php/Accueil), VisualSFM (http://ccwu.me/vsfm/), CloudCompare (http://www.cloudcompare.org/release/), SFMGeoref (http://www.lancaster.ac.uk/staff/jamesm/software/sfm_georef.htm), 123D Catch (http://www.123dapp.com/catch), Regard3D (http://www.regard3d.org/), Photosynth (https://photosynth.net/), Pix4Dmapper Discovery (https://pix4d.com/product/pix4dbim/), Photomodeler (http://photomodeler.com/products/scanner/default.html), and Capturing reality (https://www.capturingreality.com/Product).

[3] The SCENE sofwtare was released to the CIMS together with the Faro Focusa 3D laser scanner, employed in the on-field data acquisition, purchased by the CIMS Lab.

effective in terms of acquired information, was time-consuming and relatively costly (if we consider the travel costs, translator costs, on-site transport, and accommodation, as well as information gathering). Hence, an alternative strategy, supported by an open web platform and social media, with free access, is explored.

An integration of open web platforms with BIM application to support participatory informed conservation actions is also proposed. In all the process, attention was paid to the accuracy of the documentation process and to the loss of quality in the selection of techniques, tools, and applications adopted for the data processing phase.

Figure 1 Loka-hteik-pan temple, south façade. Image source: Author.

7.1 Considered aspects in the documentation of the Loka-hteik-pan temple

The proposed case study to test the outlined approach is the Loka-hteik-pan temple, in Bagan, Myanmar. The site is an outstanding example of living religious heritage particularly significant for the considerations of the research. Furthermore, it has a strong significance for local population who associate with it sacred as well as social and cultural values. Consequently, conservation choices become more relevant as materials, shapes, spatiality, decorative apparatus, lighting conditions, etc., have not only aesthetical values but multiple meanings for the local population and for the religious community.

Hence, the comprehensive documentation of the Loka-hteik-pan temple is aimed at identifying specific workflows of the building designers and workmen in the past, to better manage its conservation. Indeed, traditional practices are readily abandoned, forgotten and lost. Furthermore, when components are no longer manufactured it is easy to ignore or misinterpret them. A comprehensive documentation is useful because even if traditional techniques and components cannot be replicated, they can be rehabilitated or re-interpreted (Oriel & Clare, 2016).

The proposed case study shows how the recovering of local traditional knowledge would potentially enable better future decision-making, prevent misunderstandings and consequently misinformed decisions, and avoid damage and loss of value due to incompatible or invasive solutions. Furthermore, the importance of understanding the constructive systems and solutions of a building underpins its economic survival by developing an efficient management of the building itself (conservation, maintenance, etc.) and by enabling the building to perform as it was designed to.

Therefore, the documentation of the temple will include:

1. The study of the history and transformations of the temple and the analysis of its territorial, economic and socio-cultural context as well as the recording of shape, color and geometry and of the other tangible features of the physical structure (i.e. temple conditions).

2. The documentation of the creation processes of the structures (outlining the different construction phases to grasp the different phases of manual work and abilities needed).

3. The collection of information on experiences and know-how still present in local people, through a bottom-up strategy. This allows the documentation of the intangible aspects associated with the constructive and social features of the temple.

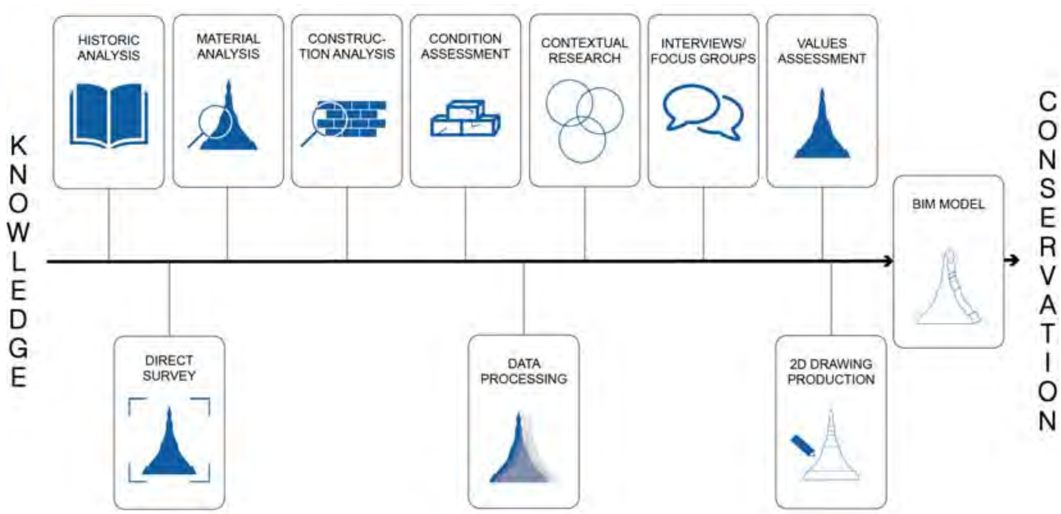


Figure 2 Diagram of the employed workflow in the Loka-hteik-pan temple. Source: Author.

Carrying out these three phases, to pursue the temple knowledge, the documentation of the tangible aspects of the temple, followed the principles elaborated by Mario Dalla Costa[4]. He defined a methodological structure to grasp the heterogeneous aspects of the built heritage (from the environmental to the historical, architectural, structural and socio-economic ones) for its thorough knowledge.

The methodological structure that oriented the documentation is reported in the table below. For each analysis is described the type of analysis and investigations that have been carried out as well as the resources used.

[4] He is an architect and Full Professor at the Politecnico di Torino.

Table 1 Adapted from Mario Dalla Costa (Dalla Costa, 2000), p. 22-24. Elaboration made by the Author.

BUILDING KNOWLEDGE			
Analysis			Analysis, sources and documentation strategies carried out on the Loka-Hteik-Pan Temple.
	1.1.1 Identification of the building in its relation with the site (urban context and natural landscape).		Understanding of the relation between the building and its built and natural context through geographic studies, territorial analysis,direct observations and interactions with professionals, researchers, and stakeholders involved in the Bagan natural and urban environment.
	1.1.2 Identification of the building in the existing inventories, legislation in terms of built heritage conservation and planning tools		Analysis of the "Inventory of Monuments at Pagan", inventory edited by the UNESCO in 1992. Analysis of the Myanmar legislations and regulations concerning protected areas, land uses and zoning. Study of the published available material for the ongoing nomination file for the inscription of the site in the WHL.
	1.2.1 Building history (reasons and implications connected to the building construction), repairs, transformations and reconstructions.		The temple history has been analyzed through the study of direct and indirect sources. Information on repairs, transformations and reconstructions are available only from the second half of the XX century. Most of this information has been deduced from the comparison of graphic sources (images) and from whenever available written sources.
	1.2.2 The original architectural culture and that one of the building transformations		Information on the original architectural culture came from the translations of the few existing secondary historical sources and from direct observations and personal communications with local knowledge keepers. Secondary sources such as technical reports, scientific papers, books as well as direct observations, provided information on the architectural culture of the latest transformations of the temple (from the second half of the XX century).
	1.2.3 The building site and the conservation of transformed and added parts		Secondary sources, direct research and ethno-demographic analysis, provided information on building site management and on the attitude towards reconstructed and transformed parts of the temple.
		1.3.1.1 Photogrammetric, photographic and geometric survey of the building including information of its shape and substance.	The survey included several techniques: total station, photogrammetry, terrestrial laser scanning, digital photography and IR camera. These techniques allowed gaining metrical information on the building (i.e. geometry and shape) as well as qualitative information (i.e. color). Since these techniques were not able to capture data of the interior structures, information

			derived from local knowledge keepers (craftsmen and masons) and partially from written and graphic sources.
		1.3.1.2 Graphic representation of the geometry, shape, and substance of the building	Data processing of the direct survey outcomes. Development of 2D measured drawings. Generation of a measured 3D semantic geometric model in a BIM environment.
	1.3.2 Indirect survey	1.3.2.1 Analysis and interpretation of existing graphic materials, texts and archival sources.	Research and analysis of translated texts and graphic material. Archival resources were very limited.
		1.4.1.1 Identification of the iconic model of the building, of the shape, of the roof and of the main cultural elements.	The identification of the structural part has been developed through the study of technical reports such as that one developed by the Institute of Earthquake Engineering and Engineering Seismology of the University "Kiril and Metodij" - Skopje[3], in the early '80s, describing the results of the structural analysis carried out for the repairs and reconstructions after the strong earthquake of the 1975. These reports describe the bearing elements as well as the loads' disposal. Structural information on the Loka-hteik-pan temple derived also from personal communications with engineers and architects involved in the temple repairs and restoration.
		1.4.1.2 Geometric and design schemata, constructive geometry, modular aggregations, main geometries employed.	The analysis of the geometric schemata and of the main design typologies and geometries employed derived from the direct survey of the building. Information on geometric schemata and main geometries employed resulted from the 3D modelling of the temple.
		1.4.2.1 The static-structural model of the building, the analysis of the foundations, of the vertical bearing structures, of elements of reinforcing elements (i.e. buttress).	This analysis was mainly developed through visual and indirect analysis. Real structural models and loads were not calculated for the temple.
		1.4.2.2 Physical and mechanical features of the building structure in relation to the building materials.	The identification of the physical and mechanical features of the temple structure in relation to the employed materials (i.e. clay, lime, etc.) was developed through visual analysis, personal communication with local and non local conservation experts, technical reports study.
		1.4.3.1 Identification of the spatial model, of the indoor and outdoor connections	Spatial analysis were developed through visual inspections and deepened in the direct survey as well as in the 3D modelling phase.
		1.4.3.2 Identification of the use level of the building spaces, differentiated between private, public and functional spaces.	The identification of the temple use was carried out through historical analysis and personal communications with individuals and experts. Similarly, information on past hierarchies in the use of the spaces of the temple was found through historical analysis and constant dialogue with locals.
	1.4.4 Analysis of the materials and technologies used	1.4.4.1 Identification of the physical-mechanical, physical-chemical, technological and functional features of the building materials.	The understanding of the material properties has been carried out through chemical analysis, visual inspections and analyzing bibliographic resources.
	1.4.5 Architectural style	1.4.5.1 Identification of the architectural elements considered in	The study of the architectural style was carried out through bibliographical resources and visual inspections.

		relation with their structural, functional and symbolic/decorative role. Understanding of the correlations among each structure and of the relation between shape and substance.	
1.5 Socio-Economic assessment	1.5.1 Identification and analysis of the socio-economic aspects of the building in relation to its urban/rural/territorial context.		The socio-economic assessment of the temple was developed applying the Nara Grid methodology. Information used to compile the grid derived from direct researches and bibliographical resources that mainly supported the definition of the social value of the temple. Additionally, the analysis of the incomes derived from the tourism has been carried out to define the economic value of the building as a site resource.
		1.6.1.1 Identification of the building pathologies and damages.	The condition assessment was developed through visual analysis and documented through photographic cameras.
		1.6.1.2 Identification and direct analysis of materials decay (supported by ad-hoc tools) including: a) homogeneous materials (stones, clay-bricks, wood, metals, etc.) b) heterogeneous (reinforced concrete, mortars, plaster, etc.)	The analysis included IR camera investigations, lab analysis of material samples.
		1.6.2.1 Causes of decay with long-term action: a) internal causes of decay (technical problems/dysfunction/design mistakes/wrong techniques/unsuitable constructive systems, etc. b) external causes of decay (ground water and moisture in soil, rain, seasonal and daily temperature changes, dust, wind, etc.	The identification of the causes of decay with a long-term action included on-site analysis, visual inspections, geographic and geomorphological analysis. Previous studies of technical reports and bibliographic sources.
		1.6.2.2 Exceptional causes of decay i.e. earthquakes, floods, exceptional winds, landslides, wildfire, etc.	Information on exceptional causes of decay on the temple derived from historical studies as well as from the analysis of geographic and geomorphological studies and technical reports.
	1.6.3 Non-natural causes of decay	1.6.3.1 a) Internal non-natural causes of decay including design faults (from the technical, functional, dimensional point of view) b) external non-natural causes of decay including man-made causes (wars, theft, fires, pollution, purposeful alterations, etc.).	The understanding of the internal and external non-natural causes of the decay of the temple derived from technical reports, bibliographical sources, on-site analysis and visual inspections.

7.2 Territorial and historical framework

The Loka-hteik-pan temple has been selected for its unique characteristics that make it one of the most outstanding temples in the Bagan plain. These are illustrated in paragraph 7.4 of this Chapter.

From the territorial point of view, the temple is located in the Bagan plain, northeast of New Bagan and southwest of Nyaung U (21°9'54"N 94°51'54"E). In terms of accessibility, it is close to one of the main roads – Anawrahtha road – and crossed by several feeder roads.

Considerations on the location of the temple are relevant since allow to understand the significance of the Loka-hteik-pan temple in its local context. Indeed, the temple is located at less than 150 meters from the Shwehsandaw pagoda (also known as Mah'peinne'), built under king Anawrahta in the XI century, at less than 650 meters from the Ananda temple, about 450 meters from the That-byin-byu temple (the highest temple in Bagan) and nearly 370 meters from the Bagan city walls (Shin, 1962). As noted by Bohma Ba Shin, the temple is within a radious of 900 meters from the most important temples and pagodas of Bagan, including the *"Palace of King Kyansittha, the Pitakat-taik, the library of Anoratha, the Shwegu temple of Alaungsithu (Cansu I), and the Pahtothamya […] all within the city walls […]"* (Shin, 1962), p.1.

This strategic location is one of the factors that indicates the importance of the temple, close to the religious edifices of Bagan monarchy.

The temple faces North towards the royal palace, contrary to the majority of the other Bagan temples, facing East.

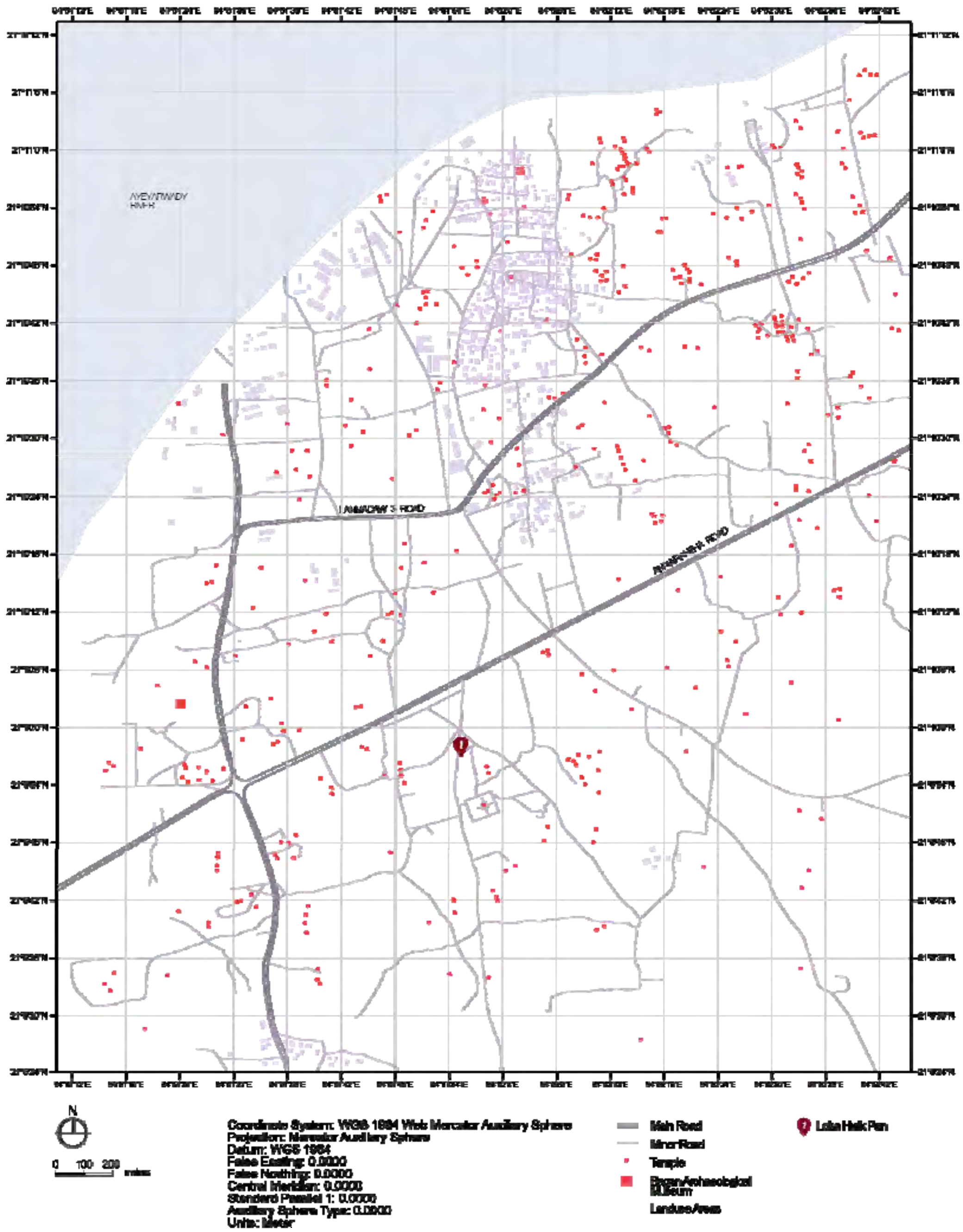


Figure 3 Loka-hteik-pan temple location within Bagan plain. Source: Author.

The construction of the temple ended in 1113 A.D. (Griswold, Hla, & Ba, 1971) in the so-called Transitional Period[5]. This period, like the name suggests, oversees the

[5] The Transitional Period ranges from the 1113 to the 1174 A.D. Gordon Luce, in his book, Old Burma-Early Pagan, identified four main periods in the Bagan temple architecture. These include: the Pre-Aniruddha Period (200 B.C. – 1044 A.D.), the Reign

gradual shift from the Old Mon style to the Old Burmese Style. The end of this period truly coincides with a shift to the Burmese style after the ascension of King Cansu II (also known as Narapatisithu, 1174 - 1211 A.D.) and his successors. The Transitional period (1113-74 A.D.) was followed by the Mongol Invasion in 1287 A.D. after that Myanmar fell into a period of dark ages (Wales, 1973).

Figure 4 Loka-hteik-pan temple and the close Shwehsandaw pagoda. Image Source: Bohmu Ba Shin (Shin, 1962), p. i.

Concerning the temple history, most of the information are missing. The causes of the lack of written information can be found in Bohmu Ba Shin, who reported that *"Burma was once rich in antiquities and authentic historical source-materials, but their value has not been properly appreciated; and some of the best have been lost, and are being lost daily. Treasure hunters have left but few old images disemboweled. Even pious Buddhists think, in a good faith, to obtain merit by plastering priceless*

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of Aniruddha (c.1044-77 A.D.; also known as Anawrahta), the Reigns of Sawlu (1077 – 1084 A.D.), Kyanzittha (1084 – 1113 A.D.), and Cansu I (1113-1160 A,D,) and the Transitional Period (1113 -74 A.D.) (Luce, Rhaṅ', & U., 1969), 10.

frescoes with gold leaf, and beautiful stucco-carving, and even stone inscriptions, with lime whitewash, little thinking that they are destroying, just as effectively as the treasure-hunters (who usually assume the respectable name, thaik saya), the wonderful tradition of their forequarters and the noble art inspired by their own religion"(Shin, 1962), p. iii.

The temple name 'Loka-hteik-pan' means "*adorning the top of the world"*(Griswold et al., 1971), p. 229. The building is a medium sized temple (according to the UNESCO inventory[6]) with a hollow-core temple and no encircling hallway. It consists of three main parts: the porch, the vestibule and the central shrine. The vestibule is a nave leading straight to the central shrine in the end. In the central shrine, a colossal image of Buddha is the only sculptural decoration of the temple, made of brick and mortar. The statue, facing north, is sitting on a molded throne recalling the shape of a lotus flower. The statue is located in correspondence of the wall painting of the south side of the temple, depicting the Bodhi tree that frames the Buddha statue with a dramatic effect (Shin, 1962), p. 7.

About the flooring, Bohmu Ba Shin reports that the repairs of the DoA covered the pre-existing *"[…] thick layer of dust and earth which was from six to four inches thick at some places, collected in the temple through passage of time. When this was removed, the original floor of the temple was found nicely laid with large bricks, and also two stumps of timber […] one at each end of the front of the throne […] the floor was probably covered with plaster originally, and the stumps of wood, perhaps, are the remains of the original posts to hold the canopy above the head of the Buddha image".* (Shin, 1962), p. 7.

[6] The inventory developed by Pierre Pichad in the '80s categorize Bagan temples into: small (less than 12 metres), medium (from 12 to 25 metres), large (from 25 to 50 metres) and very large (more than 50 metres) (Pichard, 1992).

Figure 5 Photographic framework of the Loka-hteik-pan temple. Source: Author.

The exterior of the temple is dominated by the sikhara, recalling the Indian ones, with its squared base and bulging at sides (Shin, 1962), p. 5. This four sided tower rests *"on a plinth receding outwards with a waist band […] (each face has) three planes receding towards the corners. The lanced-shaped centres of the faces are plain and bare, Tiers of horizontal grooves spread outwards with cusps at each recession."* (Shin, 1962), p. 5. Beneath the sikhara there are three terraces featured by continuous crenellations while *"At the corners of the lowest terrace there are similar but smaller sikharas; the middle terrace has small bell-shaped stupas."* (Shin, 1962), p. 5.

The shape of the lower pediment of the entrance arch recalls two stylized *makaras "[…] spouting outwards, with trunks raised and necks resting on the capital at each end. The arch proper consists of a centre bank of petal-wreathing, with rows of 'pearls' above and below. Along the apex of the arch in the lower pediment are four* *acroteria on either side of the central one at the top, rising high, like flames licking up the wall."* (Shin, 1962), p. 6.

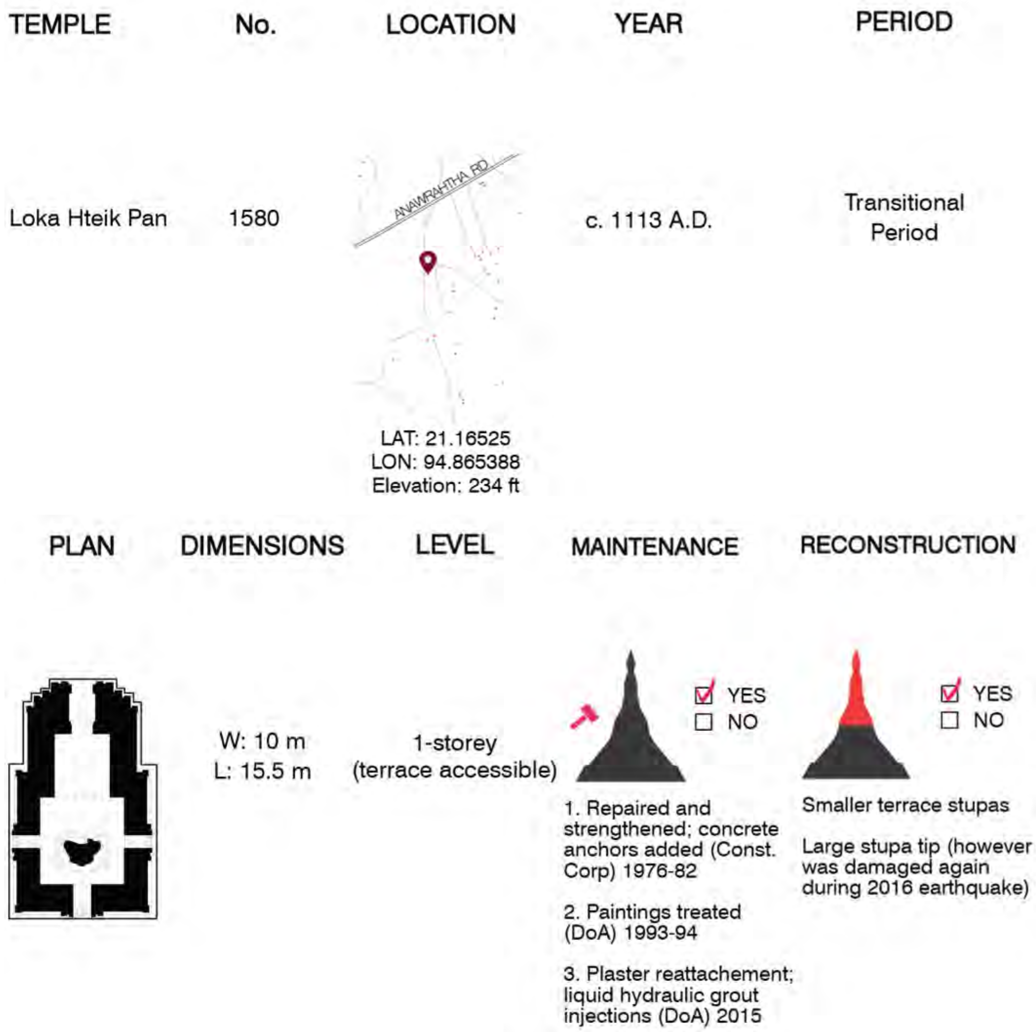

Figure 6 Main descriptive information of the Loka-hteik-pan temple. Source: Author.

The upper pediment has got a similar shape with seven acroteria on each side and a central flame that was depicting the goddess of luck (now missing) (Shin, 1962), p. 6.

As reported by Bohmu Ba Shin, Loka-hetik-pan temple, like most of the Bagan temples was previously totally coated in plaster, some parts of which are still evident today even if most of them disappeared and flaked off.

In terms of structure, the temple walls were not interlocked (Shin, 1962), p. 5, causing their structural weakness and the huge damages occurred particularly after the earthquake of 1975, after which the temple was reinforced with two belts of reinforced concrete.

The temple façade presents a double pediment, both resting on pilasters.

As a temple built in the transitional period, it features both Mon and Burmese Style characteristics. The darkness of its interior, the perforated windows, and also the single small entrance are typical of the Mon temple. In addition, the paintings are Mon style and use deep rich colors. However, the written glosses of the interior depict both Old Mon and Archaic Burmese writing. These are the earliest known narration of tales in Burmese literature (Griswold et al., 1971).

From the natural point of view, the site is surrounded by *Acacia leucophloea,* the Burmese Rosewood (*Pterocarpus macrocarpus*) and Thanaka (*Limonia acidissima*) trees and by wild plants (Married to plants, n.d.).

The temple overall external length is about 15.5 meters and its overall width (taken on the south façade) of nearly 10 meters. It has an indoor area of 53.08 square meters and a volume of 291.92 cubic meters.

Although its reduced size and outward appearance, it is a masterpiece for its interior wall paintings and written glosses (Griswold et al., 1971), p. 233. The temple first attracted attention from the DoA in 1931, and then further interests by Dr. Luce in 1958, who realized its importance as a temple documenting the evolution of the Burmese religious architecture (Griswold et al., 1971), p. 229. In 1960, U Aung

Thaw, Officiating Director of Archaeology, inscribed the temple on the List of Protected Monuments. Consequently, the Government of the Union of Burma, endorsed his recommendations for urgent repairs (Shin, 1962), p. ii.

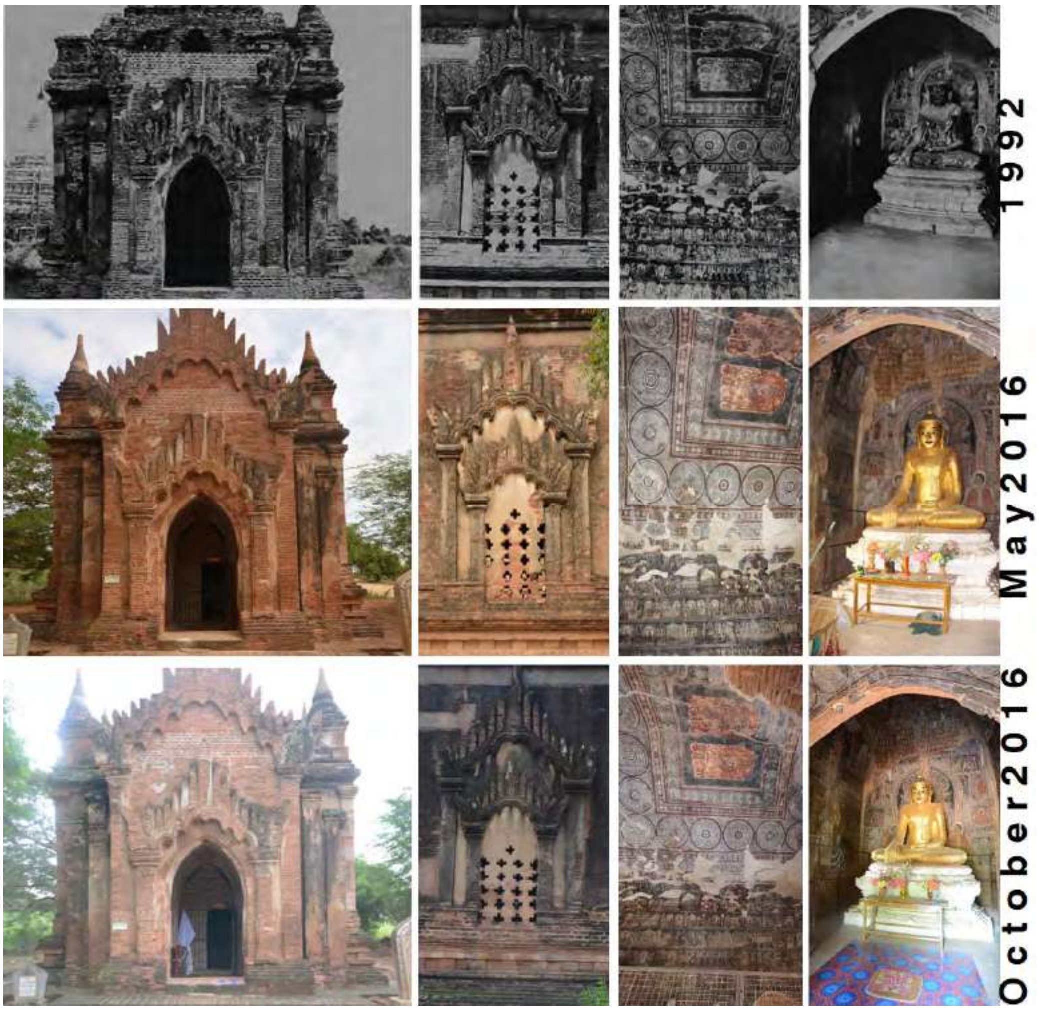

Figure 7 Visual comparison of the temple conditions in 1992, according to the images of the "Inventory of Monuments at Pagan", by Pierre Pichard and published by the UNESCO and the EFEO (Pichard, 1992), and to the photos taken before and after the Chauk earthquake of August 2016. Image source: Author.

As a temple of national interest, there have been many repairs made to the Loka-hteik-pan temple. The photograph comparison in Figure 7 evidences some repairs such as paintings treatment and liquid grout injections in 2015 to reattach the plaster to the brick wall. Nevertheless on August 24, 2016 another earthquake hit Bagan causing additional damages also to the Loka-hteik-pan temple. These included, for instance, the collapse of the main stupa of the central tower, the partial collapse of the east niche on the second level of the terrace and other additional damages and cracks on the outside as well as on the inside of the temple, causing also the detachment of some wall paintings portions.

7.3 Recording geometry, shape, and color of Loka-hteik-pan temple

Following the historical and territorial framework, the second step to grasp the knowledge of the temple consisted in its metric survey. This phase, was particular significant for the understanding of the building spatial relations, for the identification of the basic geometries and for gathering quantitative information on the building, since, according with Grazia Tucci, *"Survey has always been considered a main instrument for understanding historical architecture"* (Tucci, Bonora, Fiorini, Conti, 2016), p. 977.

Geometry, shape, color and conditions of Loka-hteik-pan temple have been documented in an on-field activity[7]. The information gathered has been processed at

[7] The documentation activity on the ground was developed by a multidisciplinary team including students and faculty members from Carleton University, the Carleton Immersive Media Studio (CIMS) and Yangon Technological University, as well as staff from the Department of Archeology, National Museum and Library (DoA) and professionals from the CyArk foundation (Mezzino & Santana Quintero, 2016). The recording of Loka-hteik-pan temple was developed in the framework of an international project, counting on the cooperation of public and private institutions from Canada, Myanmar and United States. The final aim of the project consisted in supporting Myanmar's implementation of the World Heritage Convention. To achieve this goal, the involved members of the Carleton Immersive Media Studio (CIMS), including the author, provided exposure to the most up-to-date international documentation and conservation practices. In line with the goal of inscribing the site of 'Bagan Archaeological Area and Monuments' in the World Heritage List, (since 1996, it is inscribed in the UNESCO Tentative List). The developed project upgraded local capacities to document, monitor, conserve and manage this site.The documentation activity lasted fifteen days, a period during which also other Bagan monuments were documented. The project aimed at developing a coordinated strategy to document four temples in the site of Bagan (Myanmar). Information acquired during the field work was processed in order to elaborate a solid base for the conservation and monitoring of the documented temples (Mezzino & Santana Quintero, 2016).

the Carleton Immersive Media Studio (CIMS) employing software and IT support of the Lab[8].

Figure 8 Image of the east façade of the Loka-hteik-pan temple. Source: Author.

In recording the shape and as found condition (Mezzino & Santana Quintero, 2016) of this religious building, 3D photogrammetric, Laser Scanning techniques, Total Station and hand measurements, as well as cutting edge technologies (Tucci et al., 2016) have been employed.

Testing different techniques and tools to capture quantitative as well as qualitative information on the documented temple, allowed an assessment of the advantages and disadvantages of these tools and techniques, also considering cost and time issues as well as the specificities of the monument and the site of Bagan. The table 2 presents

[8] Within the Ph.D. program in co-tutelle between the Politecnico di Torino and Carleton University, the author worked as researcher within the Carleton Immersive Media Studio (CIMS) under the coordination and supervision of the Lab Director, Professor Stephen Willliam Fai, and the thesis advisor Professor Mario Santana Quintero.

the assessment of the employed techniques to capture shape and color and conditions of Loka-hteik-pan temple.

In setting up the survey, past existing surveys of the temple, such as that one contained in the UNESCO inventory of 1992, were examined and used, if possible, as starting reference.

The following paragraphs deepen the specifications of each tool employed for image-based as well as non-image based recording techniques.

7.3.1 Total Station survey: setting up the survey network

Reflectorless Electronic Distance Meter (REDM)[9] Total Station survey has been employed to record both the interior and exterior of the Loka-hteik-pan temple. The Total Station established a local coordinate system of the temple, oriented towards North using the Azimuth to then reference the photogrammetric and laser scanning records.

The first step consisted in setting up the survey network, connecting the interior and exterior of the temple. The survey network was measured using a Leica Total Station TS11, owned by the CIMS. The Total Stations was used to support the photogrammetric and laser scanner records and the survey of the individual spaces (floorplans, elevations, and cross-sections), by calculating a survey network of the interior and exterior perimeter of the building. The external loop was adjusted fixing

[9] The reflectorless EDM (REDM) Total Station allowed to measure distances straight from a surface without a reflector. This helped to speed up the survey that required only one set-up or operator.

the point coordinates to then generate a subnetwork in the building interior (porch, vestibule, staircase and main shrine).

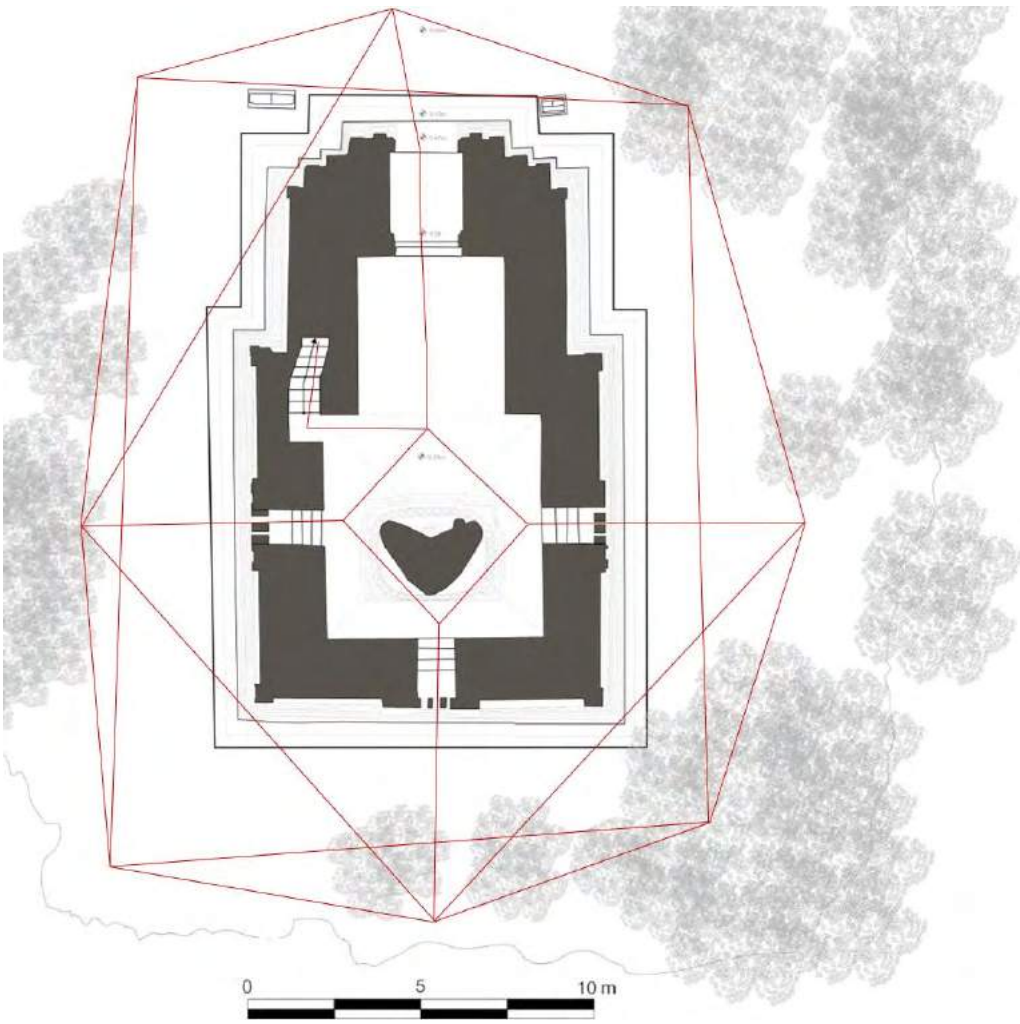

Figure 9 Survey network of the Loka-hteik-pan temple. Source: Author.

By using a minimum of three targets per room, the rooms were joined together via clusters of smaller surveys, which were grouped and then tied back to the main survey network.

In the second order network, each new room was established by resection from the previous room. Once in a new room, the network of targets was surveyed.

Then an outline of the walls of the room was drawn approximately 1.5 m from the floor[10].

The lines in AutoCAD were divided into different layers, such as windows, wall sections, projected lines, etc. Features of the room, such as stairs, floor height elevations, changes in grade, finishes, and openings were also measured.

One of the advantages of drawing directly in AutoCAD from the Total Station TS11 consisted in the immediate visualization of the collected information.

Total Station survey supported Photogrammetric and 3D scanning records.

Once set up the survey network, it was possible to draw the wall outlines and the main temple features directly in AutoCAD from the Total Station. The lines in AutoCAD were divided into different layers such as windows, wall sections, projected lines, vaults and arches projections, etc.

Figure 10 Surveying the targets on the temple employing a Leica Total Station TS11. Source: Author.

[10] The high of 1.5 m was set in order to be able to section also all the three temple's windows.

7.3.2 Technology supported analysis: non-destructive techniques

The documentation of Loka-hteik-pan temple has been carried out employing different non-destructive techniques in order to preserve the building conditions. These included: Total Station survey, terrestrial and aerial Photogrammetry, Laser Scanning, Record Photography and Hand Measurements.

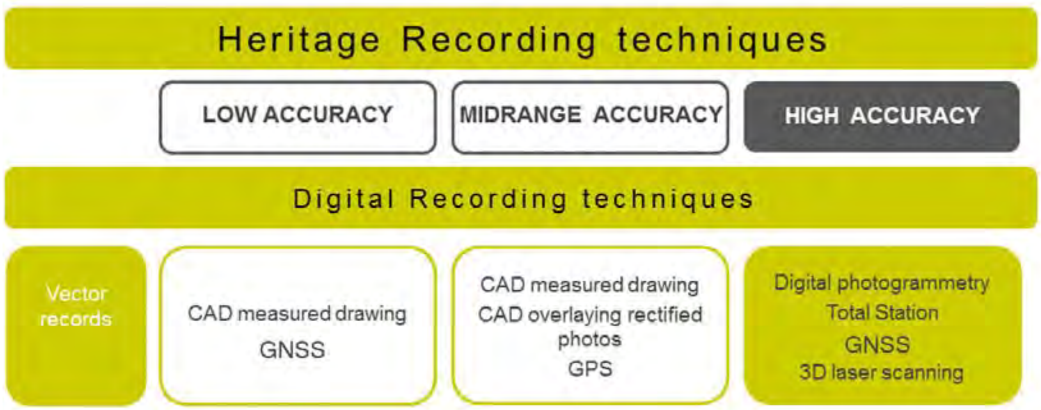

Figure 11 Diagram illustrating how the recording techniques employed – digital photogrammetry, laser scanning, total station and GNSS – allowed to reach high accuracy records. Adapted from Letellier, R. Schmid, W. LeBlanc, F., 2007. (Letellier, R. Schmid, W. LeBlanc, 2007).

Each employed technique presented midrange and (mainly) high accuracy (apart for sketches and field notes that have been used only as support to the digital documentation). The image above illustrates the level of accuracy of the employed techniques and associated tools.

Furthermore, the selected techniques present different engagement levels and different requirements in terms of types of interaction (active or passive). Figure 12 illustrates this characterization between active and passive techniques types. This differentiation has been developed according to the sensors used in the data acquiring phase. The engagement level instead indicates the level of interaction required by the different techniques during the data acquisition phase. This provides also information on the automation process of each employed technique. Figure 12 illustrates this classification limited to the recording techniques used.

In the selection of techniques and tools, a key role was played by the required outcomes, aimed at gathering detailed records in a 1:50 scale. Therefore, the digital recording has been carried out with the support of several surveying instruments. These included: a Total Station, DSLR cameras, a GNSS device and a Laser Scanner[11].

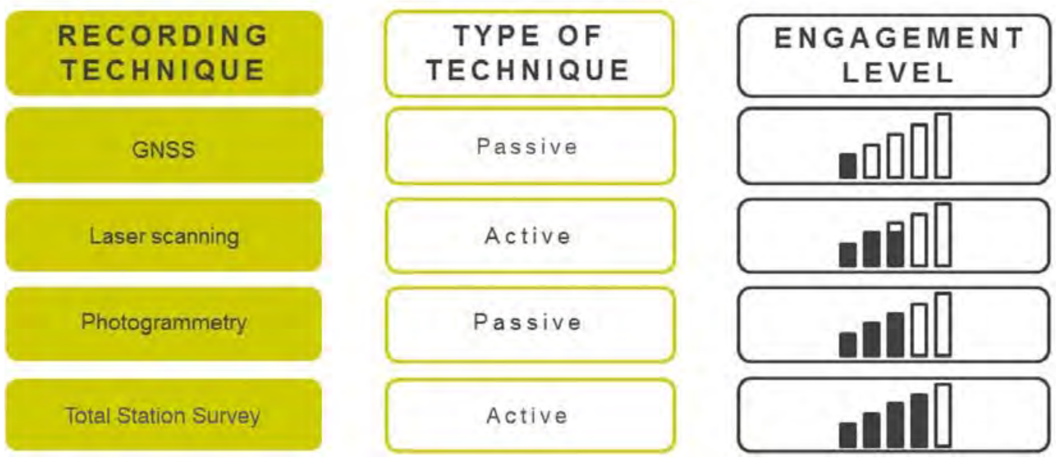

Figure 12 Engagement level of the recording techniques employed in the data capturing phase. These techniques have been used in the documentation of Loka-hteik-pan temple. Image source: Author.

[11] More specifically, the list of the equipment included:

- Leica Geosystems Total Station TS11, with a distance accuracy of 2 mm and angular 2 ppm for line work;
- Nikon D800 DSLR camera with 36 MP;
- tripods;
- Drone Phantom 2 Vision +;
- DJI Inspire 1;
- fisheye Nikkor 10.5mm lens;
- Garmin GPS;
- Faro Laser Scanner Focus 3D.

The data generated from each technique required different workflows.

In term of storage and processing, the size of data presented high-performance requirements in terms of computers hard disk and storage space, memory, ground processing unit (GPU) and central processing unit (CPU).

Table 2 The following table presents the specifications of the computer requirements to process and integrate data coming from the employed recording techniques. Source: Author.

HARD DISK SPACE	STORAGE SPACE	MEMORY	GPU	CPU
About 60 GB space of the rigid disk to install the applications (software) needed[13].	▪ Server/Local Disk more than 1 TB[14]. ▪ Cloud server 5-500 GB[15]	8-10 MB Memory of the graphic card	2-6 GHz	3-4 GHz

Specifications of the computer requirements, here reported, despite specifically related to the case study, can be extended to similar applications.

Detailed information about type and size of information recorded in the documentation of Loka-hteik-pan temple are reported in the chart below.

Table 3 Specifications of the information recorded to document Loka-hteik-pan temple. Source: Author.

TECHNIQUE	TYPE OF DATA	FILE FORMAT	NUMBER	SIZE
AERIAL PHOTOGRAMMETRY	Images	.jpg.	69	975 MB
TERRESTRIAL PHOTOGRAMMETRY	Images	.NEF,.xmp	372	47,7 GB
DIGITAL PHOTOGRAPHY	Images	.jpg, .NEF	80	47,8 GB
LASER SCANNER	Scans	.fls	46	6,53 GB
TOTAL STATION DATA	Points and lines	.dat, .txt, .dwg, .dxf	15	329 KB
GNSS	Coordinates (points)	.shx, .prj, .dbf, .shp, .kml	5	10,7 KB

In terms of precision, the resulting pointcloud generated combining photogrammetry and laser scanning techniques, range from +/- 6 mm (for terrestrial laser scanning) to +/- 1 cm (for photogrammetry).

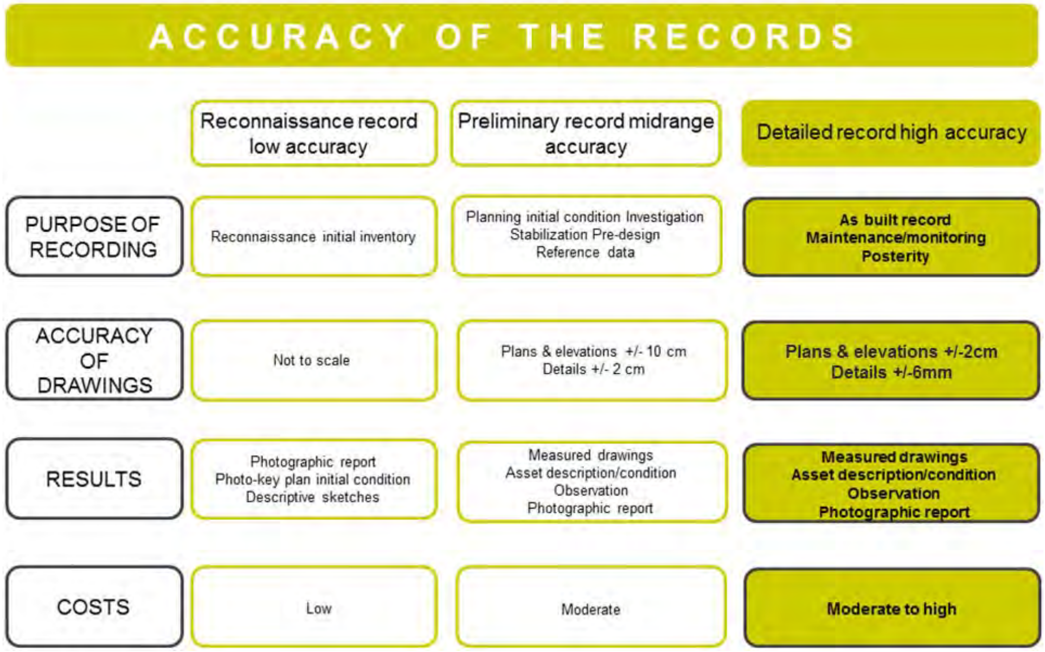

Figure 13 Diagram illustrating the accuracy of the records according to expected outcomes, purposes of the documentation and budget constraints. Image source: Adapted from Letellier, R. Schmid, W. LeBlanc, F., 2007. (Letellier, R. Schmid, W. LeBlanc, 2007).

The following paragraphs provide a detailed description of workflows and tools associated with each technique. This description has been developed dividing between image based recording and non-image based recording techniques.

7.3.3 Image-based recording techniques and tools

a) Photogrammetry

Photogrammetry has been defined as *"the art, science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images"* (Wolf, Dewitt, 2014). In other words, photogrammetry is the science of extracting metric information of objects, such as artifacts, buildings or landscapes, from photographs.

This technique allows obtaining measurements of objects (intended as artifacts, buildings, sites or earth surfaces) from bi-dimensional images.

This approach is the product of developments in computer vision that allows obtaining 3D scenes from 2D images using highly automated workflows. Algorithms allow features to be matched between pairs of sequential photographs[12]. The final result of this technique consists of mesh models of the recorded surfaces (Santana Quintero, 2016). Considering how photogrammetry provides spatial data - from the pointcloud – as well as qualitative information - from the photos - it has been considered a suitable recording strategy to document the Loka-hteik-pan temple. According to this brief introduction *“multi-image photogrammetry or structure from motion”* (McCarthy, 2014) was used to complement the Total Station survey and laser scanning record, gaining metric information of the Loka-hteik-pan temple.

Due to the irregular shape of the temple, photogrammetry has been used to record the complex geometry of the building (i.e. corner elements, decorations, etc.). This technique worked particularly well due to the heterogeneity of the temple surfaces – differences in color, shape, wall’s pattern, etc.

Photogrammetry models were generated using the Agisoft PhotoScan software (Agisoft, 2015) and exported in .e57 formats readable in Autodesk ReCap and henceforth accessible in Autodesk AutoCAD or Revit 2016 for further processing.

[12] The camera uses these matched features, along with the information contained in the images (adequate camera motion, overlap and structure scene) to calibrate the images. In this process, a depth map is created, with each pixel in the image producing a 3D dense pointcloud and/or surface model.

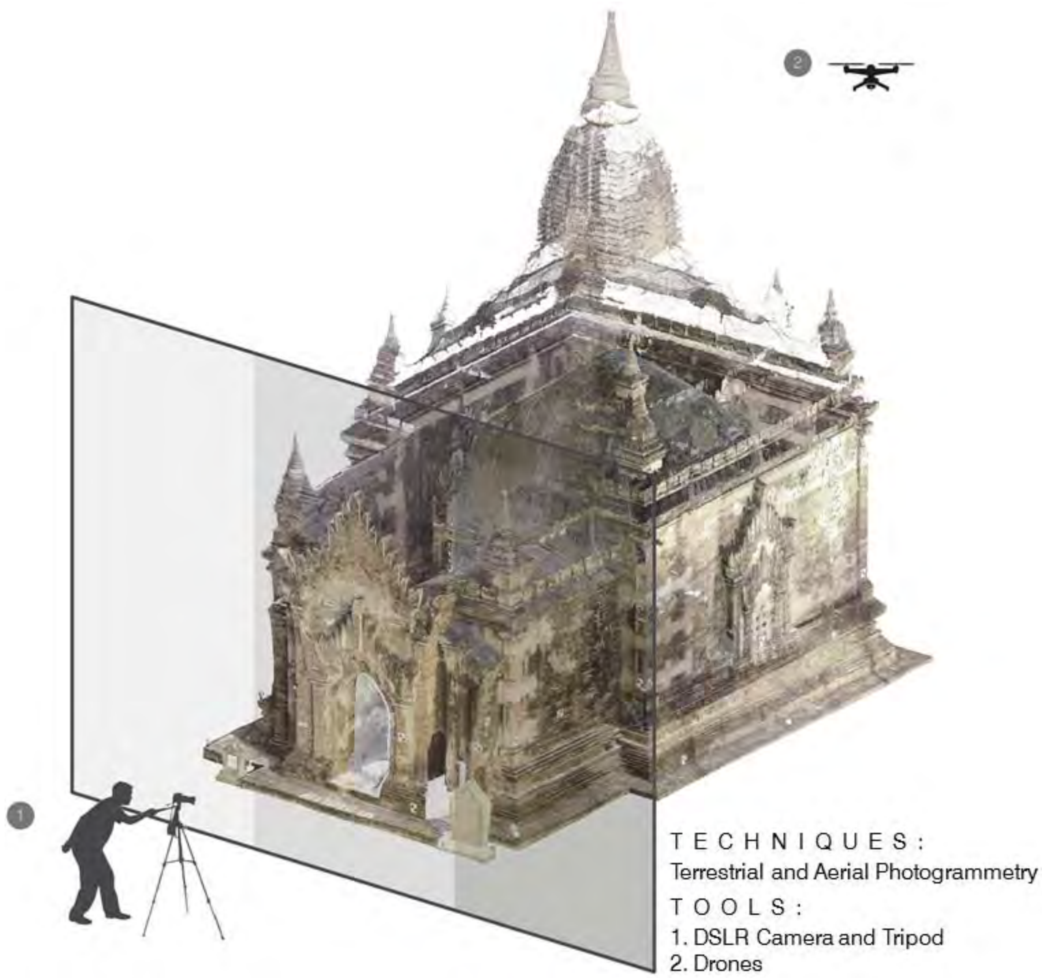

Figure 14 Image illustrating the use of photogrammetry (terrestrial and aerial) to capture the different parts of Loka-hteik-pan temple. Image source: Author.

Terrestrial Photogrammetry

Structure from motion (SFM) terrestrial photogrammetry has been carried out to estimate 3D geometry – structure - and camera pose – motion (Ullman, 1979). Photos of elevations were taken adapting the photogrammetric rule (3x3) (Waldhäusl, Ogleby, 1994), established by CIPA, (employing photogrammetric strips with 80% of overlap). The photos were referenced to the Total Station data and project coordinate system, using the targets placed on the elevations and captured in the same photos (Santana Quintero, 2016).

Data Capturing

The data capturing workflow consisted of three main phases:

1) planning the camera stations in order to cover all the surfaces of the building to be recorded;

2) setting up the camera settings according to the required accuracy and to the lighting conditions;

3) define the distances at which the photos should be taken and the overlap between them.

In order to consistently cover all the temple, photos have been taken at different heights. In this phase, the support of a tripod has been useful to avoid blurry images while moving all around the building.

To establish the distance at which every photo should have been taken, according to the scale required, the following formula has been applied:

$$D = \frac{f \;\; 0.2 \;\; scale}{px\ size}$$ [13]

Where[14]:

D = Object distance, or in other words, the distance at which the photos should be taken according to the required scale.

f= Focal length of the camera.

px size = Pixel size. The pixel size can be calculated with the following formula $px\ sixe = \frac{sensor\ height\ (mm)}{image\ height\ (pixels)}$.

scale = It indicates the required scale of the photogrammetric project.

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[13] The 0.2 x scale is the maximum Ground Sample Distance (GSD) at the ‘n’ scale.

[14] The information here reported does extensive reference to the material of the CIPA international Summer School “Cultural Heritage 3D surveying & modeling”, held in Valencia, Spain, form August 30 to September 3, 2016. The material has been elaborated by Erica Nocerino, researcher at the 3D Optical Metrology (3DOM) unit of the Bruno Kessler Foundation (FBK).

Figure 15 Image illustrating the use of the tripod to take photos at different heights and from different distances from the Loka-hteik-pan temple to gain information of the different parts of the building. The tripod has been useful to avoid blurry photos. Image source: Author.

Figure 16 Image presenting the employed DSLR camera Nikon D800. Image source: Nikon website (Nikon, n.d.).

In the specific case the scale was established at 1:5 m. Despite the 3D model and the drawings have been developed at a 1:50 scale. This choice was justified by the intention of having a higher detail documentation in case of need for additional analysis. It also aimed to be consistent with the data captured with laser scanning techniques[15].

Hence, the distance to take photos of the temple, has been determined with the following calculation:

$D = \frac{10\ 0.2\ 5}{0.0048}$ >> $D =$ 2083.33 mm = 2.083 m

Where:

D = Object distance, or in other words, the distance at which the photos should be taken according to the required scale.

f = 10 mm. The Focal length can be obtained reading the values on the camera bezel. The Focal length can also be obtained checking the properties of the taken images.

px size = 0.0048 mm Pixel size. The value has been calculated with the following formula $px\ size = \frac{24}{4912}$ mm.

Information on the sensor height, in this case, 24 (Image sensor 35,9 x 24,0 mm), has been taken from the specification of the Nikon Digital SLR Camera D800 available on line on the Nikon web site (Nikon, n.d.) and to the manual set up considering that all the images have been shot in large format 7,360 x 4,912 (L).

Scale = 5 (due to the required scale 1:5).

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[15] Data caputured with the laser scanner present an accuracy of +/- 4 mm.

On the site, the average distance from the building at which the photos have been shot was approximated to 2 m with an accuracy of +/- 20 cm (due to the ground conditions, human error nd natural obstacles such as trees, vegetation, etc.).

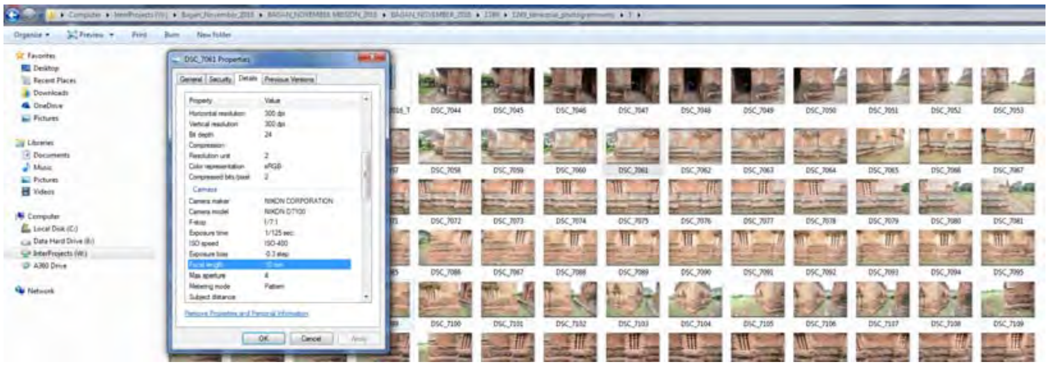

Figure 17 Image illustrating the information on the focal length of the images taken. Image source: Author.

Then, in order to determine the distance between each camera position, the following formula has been used.

$$baseline\ distance\ between\ photographs = \left(1 - \frac{Overlap\ \%}{100}\right)\ W$$

Where:

$$\mathrm{W} = \frac{Distance\ to\ object}{focal\ lenght}\ w\ (sensor\ width)$$

The overlap % is the required overlap percentage (usually included between 60-80%, according to the 3x3 established by CIPA) (ICOMOS CIPA, 2013).

In the specific case of the Loka-hteik-pan temple the formula has been applied as follow:

$$baseline\ distance\ between\ photographs = \left(1 - \frac{80}{100}\right)7477{,}97\ = (0.2)\ 7477{,}97$$
$$= 1495{,}594\ mm = 1{,}495\ m$$

Where:

Overlap % = 80. The overlap chosen, according to the required outputs was 80%.

W= $= \frac{2083}{10}\ 35.9$ = 7477,97 mm

Distance to object is 2,083 m = 2083 mm. It has been previously calculated with the formula: $D = \frac{f\ 0.2\ scale}{px\ size}$

Sensor width is 35.9 mm. The sensor width has been obtained from the image sensor of the camera 35.9 x 24.0 mm (Nikon, n.d.).

Once, established a starting point, the photos have been taken moving around the temple taking photos every 1.4 m[16].

In this process, the following data sheet has been employed to calculate the distance between the object and the camera and among the different camera stations in order to guarantee an 80% consistent overlap.

All this information has been calculated in a metric system.

This allowed having a consistent overlap between each photo. Within this workflow, photos have been shot at regular distances, following regular path according to the building geometry.

In the data capturing photogrammetric rules and recommendations established by CIPA, ICOMOS (ICOMOS CIPA, 2013) have been followed. These included

[16] Considering the uncertainty and the challenging working conditions, the baseline distance between photographs in the amount of 1.495 m, has been approximated to the lower value of 1.4 m.

particular attention to uniform lighting conditions (compatibly to the site weather, very close to the equator and characterized by a strong sunlight). In terms of photos' quality, all the photos have been shot in RAW format using a tripod to avoid blurry images and setting the focus so that all parts of the photo were sharp.

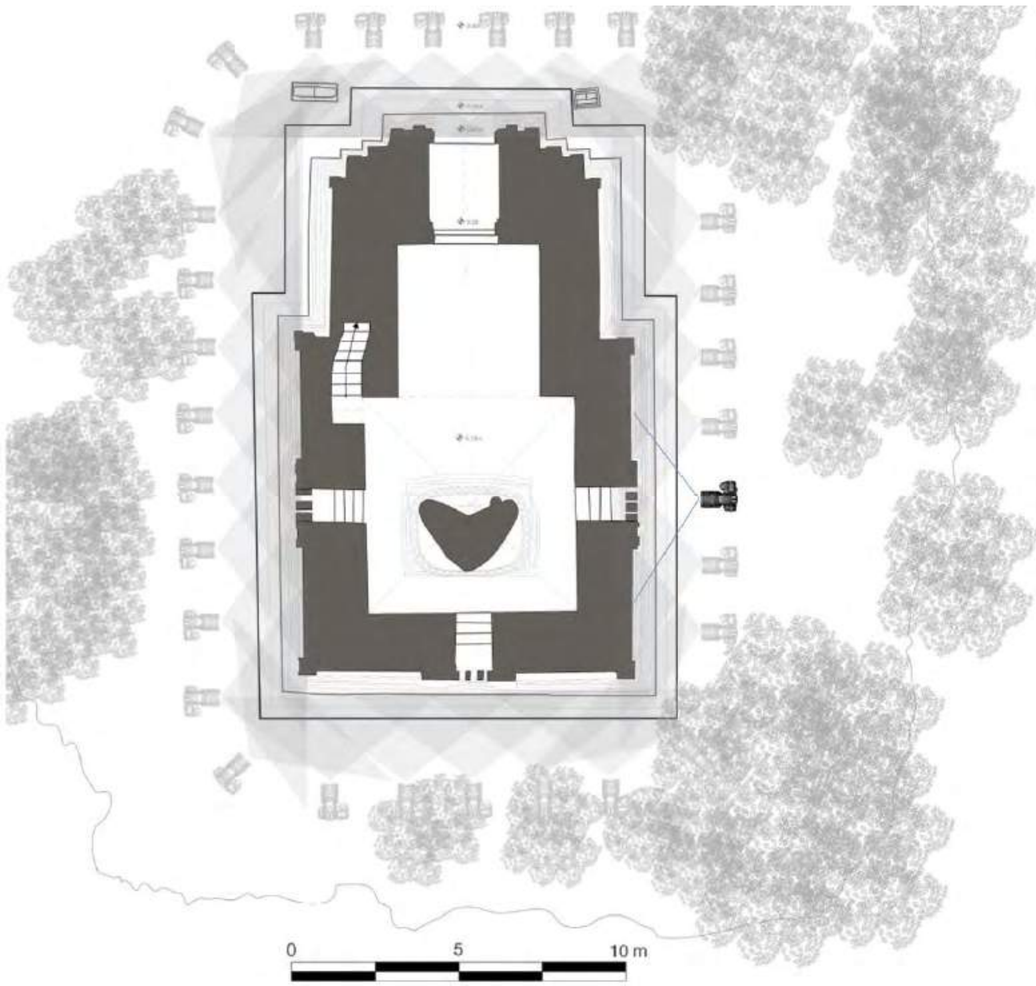

Figure 18 Cameras' positions for the terrestrial photogrammetry of the Loka-hteik-pan temple. The positions of the cameras have been calculated to have an 80% overlap as well as to capture the details of the temple according to the required scale of the photogrammetric project.

Table 4 Employed datasheet used to report the DSLR Camera specifications. These specifications have been used to calculate and calibrate the terrestrial photogrammetry data acquisition. This table does extensive reference to the material elaborated by Erica Nocerino and presented at the CIPA international Summer School "Cultural Heritage 3D surveying & modelling", held in Valencia, Spain, 30 August – 3 September 2016.

CAMERA BODY		
Camera Brand		
Camera Model		
Sensor Type		
Sensor Size (mm)		
Image resolution (pixel)	Width (#columns)	
	Height (#rows)	
Pixel Size (mm)	$px\ sixe = \frac{sensor\ height}{image\ height}$	
Focal length (mm)		
LENS		
Lens Brand		
Lens Name		
Focal Length (mm)		
Maximum Aperture (f-number)		
Minimum Aperture (f-number)		

Figure 19 Capturing images of the Loka-hteik-pan temple tower from the temple roof. Image shot by Ross Davidson.

Data processing

In terms of data processing the workflow included 3 main steps:

1. Photos check[17];
2. Photos correction;
3. Photos processing.

The photos have been opened all together in Adobe Bridge CS6 editing the saturation and contrast in order to optimize their exposure and quality. Once finished the enhancing, the photos have been saved in .TIFF format.

The last step consisted in the photos processing employing the software Agisoft Photoscan Professional (64 bit). The images were aligned, to create a dense cloud model, to then build mesh and texture of it.

Aerial Photogrammetry

To capture information on the upper parts of the temple and its sections inaccessible by laser scanning and terrestrial photogrammetry, aerial photogrammetry was employed. This technique allowed, using a drone Phantom 2 Vision + and a drone DJI Inspire 1, to record corner stupas of the roof as well as all the tiered terraces and other upper parts (including decorations, tower, spire, the hti, the umbrella, etc.).

Data Capturing

To capture the data with the drone DJI Inspire 1 the Pix4D application has been employed while for the drone Phantom 2 Vision + was used the DJI GO application.

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[17] The photos had been already selected in the data acquisition on the site. Nevertheless, an additional selection proved useful to double check possible redundant or blurry images.

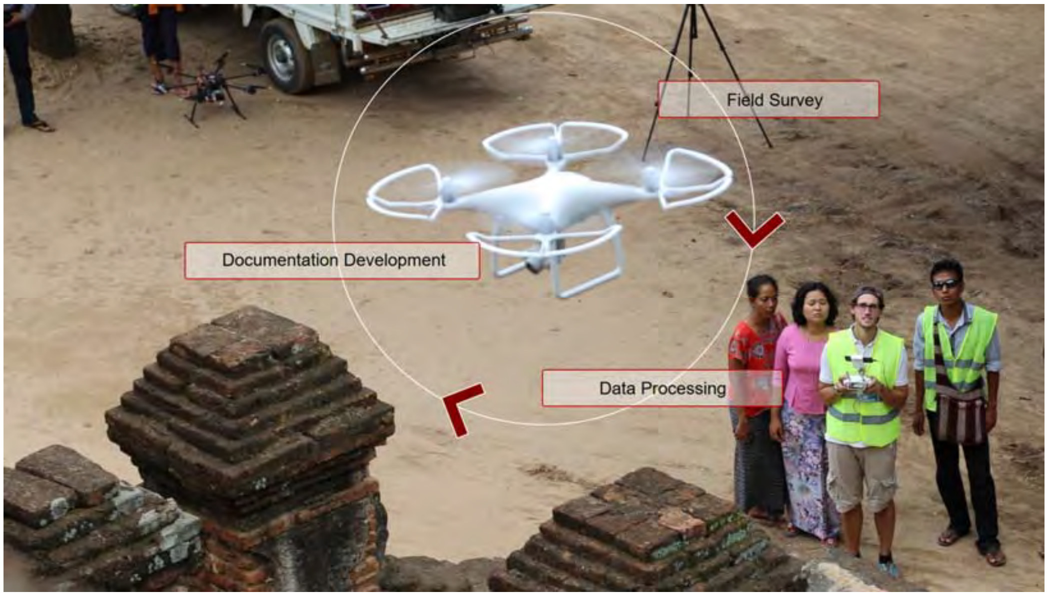

Figure 20 Example of flight in manual mode. Photo shot by Ross Davidson.

According to the shape of the temple, aerial photogrammetry has been developed employing two different flight modalities (for both drones): automatic and manual mode.

This allowed capturing the different parts of this irregular building such as the hti, the terraced roof, the tiered part of the tower, the corner stupas and the spires.

During the automatic flight, a reticular path was planned in order to capture all the parts.

Then, in the same mode, the drone flight path was set circularly around the main tower, supporting the central stupa, in order to record the shape of this building component and gain data about its complex geometry.

In manual mode, the drones were used also to capture the higher part of the façade, difficult to take through terrestrial photogrammetry.

Figure 21 Example of drone flying in a pre-set circular path. Image taken by Ross Davidson and edited by the Author.

Figure 22 Example of the flight path of the drone in manual mode to capture details of the upper parts of a monument difficult to take through terrestrial photogrammetry. Image source: Author.

In automatic as well as manual mode photos were taken with different camera inclinations: 90° for the top views, 45° degrees for the inclined views and 0° to record the upper parts of the façades. In the automatic and manual mode, photos were taken according to the photogrammetric rule (3x3), established by CIPA (ICOMOS CIPA, 2013), using photogrammetric strips with 80% of overlap.

Figure 23 Image showing different drones' camera orientations to capture different information of Bagan temples. Source: Author.

Compatibly with a safe distance of the drone from the building, also considering wind conditions, photos were taken at an appropriate distance in order to capture the details of the structure with the same exposure and camera settings. To establish at which distance take the photos, the same formulas used for terrestrial photogrammetry were employed.

Data processing

Data processing followed the same workflow as terrestrial photogrammetry.

Outcomes

Outcomes of the photogrammetric survey consisted in a dense pointcloud of the upper exterior parts of the temple. Exterior and interior information of the building derived from the integration of terrestrial and aerial photogrammetry. Information was combined through the targets measured with the Total Station. Camera quality, high photos resolution and the consistent workflow adopted for the data processing, provided a final photogrammetric model with an overall accuracy of +/- 1 cm[18].

b) IR Camera

In order to gain information about the moisture conditions of the temple, an Infrared Thermography was also employed. The adopted Thermographic infrared camera detected long infrared radiation producing images of that radiation by recording the temperature difference.

In the Loka-hteik-pan temple, thermography was used to determine the areas of rising damp and water penetration (particularly in correspondence of the interior wall paintings). This analysis has been significant to detect and localize moisture penetration, a major cause of damage to the temple, particularly considering its interior decoration. Hence, the understanding and localization of the moisture penetration sources were relevant to orient the temple's conservation actions.

[18] The accuracy of the photogrammetric model derived from the comparison with the survey carried out with the Total Station. To develop the comparison, twenty different distances were measured on the temple with the Total Station. These included portions of the inside and outside of the temple. Then, these measurements have been compared with the same distances in the photogrammetric model (the pointcloud generated from the photogrammetric survey). The average of the accuracy derived from this comparison was inferior to 1 cm.

Additionally, this analysis helped to identify and locate material discontinuity, usually due to new interventions.

The thermocamera was provided by the CIMS lab as well as the FLIR application software to process the images. The thermocamera employed is the FLIR E6.

Data Capturing

In order to capture significant information, the images were taken at the sunrise. This helped to avoid faults deriving from the heating of the materials due to the strong solar radiation. To take the images, the thermocamera settings were set up at 1m distance, hence it was kept at less than 1 m distance from the surface areas. To detect possible cases of rising dump humidity, the data were collected right after a raining day. In taking the images the range has been set between 25°C and 36°C so to enhance the temperature differences and to quickly identify the most affected areas of the temple that needed analysis. To gain information on the absolute temperature of the material the emissivity was set up in the thermocamera. The thermocamera provided a brick emissivity value of 0.81 in the pre-set emissivity material values.

Figure 24 Image illustrating the data capturing process employing the FLIR E6 thermocamera. Source: Author.

Data processing

To evidence temperature differences and to associate numeric values to the images taken, the FLIR Tools application has been used.

Outcomes

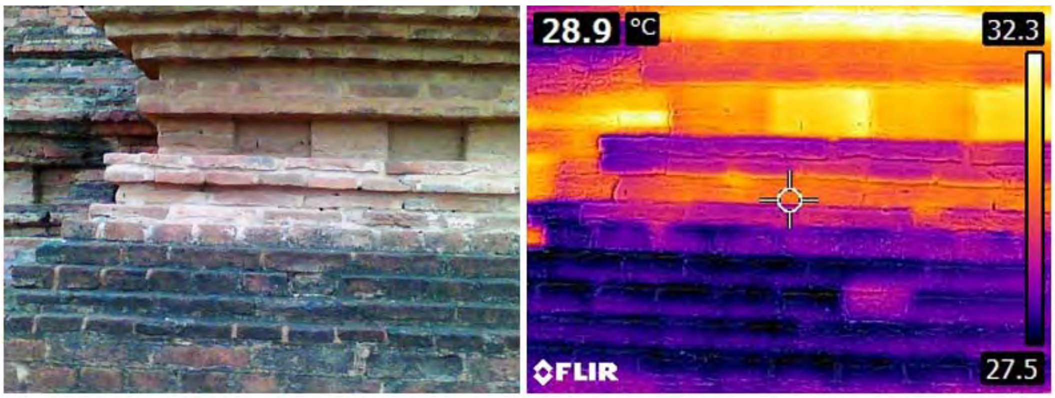

Figure 25 Results of the images taken with the FLIR E6 thermocamera. The images indicate a relevant temperature difference between the basement and the upper part of the temple. Software employed to process the image: FLIR tool. Source: Author.

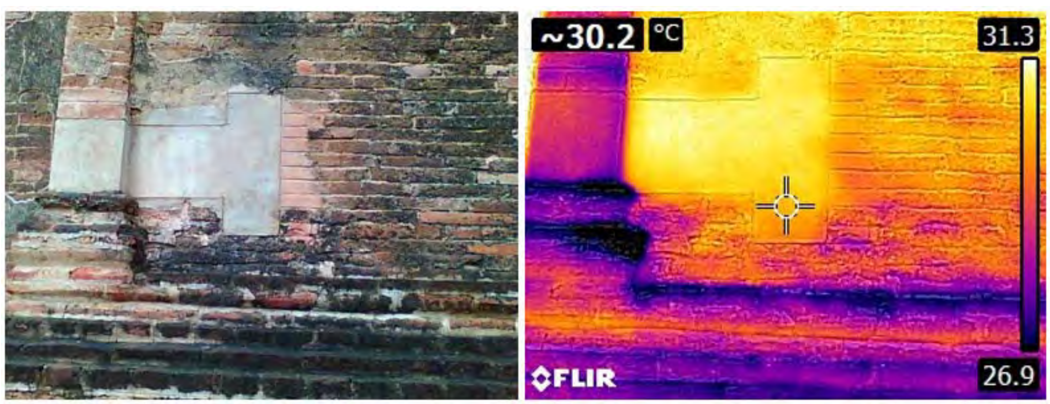

Figure 26 Images taken with the FLIR E6 thermocamera underlining the material discontinuity caused by interventions in reinforced contrete placed after the 1975 earthquake. Software used to process the image: FLIR tool. Source: Author.

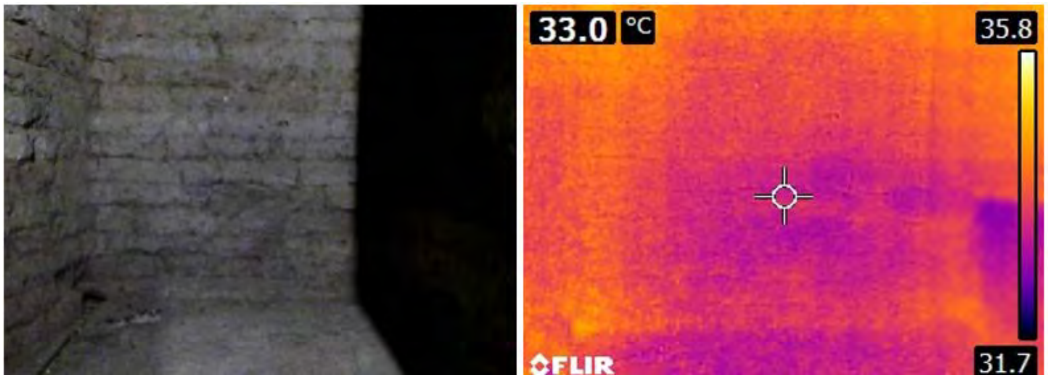

Figure 27 Images taken with the FLIR E6 thermocamera underlining the brick masonry rising damp humidity caused by interventions in reinforced concrete placed after the 1975 earthquake. Software used to process the image: FLIR tool. Source: Author

Contrary to expectations, the obtained results were not so significant. Indeed, the wall did not present extensive anomalies or inconsistencies in its superficial structure. Nevertheless, the results were useful to detect and localize the structural interventions, realized with reinforced concrete belts, to stabilize the temple after the 1975 earthquake that strongly affected the building. Thermocamera analyses also supported the identification of different materials and of thermic discontinuities among similar building components (i.e. old and more recent bricks). Furthermore, the results underlined the areas more exposed to raising dump humidity.

7.3.4 Non-image based recording techniques and tools

a) Global Navigation Satellite Systems (GNSS): Global Positioning of the Survey Network

To globally positioning the surveyed temple, a Garmin GPS was employed. The device was used to measure the station points of the survey network; this allowed situating the records in a global context.

Six station points of the survey networks have been used to geo-reference the Total Station measurements. The GPS measurements were processed in ArcGIS to geolocate the site plan.

b) Laser Scanner

Terrestrial Laser Scanning techniques have been selected in order to capture information with high accuracy level and in short time. It allowed reaching an accuracy of +/- 4 mm of the scanned surfaces. To address this goal a Laser Scanner Faro Focus 3D was employed.

For the data capturing a phase-based laser scanner was employed. This kind of laser scanner is included in the family of the time of flight systems (the phase difference is proportional to the signal traveling time).

The employed Laser Scanner was the Faro Focus3D X 330. This tool is produced by the FARO, a consolidated company in the 3D measurement technology sector. This type of scanning device acquires measurements by using a two-way travel time of a pulse of laser energy to calculate a range (Böhler & Marbs, 2002), (Faro, n.d.).

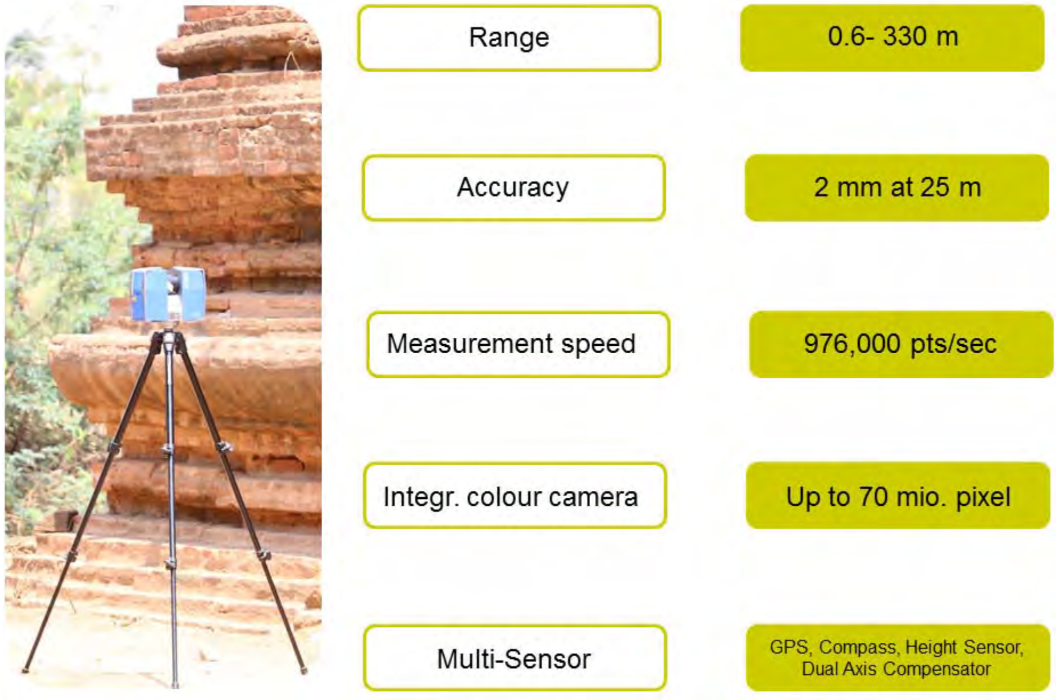

Figure 28 Specification of the employed Faro Laser Scanner Focus3D X 330. Source: Image adapted from (Faro, n.d.) and (Grussenmeyer, Landes, Doneus, & Lerna, 2016).

This type of scanner can be expected to collect many tens of thousands of points every minute by deflecting the laser pulse across the surface of an object, using a rotating mirror or prism. (Heritage 2011), (Böhler & Marbs, 2002). About its specific features, in term of range it goes from a minimum of 0.6 m to a maximum of 330 m; concerning its accuracy, the range goes from 2 mm up to 25 m. The measurement rate of this laser scanner goes up to 976,000 points per second. The resulting data is a pointcloud, comprising millions of points in 3D space. Böhler and Marbs generically describe a laser scanner as a: *“device that collects 3D co-ordinates of a given region of an object’s surface automatically and in a systematic pattern at a high rate (hundreds or thousands of points per second) achieving the results (i.e. three-dimensional co-ordinates) in (near) real time*.” (Böhler & Marbs, 2002).

Despite the high costs related to the tool, this technique was particularly useful in achieving a high level of detail in a relatively short time.

Data Capturing

Due to the tool specifications, in the data acquisition phase, scans were taken at a distance < 10 meters from the temple. Henceforth, each scan has a point density of <7.8 mm[19] (FARO 2016b). According to English Heritage, 35 mm is the optimal resolution interval *"for point density required to give 66% probability that the feature will be visible"* (English Heritage, 2011), p. 10. In this case, the survey was conducted using higher resolution intervals to ensure multiple uses of the generated data. Additionally, particular attention has been paid to the scanner positions in order to capture as many details as possible. This was carried out compatibly with the safety of the scanner itself (i.e. when scanning on the roof of the temple).

At the same time attention has been paid to scan also parts that could have been hidden by other building components, considering the complex geometry of the temple. Scans were captured diametrically opposite one to the other. Further, targets were distributed on different surfaces so to be visible from different scans.

More specifically, from each scan position, it was possible to see more than three targets (three of which common between one scan and the following). The targets included black and white checkboard targets (21 x 21cm) as well as reference spheres that can be automatically recognized by the SCENE software in the data processing phase. The checkboard targets have been measured with the total station and used as control points to reference the scans in the local reference system.

[19] This choice was oriented to capture accurate information of the scanned parts. Indeed, the scans' accuracy decreases with the distance .

Figure 29 Scanning on the terrace of the Loka-hteik-pan temple. Image source: Author.

In the data acquisition, even if slightly more time-consuming (from 1 to 2 additional minutes for each scan) colorized scans were taken[20]. More specifically, the scan took 360 photographs to assign color to the points[21].

[20] In this way it was possible to obtain a convincing and realistic 3D representation of the scanned information.

Data processing

To process the scans, the software SCENE 6.0.6.5 was used. Within the software it was possible to process, combine and colorize all the scans. The scans were also referenced using the targets measured with the total station to generate a referenced pointcloud that was later combined with the pointcloud coming from aerial and terrestrial photogrammetry.

Figure 30 Image illustrating targets and sphere used to document Loka-hteik-pan temple. Image source: Author.

[21] Nevertheless, in this process no geometry is created; the information is recorded simply as points in space. Other methods were employed to process the data and use it in different ways.

The adopted workflow included the following steps:

1) Import the scans into SCENE 6.0.6.5

2) Divide the imported scans into different clusters (each cluster included about 10 scans).

The clusters have been broken down as follows:

a) 'Interior' Cluster >

>>Scans 1 - 9 (Cluster 1)

>>Scans 9 - 18 (Cluster 2)

>>Scans 18- 25 (Cluster 3)

b) 'Exterior' Cluster >

>>Scans 25 - 32 (Cluster 4)

>>Scans 33 – 40 (Cluster 5)

>>Scans 40 – 46 (Cluster 6)

3) Align the scans within each cluster. To do this the scans were oriented through the "Top view based" and then aligned using the "Cloud to Cloud" option. Because the scans had been acquired with a consistent workflow and with a good overlap, the "Cloud to Cloud" procedure was preferred instead of the "Target-based" one. This allowed for an overall overlap of the scans > 80%. This workflow was preferred because it was less time-consuming.

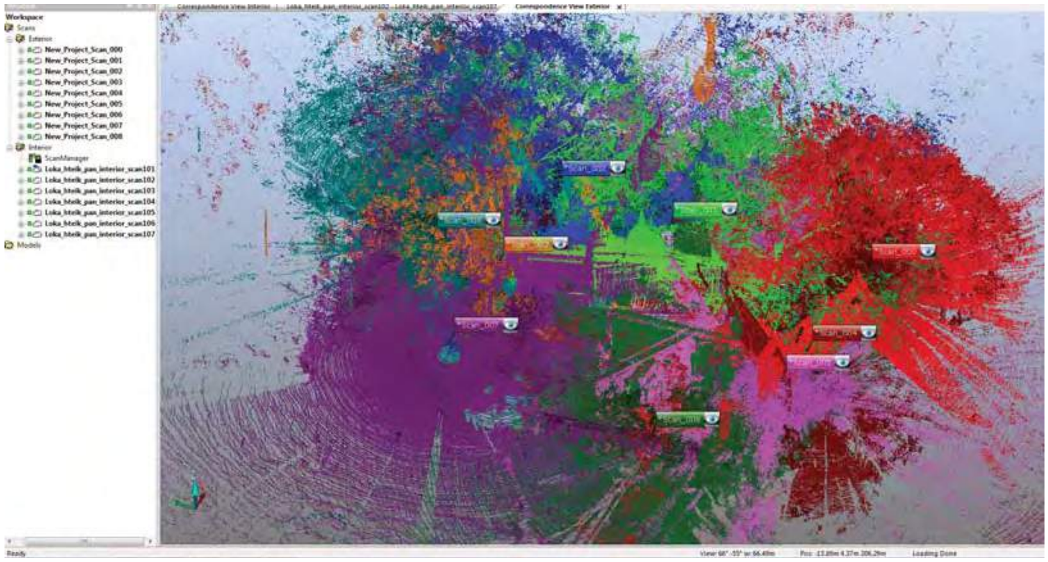

Figure 31 Screenshot of the Loka-hteik-pan exterior scans prior to registration. Software employed SCENE 6.0.6.5. Image source: Author.

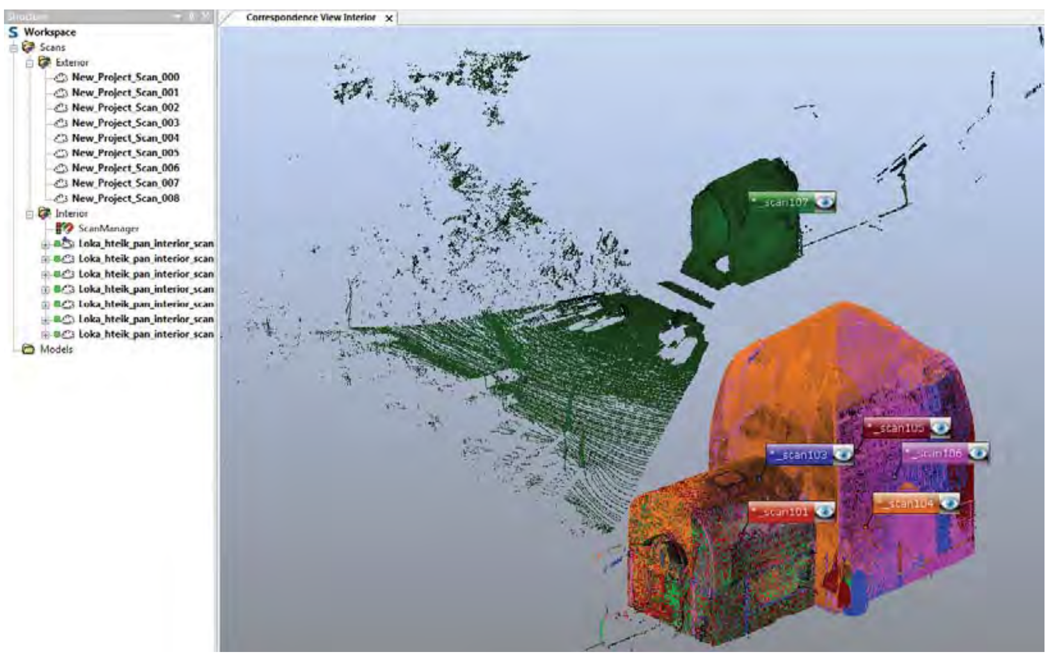

Figure 32 Screenshot of the interior scans after top view registration. Software employed SCENE 6.0.6.5. Image source: Author.

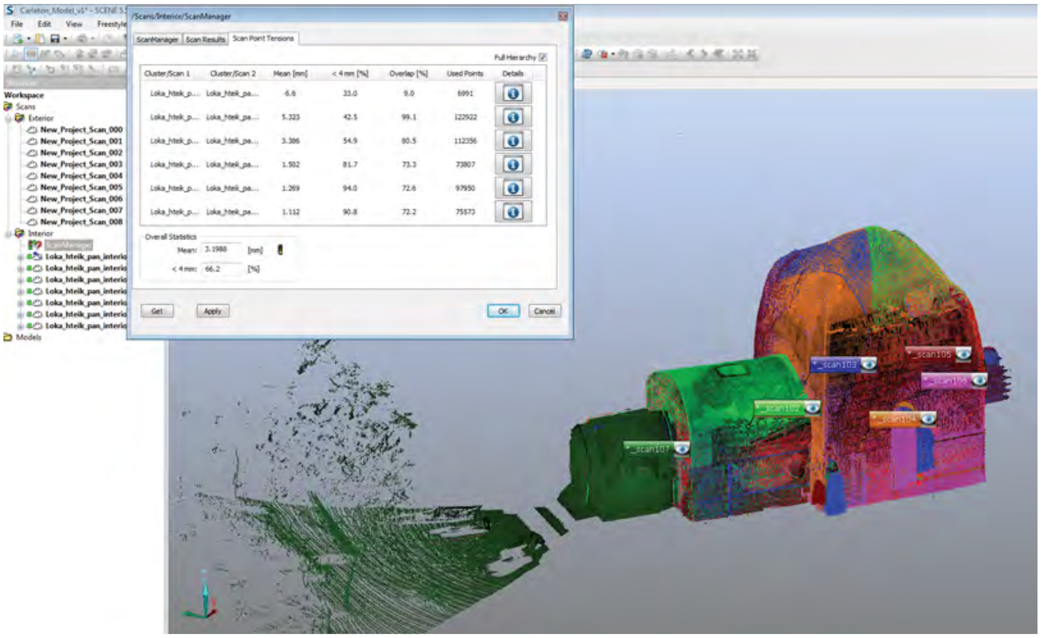

Figure 33 Interior scans processed with the 'Cloud-to-Cloud' function. The table shows the good accuracy of the scans alignment. The green 'traffic light' indicates the good accuracy of the alignment process that can be double checked with the related parameters (including but not limited to: overlap %, scans results, mean, etc.). Software employed SCENE 6.0.6.5. Image source: Author.

4) This operation was repeated for all the clusters (the 'Interior' cluster, containing the sub-clusters with the interior scans as well as the 'Exterior' cluster containing the sub-clusters with the exterior scans). Finally, the 'Interior' and 'Exterior' clusters were aligned between them.

In the overall registration process, the resolution of the scans ranged from 2 to 3 mm.

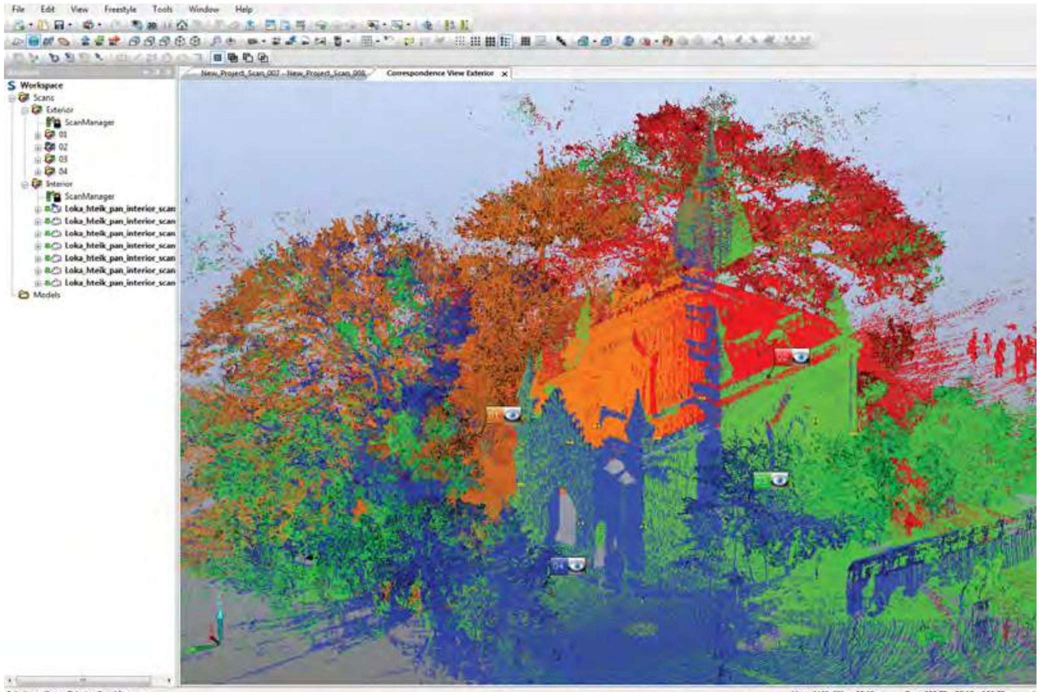

Figure 34 Loka-hteik-pan exterior scans after the registration. Software employed SCENE 6.0.6.5. Image source: Author.

5) Once the registration and the alignment of the scans were completed, they were colorized. To optimize the colour of the scans, the aspheric images from the scanner have been exported and treated using filters in Photoshop CC2016 (Adobe 2016). Once the quality of the digital images was improved, the files were imported again into SCENE. This process improved color and quality of the pointcloud. This additional step has been particularly useful considering the different lighting conditions of the scans - caused by differences in solar radiation throughout the day and by the shadow generated by trees' branches and by the temple itself.

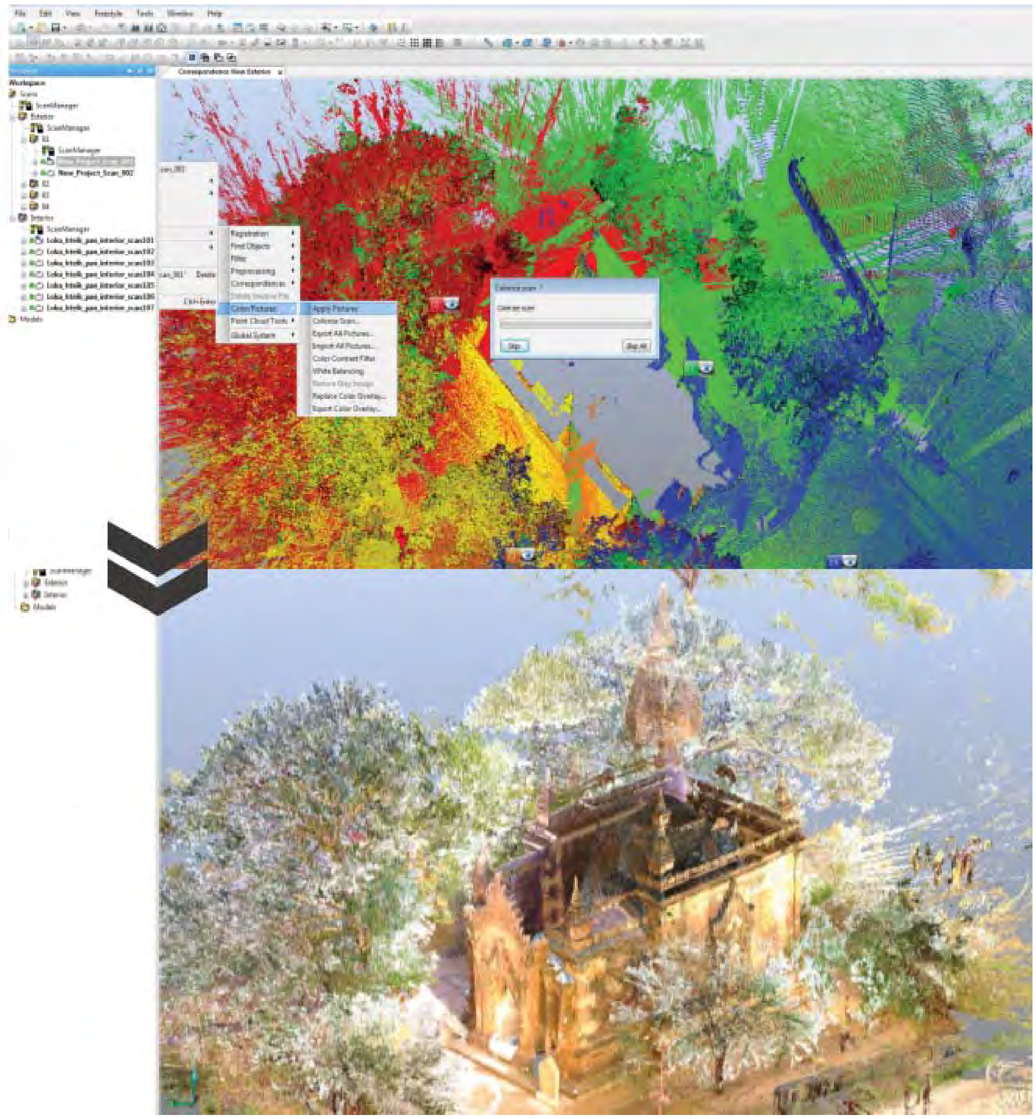

Figure 35 Employed workflow to colorize the scans. Software employed SCENE 6.0.6.5. Image source: Author.

6) To reference the pointcloud, in each scan, targets[22] (previously measured with the Total Station) were selected and named. After that, the targets’ coordinates, surveyed with the Total Station, were imported into the SCENE project. In this way, the

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[22] In the outside about twenty-five control points were measured. In the interior instead mainly natural points were used as reference in order not to damage the wall paintings surface.

selected targets were associated with the coordinates of each point, thus referencing the scan model in the local reference system established with the Total Station survey.

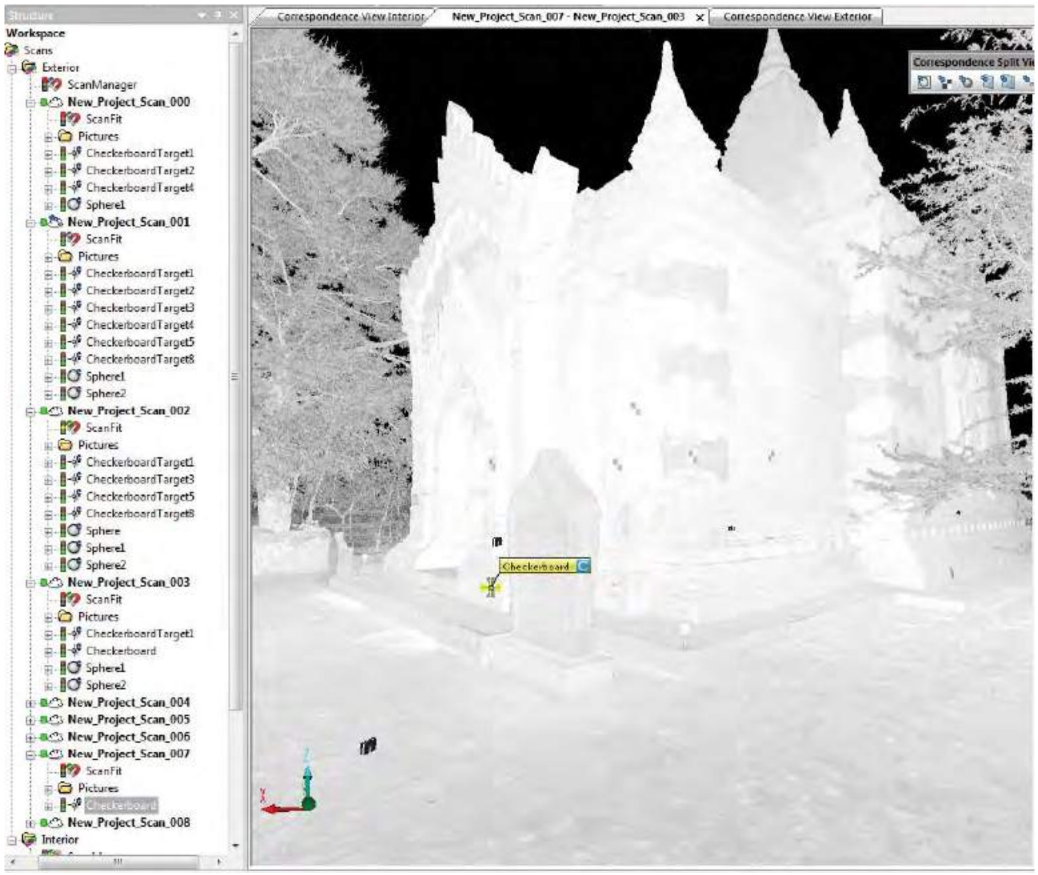

Figure 36 Marking process of the checkboard targets measured with the Total Station. The process was repeated for each scan. Software employed SCENE 6.0.6.5. Image source: Author.

The documentation process to capture geometry, shape and color of the Loka-hteik-pan temple included several phases as well as different techniques and tools. The following table presents a summary of the main information associated with the data acquisition phase.

Table 5 A summary of the main information on tools, data and outcomes of the data. Source: Author.

DATA ACQUISITION		
	Software applications	Autodesk AutoCAD 2016, Autodesk Revit2016, Autodesk ReCap2016, AgisoftPhotoscan, SCENE, GeomagicStudio2014, Adobe Photoshop, Adobe Bridge, Bentley Pointools Connect and Bentley Pointools POD creator
	Hardware applications	Leica Geosystems Total Station TS11, with a distance accuracy of 2 mm and angular 2 ppm for line work; Nikon D800 DSLR camera with 36 MP; tripods; Drone Phantom 2 Vision +; DJI Inspire 1; fisheye Nikkor 10.5mm lens; Garmin GPS, Faro Laser Scanner Focus 3D.
Surveyed surface	$53.08\ m^2$	
Surveyed volume	$291.92\ m^3$	
Control network vertices measured with the Total Station)	15	
Coordinates points measured with GNSS	5	
Number of photos	441	
Accuracy of the pointcloud generated through laser scanning technique	+/- 4 mm	
Number of scans	46	
Accuracy of the pointcloud generated through photogrammetric technique	+/- 1 cm	
Total time required for the data acquisition	42 hours	
Number of people	Two people	

7.3.5 Outcomes: from the pointcloud to 2D measured drawings

Once all data were referenced in the same coordinate system, it was possible to combine them together into Autodesk ReCap 2016 obtaining a consolidated 3D pointcloud model.

To do this the SCENE project was exported as pointcloud in the .e57 format. The pointcoud was generated from 46 scans containing 330 million points.

After that it was imported in Autodesk ReCap 2016. In ReCap the pointcloud was 'cleaned' deleting the parts that did not need to be modeled, such as trees, cars, people, etc.

The photogrammetric model was exported in the .e57 format and then imported in Autodesk ReCap 2016 where it was combined with the laser scanner project previously imported. The project was saved as .rcp and .pts file.

Figure 37 Screenshot of the ReCap model showing the interior of Loka-hteik-pan temple. Source: Author.

The .rcp file has been used to import the pointcloud into Autodesk Revit2016.

The pointcloud saved in .pts file was used to develop 2D drawings, whose accuracy was compared with the one of the 3D model. To develop the vectorized line drawings a different workflow was employed.

The Recap model was exported as .pts and .e57 file.

The .pts file was imported into GeomagicStudio2014 to generate orthophotos then used to develop the 2D linedrawings traced in AutoCAD environment. The same workflow was followed employing Bentley Pointools software (Bentley Pointools POD creator first and Bentley Pointools Connect after). The comparison of the two software evidenced that Bentley Pointools was faster maintaining the same accuracy as GeomagicStudio2014 in the orthophoto generation.

Figure 38 Screenshot of the ReCap model showing an exterior axonometric view of the Loka-hteik-pan temple pointcloud. It has been generated combining photogrammetric and laser scanning data. Source: Author.

7.4 Documentation of materials, significance and values of the temple

The following paragraphs illustrate the results of the analyses of the specific features of the Loka-hteik-pan temple. These range from the materials analysis and the understanding of the structural features, to the identification of meanings and functions of the spatial design, uses, significance and values of associated architectural elements.

7.4.1 Construction Materials and Structural Systems

For a comprehensive understanding of the building, its materials, construction techniques, structural systems and building components assembly have been analyzed and studied in depth.

The analysis took into account the constraints of 3D terrestrial laser scanning, photogrammetry, digital photography and electronic distance measurements to capture metric information that is necessarily limited to the exterior surfaces of building interior and exterior components. To complement and integrate such information, alternative documentation techniques were used through fieldwork carried out on the site. These included IR camera, indirect and direct analysis such as historical and archival researches and personal communications (with masons, workmen, bricks-makers, archaeologists, heritage specialists, architects and engineers involved in the conservation and reconstructions projects in Bagan) as well as direct visual analysis[23].

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[23] During the mission carried out between September and October 2016, it was possible to visually investigate the inner structure of several temples and stupas, partially collapsed after the earthquake of August 2016. This allowed a comparative study with

Furthermore, for a more detailed understanding of these structures, destructive analysis on some selected bricks were also developed.

The general aim of this documentation consisted in gaining full awareness of the Loka-hteik-pan temple and its building components in order to be able to effectively manage the followings aspects:

- understanding the temple's structure;
- understanding and assessing the (original) materials employed;
- identifying the innovative technical aspects of the building (constructive techniques, material use, etc.) used at the time of the construction;
- assessing and identifying the adaptive constructive techniques employed in the conservation of the temple;
- assessing the compatibility and integrity of new interventions and repairs.

From the technical point of view, destructive and non-destructive techniques were employed along with direct and indirect analysis. To test the material strength of old bricks and compare it to the new ones, compressive strength tests, density measurements and absorption tests were carried out.

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other temples built in the same period as the Loka-hteik-pan temple and presumably with similar techniques and materials, allowing to hypothize the inner structure of the temple.

Figure 39 Image of the documentation of the bricks. After a photographic and photogrammetric documentation, this material has been delivered for analysis to the National Research Council (NRC), Ottawa, Canada. Image shot by Adam Weigert.

These destructive tests provided information on the resistance under compression of the two different selected bricks on their density and cold water absorption. The two bricks used as testers were selected in Bagan in consultation with experts from the local department of archeology DoA and with professors from the Yangon Technological University as well as UNESCO experts and consultants.

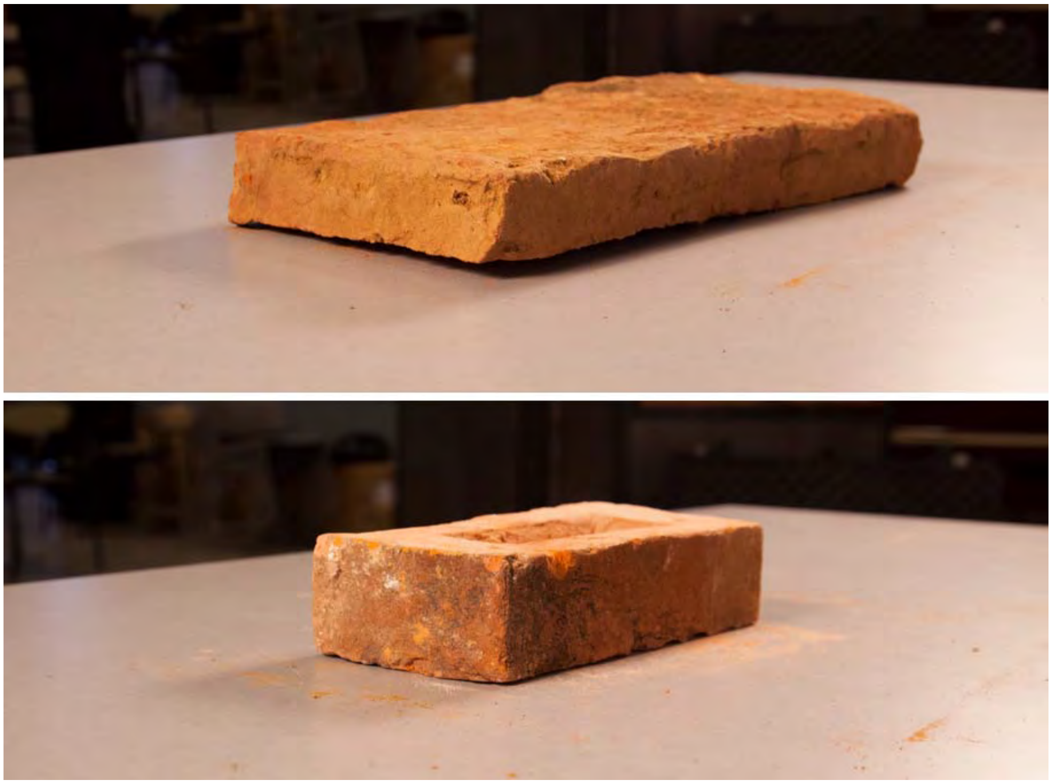

Figure 40 Tested brick samples. The first one dates back to the temple construction, XII century (above); the second one is a contemporary brick (below) used for reconstruction and repair after the 1975 earthquake that strongly affected the temple. Image source: Author.

Figure 41 Images illustrating the documentation process of the materials analyzed through destructive tests. Image shot by Adam Weigert.

Before the destructive analysis, the components were measured and documented employing digital photography and photogrammetry. This documentation was developed within the Carleton Immersive Media Studio (CIMS), at Carleton University, Ottawa.

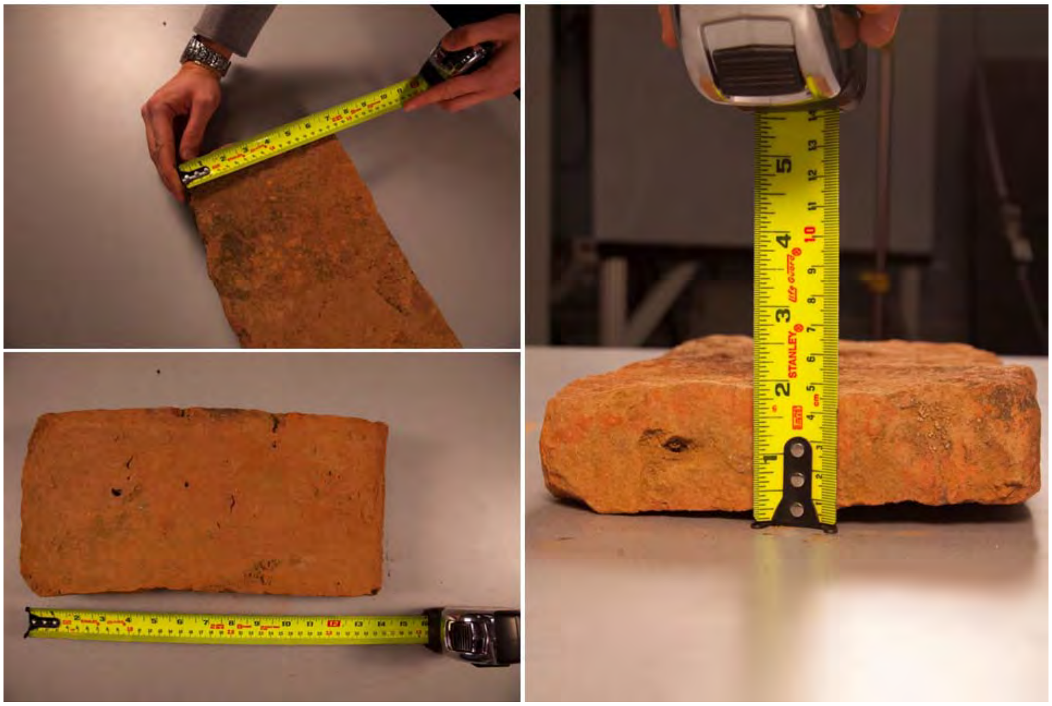

Figure 42 Documentation of the original brick measures. The recorded dimensions are 35 cm of length; 18 cm of width; and 5 cm of thickness. Source: Author.

Figure 43 Documentation of the contemporary brick measures. The recorded dimensions are 22 cm of length; 10 cm of width and 5 cm of thickness. Source: Author.

The assumptions about the higher quality of the old bricks compared to the new ones has been verified by scientific evidence. At the National Research Council (NRC) labs[24] compressive strength, absorption and density tests were carried out on the two bricks.

These tests evidenced different mechanical properties of the two bricks. Despite both bricks were handmade, they showed different resistance due to different cooking processes, materials used for its fabrication and age.

The workflow adopted consisted into three main steps:

1) The XII century large brick was sectioned in to four homogeneous cubes into 5 cm x 5 cm x 5 cm sections[25]. The modern brick instead was cut into two parts.

2) Samples were capped with a sulfur capping compound to level the tested surfaces in the compressive test. This was done in order to make the bricks sample top and bottom surfaces even, thus achieving uniform loading to the samples.

3) Masonry samples were loaded in an Instron 500000 lb universal testing frame[26] and tested as per the National Standard of Canada CSA A82 "Fired Masonry Brick made from Clay or Shale" of 2014 (National Research Council, 2014).

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[24] The test was carried out in the National Research Council (NRC) Lab in Ottawa, Canada, thanks to the kind collaboration and support of Professor Mariana Esponda, Carleton University and Mr. Kenneth Trischuk, Technical Officer for National Research Council Canada.

[25] Since the old brick had bigger dimensions, four samples were obtained out of it. This choice was motivated by the will of testing the strength of the different brick portion. Considering the smallest dimensions of the newer brick instead, only one sample was cut out of it.

[26] The Satec system Instron compression machine has a maximum load of 449600 lb = 203935 kg. Therefore is also possible to express its maximum load as 2000602.35 N (approximately 2000kN).

Table 6 Results of the compressive strength tests on the four homogeneous cubes obtained from the XII century brick. Source: Author.

XII century brick					
Sample	Length(mm)	Width (mm)	Area (mm²)	Failure load (kN)	Stress (MPa)
1	58	57	3306	125.66	38.0
2	58	54	3132	118.38	37.8
3	55	60	3300	144.01	43.6
4	56	55	3080	94.05	30.5
Average					37.5

Table 7 Results of the compressive strength tests on the sectioned portion of a contemporary brick. Source: Author.

Modern brick					
Sample	Length(mm)	Width (mm)	Area (mm²)	Failure load (kN)	Stress (MPa)
1	112	115	12880	172.24	13.4

The mechanical properties of the old brick provided a higher compressive strength (almost three time more than the modern one). The results of the compressive strength show that the old brick resists to a stress of about 37.5 MPa while the modern brick resists only to a stress of 13.4 MPa.

According to the National Standard of Canada CSA A82 (National Research Council, 2014) - compressive strength is to be calculated based on gross area. Therefore, the results of the test carried out on the contemporary brick did not take into account its concavity. In the case of the ancient brick, instead, the set of samples was flat[27] so no correction was needed. Nevertheless, it is worthwhile to also know that the net area is what truly carries the load. Consequently, compressive strength calculations based on the net area were carried out for the modern brick. The results are reported in the table below.

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[27] Even if most of the ancient bricks presented a concavity in their interior, the selected one did not. The reason of this should be found in the different moulds used in the bricks fabrication. Indeed, as mentioned in Chapter 6, bricks were coming from different villages as a form of donation.

Table 8 Results of the compressive strength tests of the Net Area of the sectioned portion of a contemporary brick. Source: Author.

Modern brick (compressive strength calculations based on the net area)					
Sample	Length (mm)	Width (mm)	Area (mm^2)	Failure load (kN)	Stress (MPa)
1	112	115	9195	172.24	18.7

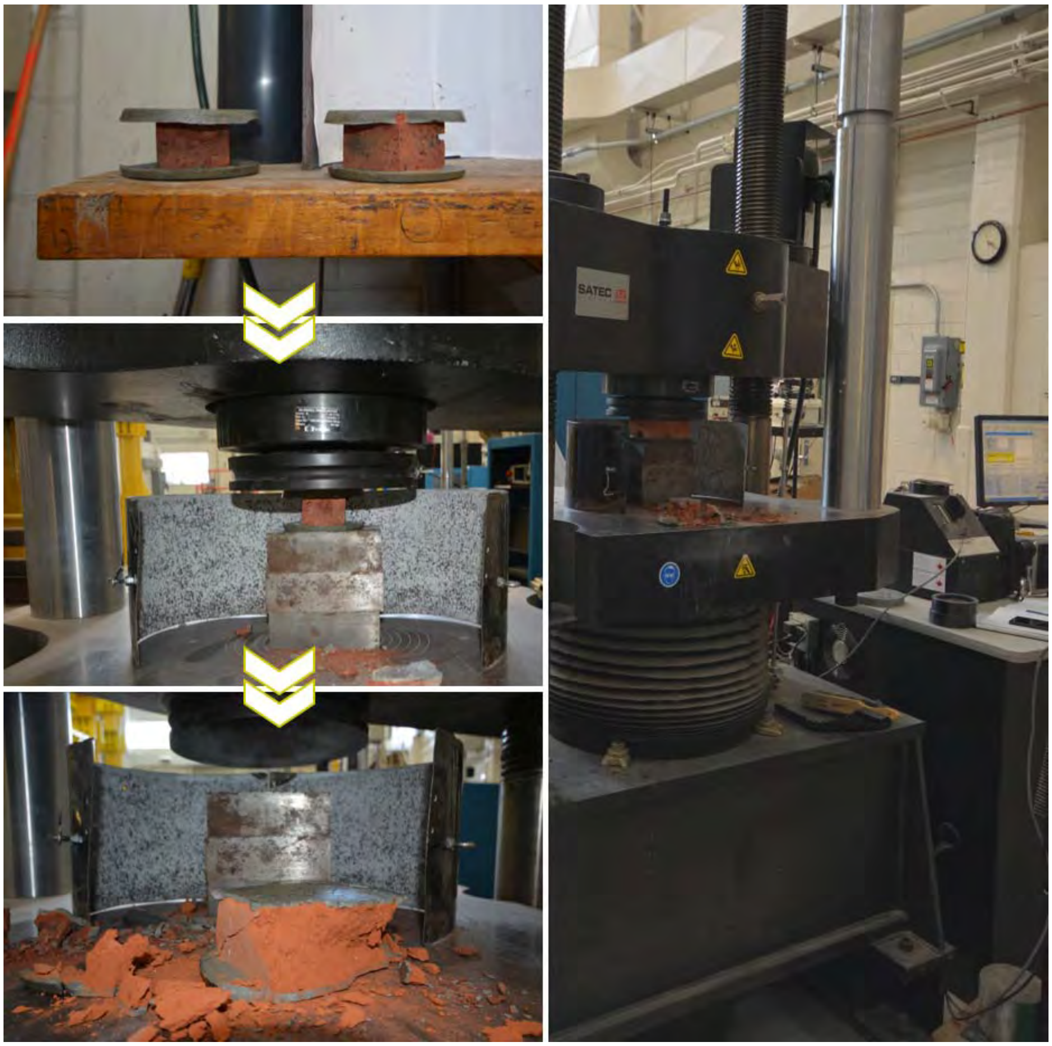

Figure 44 Images illustrating the three main steps followed in the compressive strength test carried out on the samples of the ancient and new bricks. Image source: Author.

Even considering the net area of the brick, the ancient brick resistance under stress (37.5 MPa) is approximately double of the modern brick (18.7 MPa).

The explanation of these results, can be associated with the longer cooking time processes (about eleven days against the approximately twenty-four hours for the new bricks, according with the conversations with the local masons, local experts and the DoA staff in Bagan).

Indeed, longer cooking process improves the sintering[28] of ceramic materials and consequently mechanical properties.

Considering that Bagan is affected by heavy rains particularly during the monsoons season, absorption tests and density characteristics on both bricks samples were also carried out. The tests allowed to identify which of the two bricks has better resistance to cold water absorption[29].

Figure 45 Image illustrating the cold water absorption test in progress. Image source: Author.

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[28] The sintering for ceramic materials is a physical-chemical process that transforms inconsistent material (such as the clay of the bricks) into consistent material. This process happen when the material is submitted to high temperatures not far from the melting temperature. The higher is the sintering temperature, the better is the welding of the particles and consequently the mechanical properties (Licciulli, 2005).

[29] The test consisted in placing the dry bricks samples in water for 24 hours, measuring after that the percentage of moisture absorbed (recorded % of Cold Water Absorption).

Tests were carried out according with the National Standard of Canada CSA A82 (National Research Council, 2014).

Table 9 Results of the cold water absorption and density characteristics of the XII century brick. Source: Author.

XII Century brick					
Sample	Oven Dry (g)	24 hours Wet (g)	Displaced water mass[34] (g)	Cold water absorption (%)	Density[35] (kg/m³)
1	109.1	122.55	60.9	12.3	1769.667
2	156.64	175.09	87.2	11.8	1782.228
3	703.73	803.04	407.5	14.1	1779.163
Average				12.7	1777.0

Table 10 Results of the absorption and density characteristics of the contemporary brick. Source: Author.

Modern brick					
Sample	Oven Dry (g)	24 hours Wet (g)	Displaced water mass (g)	Cold water absorption (%)	Density (kg/m³)
1	784.19	934.36	451.4	19.1	1623.716

The absorption test and density characteristics analysis evidenced:

- a lower density of the modern brick (1623.716 kg/m^3) compared with the average density of the ancient brick samples (1777.0 kg/m^3);
- a higher absorption of the modern brick (19%) in comparison with the absorption of the XII century brick's samples (12.7%).

Therefore, the developed tests proved the initial assumptions and the information gathered through the REAP methods. Indeed, the modern brick is more porous and less dense than its XII century equivalent. These results agree with the compressive strength values, which evidenced the lower strength of the modern brick compared to the stronger compressive strength of the XII century brick.

In conclusion, the tests provided scientific evidence of the higher quality of the ancient brick, thus confirming the high performance of traditional materials and workflows, validating the thesis initial assumptions.

In term of non-destructive techniques, IR camera analysis have been carried out in some selected areas of the building. This technique was employed to check superficial material inconsistencies or anomalies in the masonry structure. This technique and its workflow are described in depth in the paragraph *7.3.3 Image-based recording techniques and tools, b) IR Camera* in this chapter.

All the information gathered was used to characterize the developed BIM model. The aim consisted in integrating this ‘knowledge’ within the tool used to design and manage conservation and/or maintenance actions. This would provide a relevant support to address compatible and sustainable interventions required for the recovery and constant maintenance of the temple.

7.4.2 Form, design, spatial composition, significance and uses

For the preservation of the temple’s integrity, a study on the peculiarity of the forms and spatial composition of the building was carried out. The study aimed at understanding and documenting the tangible character-defining elements of the building and its associated meanings. To fill the gaps between the intangible elements of the built structures, the research gathered historical, archival and contextual data, and collected information through personal communication with the keepers of the local knowledge.

In terms of design, the temple fulfills a double goal. It has an open vaulted shrine in the interior – to preserve the inside worship function – and high and soared stupas on the roof - in order to evoke ascension effects from the outside.

Figure 46 Image illustrating how the high and soared stupas evoking ascension effects. Loka-hteik-pan temple, Bagan. Image source: Author.

In terms of architectural elements, square tower, *sikhara*, composed by *hti*/umbrella and tower lancet, defines and characterizes the temple in term of exterior shape and visual impact. The *sikhara* stands on the terrace of the temple. It consists of three parts, *hti*/umbrella, which is on the top of the *sikhara*; the main tower, and the tower lancet, which is the decorative part on the middle of the *sikhara*. From the visual and hierarchic point of view, the main *stupa* dominates the corner ones. Corner *stupas* symbolically represent the Buddhas who support the present Buddha (main *stupa*). These elements stand on the four corners of the temple on the upper level.

The terraces have strong symbolic connotations too. Their hierarchy symbolizes the steps to enlightenment.

From the functional point of view, instead, the discontinuous parapet on the upper level of the temple, also known as crenellations, is a traditional solution for draining rainwater from the structure. A similar function is played by the stepped base (base with recess) on the lower level of the base, consisting of a series of rectangle bricks recess and bulge, which protects the structure from the heavy rain of the monsoon season.

Figure 47 Image illustrating the sikhara of Loka-hteik-pan temple as perceived and seen from the ground. Image source: Author.

Figure 48 Description of some elements of the Loka-hteik-pan temple. Image source: Author.

Accessibility to the different parts of the temple also has symbolic connotations. For instance, the narrow axial niche/*nat-lan,* stairway to the upper *stupa*, restricts worship of the main *stupa* to a specific group of people.

The interior spatial arrangement presents three environments: a porch, a vestibule, and a central shrine. In the central shrine, there is a Buddha figure that rests on a pedestal shaped as a Lotus Flower. All this space is covered by a high-vaulted shrine with a domical vault. The vestibule instead, with its rectangular layout typical of most Burmese temples, is covered with a barrel vault.

Physical aspects and decorative elements

The documentation activity included also the identification of the (functional and symbolic) meanings of the decorative elements of the temple and their associated values. This information has been researched through a perusal of the existing published sources. These included inscriptions, travel diaries, novels and documents of the British colonial period. Among these sources, recent technical documents provided most of the information on the decorative features and meanings of the temple.

Figure 49 DoA archive, Bagan, main quarters of the Department of Archeology. Image source: Author.

Nevertheless, considering the scarcity of ancient written sources on Bagan and its architecture[30], the main information sources came from consultations with individuals and experts as well as focus groups with local people.

In terms of decorative apparatus, the inside of the temple is totally covered with wall paintings. These display not only the excellent artisanal skills of the Ancient Burmese, but also their avid devotion to the Buddhist religion. The wall paintings contain narrative pieces, depicting stories of Buddha's life[31]. These pieces of decorative art had a didactic function, encouraging the community to lead a faithful life disseminating Buddha's teachings[32]. The West Wall of temple Loka-hteik-pan is an example of this narration, with fourteen rows of panels illustrating stories and legible glosses underneath.[33]

Loka-hteik-pan wall paintings are the longest series of documented illustrations of the 550 Jataka Stories and the largest painting in Bagan where all the Eight Grand events of Buddha's life are shown together.

[30] Most of the written sources date back to the last two centuries and the majority of the authors are foreigners, mainly European and North American travellers and scholars. The higher number of publications was written during the British domination and from the 1970s and 1980s.

[31] In the XVIII century, scenes of both court life and daily life of ordinary people began to appear, especially in the Konbaung Dynasty (1752-1855). After the takeover of British Rule in Burma in 1824, Bagan artists began to incorporate Western influences such as the use of linear and aerial perspective (Falconer et al., 1998), p.160.

[32] Communicated through the *Jatakas* paintings – the 550 lives of Buddha before he was born as Prince Siddartha Gautama.

[33]. Loka-hteik-pan predominantly focuses on the last ten Jatakas, called the Mahanipata. These glosses in this temple are in Old Mon for the top two rows, and those underneath are in Archaic Burmese (Griswold et al., 1971), p. 17.

Figure 50 Loka-hteik-pan temple, inside decorated with mural paintings. Image source: Author.

Figure 51 Samples of decorated mural paintings in Loka-hteik-pan temple. Image source: Author.

ROOM NO.	LOCATION PLAN	TYPE AND RATING	HISTORIC	ARTISTIC	TECHNICAL	CONCEPTUAL
GROUND LEVEL						
1580.01.01		Porch ++	Example of the so-called Transitional Period (1113-1174) ranging from the Old Mon to the Old Burmese Style.	Plainly decorated with stucco and paint, contrasts against the rich interior.	Barrel Vault constructed of bricks	Entrance into the central shrine.
1580.01.02		Vestibule +++	The darkness of the vestibule with its single small entrance is evidence of the Mon Style.	This transitory space is decorated with wall paintings. These have a deep rich color representative of the Mon style.	Barrel Vault constructed of bricks; brick walls are prepared with a stucco layer before paint is applied.	Narrow entryway leading to the shrine. The absence of lighting creates dramatic effects leading into the shiny central shrine.
1580.01.03		Central Shrine +++	The Central Shrine is representative of the XI century design.	Mural paintings inspire reverence and awe. These are the longest series of documented illustrations of the Jataka stories, and largest painting in Bagan. The temple features a rich collection of Archaic Burmese and old Mon writings.	Domical Vault made of vertical standing bricks. Wall paintings display the excellent artisanal skills of the ancient Burmese.	Perforated windows act as the sole light source, highlighting the central Buddha figure. A dim interior aids with meditation, creating a feeling of reverence. This is the most important space of the temple. It is the central area of worship, the most sacred space of the temple. Wall paintings contain narrative pieces with a didactic function.
TERRACE LEVEL						
1580.02.01		Upper Terrace ++	Heavily repaired after 1975 earthquake.	Plaster decoration with floral motifs recalling Bagan natural context. Motifs and moldings are in Early Bagan style.	A practical access to the temple's roof. Crenellation (discontinuous parapet) is used along the upper level for draining rainwater.	The Yar-Ma fingers at the entrances act to protect the temple from evil spirits, this practice bagan in the XI century.
1580.02.02		Square Tower +++	A large central stupa is a common feature of all Bagan temple typologies.	The use of heterogeneous geometric forms creates variations in spatial perception.	The main stupa consists of three parts: Hti/umbrella (on top of the sikhara), the main tower, and the tower lancet (decorative centre). The mortar binding the bricks is composed of 9 local ingredients	The hierarchy of the terraces symbolizes the steps to enlightenment. The main stupa visually dominates the corner stupas, and is representative of the Buddha gaining enlightenment The corner stupas represent the supporting future Buddhas.

LEGEND

+++ Highest values ++ High value + Valuable - No rating -- Devaluating

Figure 52 Room book of the Loka-hteik-pan temple. Image source: Author.

Significance and uses

As for the information on physical aspects and decorative elements, the inscriptions, travel diaries, novels and documents (dating back to the British colonization) provided only partial information on the significance and uses of Bagan temples.

Hence, contemporary sources (from the ‘80s up to now) have been employed. Furthermore, information on significance and uses of the temples was collected on the site, mainly through direct observation and oral sources. Consultations with individual and expert, behavioral mapping, transect walks, behavioral mapping and direct observations discussion with local people (De La Torre, 2002) are the main methodologies used to gain information. Furthermore, this work allowed to gather documentation of oral sources on digital format (text, photos, video and audio recordings), preserving them from possible loss. This issue became particularly sensitive in the case of Bagan in the last years, as a consequence of the growing globalization processes that are among the main causes of the loss of traditional skills and jobs that migrate to the new ones required by the market.

Most of the results of these analysis have been combined in the Nara Grid reported in Table 6.

Table 11 Nara Grid of the Loka-hteik-pan temple.

ASPECT	ARTISTIC	HISTORIC	SOCIAL	SCIENTIFIC
Form & Design	Exterior: - Decorative floral patterns (kanote) on moldings - Hierarchy of the terraces symbolize the steps to enlightenment - The main stupa visually dominates the corners stupas - Proper proportions created through use of wide base and narrow top - Screened wall with 17 cross-shaped openings to diffuse light -Relatively plain facades with few ornaments - Symmetry in the plan and facades - Use of geometric forms to create variations in spatial perception	Context: -Representative example of the of the spatial conception of the Transitional period, with the typical design of the XI century -It illustrates the architectural style under King Cansu I and of the following kingdoms until 1374 Exterior: - The Yar-Ma finger reflect the art and culture of Bagan period Interior: - The pictorial decoration presents inscriptions in Burmese and Mon typical of the Transitional period. -Mural paintings exemplify the artistic style of the period (ex: halo around heads, and illustrations from Buddha's life)	Exterior: - Corner Stupas represent the Buddha's to be supporting the present Buddha (main stupa) - Hierarchy of the terraces symbolize the steps to enlightenment - Decorative motifs represent the 10 Myanmar traditional arts - Yar-Ma fingers at the entrances act to protect the temple from evil spirits, this practice began in the XI century Interior: - The natural lighting design illuminates the Buddha, leaving the other areas in shade, allowing worshipers to concentrate mainly on the Buddha - Narrow entry vestibule transitions to a larger open sanctuary to heighten spatial experience - There are no windows in the porch in order to create a sense of detachment from the outside world. This symbolizes the spiritual journey from darkness into the light of Buddha in the central shrine	Interior: - Pointed arches form the barrel vault for structural stability
Material & Substance	Interior: - Red, black, white, yellow, and dark blue pigments used in the mural paintings. The red color was originated from iron while yellow and black respectively from claystone and carbon. White was generated from lime stone. These four colors were mainly used between the X-XII century. Blue was instead imported from India after the XII century	Context: - Fired mud bricks were traditionally produced along the Irrawaddy River Bank.	Context: - Materials sourced locally by donation from villages along the Irrawaddy river bank	Context: - Mortar composed of 9 different local ingredients: including Kywal Kaw (plant sap), and Oat Shik Thee (Bael fruit) - Use of local materials compatible with the local weather conditions - Arrangement of vertical and horizontal bricks as structural system to improve structural integrity

Use & Function	Exterior: - Narrow walkway on terraces and stairway as a method of restricting worship of the main stupa to a specific group of people	Context: - Temple is used for praying and meditation, but not for festivals.	Interior: - Bands of writing underneath the wall murals relay the 550 Buddha stories to worshipers - Instead of a corridor there is just enough room to make one's circuit of respect around the statue of Buddha - In the NW corner of the shrine a narrow staircase (Nat-Lann) leads up to the roof, this acts as a way of restricting worship of the main stupa to a small specific group of people	Exterior: - Parapet aids in draining rainwater from the structure - The lighting design was used facilitate meditation
Traditional technique & Workmanship	Context: - Motif and molding in of the Transition Period style Exterior: - Creative carving and assembling of the bricks for the development of decorative elements Interior: - Mural paintings color are restricted to those found within the local context, these pigments were produced and used by local artisans - Wall murals exemplify the artistic style of the period, ex: halo around heads, and illustrations from Buddha's life	Interior: - Construction of Yar-ma fingers reveal the culture and craftsmanship of the Bagan period	Context: - The construction of temple utilizes local workers and craftsmen	Exterior: - Stepped base, parapet wall, and roof slope protect the structure from precipitation. These elements are just some examples of the adaptive building solution to the local climate, developed by local workmen and builders.
Location & Setting	--	Context: - The temple faces North towards the old city, symbolically facing the Royal Palace.	Context: - The location of the temple - close to the Shwehsandaw pagoda, the Ananda temple and the That-byin-byu temple the highest in Bagan) and the Bagan city walls - indicates the importance of the temple, near to the religious edifices of Bagan monarchy.	Exterior: -The three brick windows are located on the east, south and west side to guarantee basic lighting condition and screening the central shrine from the direct sun.

Location & Setting	–	Context: - The temple faces North towards the old city, symbolically facing the Royal Palace.	Context: - The location of the temple - close to the Shwehsandaw pagoda, the Ananda temple and the That-byin-byu temple the highest in Bagan) and the Bagan city walls - indicates the importance of the temple, near to the religious edifices of Bagan monarchy.	Exterior: -The three brick windows are located on the east, south and west side to guarantee basic lighting condition and screening the central shrine from the direct sun.
Spirit & Feeling	Context: - Symmetrical composition gives the feeling of perfection, grandeur, balance and harmony - Painting of Buddha's footprint on the vault of the vestibule represent luck and fortune - Screened windows enhance meditative atmosphere by balancing the amount of light and dark inside the temple	Interior: - Dark and secluded interior aids in meditation and is reflective of temple design in the early XI century	Interior: - Statue of Buddha provides feeling of protection and warmth - Central location of the Buddha and lotus pedestal is an important aspect of Buddhist worship - Mural paintings inspire reverence and awe	Context: - Plan and design derived from worshiper's religious needs

The Nara Grid theorized and developed by Koen Van Balen at the R. Lemaire International Centre for Conservation, University of Leuven, is based on ICOMOS Nara Authenticity Document, as a result of the Nara Conference held in Japan in 1994 (Van Balen, 2008).

It provided a valid support to summarize and structure the information collected into a comprehensive document.

The presented features illustrate the embedded values of the temple associated with its history, its design, religious meanings, fine arts details and the intangible knowledge that produce them.

7.4.3 The results of the Rapid Ethnographic Assessment Procedures (REAP)

The results of the REAP methodology, described in the paragraph *3.2.1 The Rapid Ethnographic Assessment Procedures (REAP)* are here presented.

The application of this method, borrowed from the field of ethnography, aimed at gaining information on the current role of Bagan built heritage for the local community[34].

The REAP allows determining social, cultural and economic values associated with Bagan monuments by taking into account local people perceptions. This analysis was based on consultations made to different types of actors, directly and indirectly, engaged with Bagan built heritage.

While indirect research provided the basis to develop assumptions and hypotheses, direct research allowed to gather information on relevant aspects related to everyday life, workflows and ongoing change in the site of Bagan.

Furthermore, the REAP methodology allowed to obtain updated information on the "living" component of Bagan site, understanding social dynamics, people behaviors and attitudes towards their built heritage. This has also been extremely useful for the value recognition of Bagan architecture and its features as well as its associated landscape. Further, considering that, in Bagan, information and knowledge on building construction is mainly transmitted by oral means, the research analyses exceeded the architectural field, including anthropological investigations.

[34] Despite the "Rapid" connotations of this method are connected to a "researcher-team interaction" (Low, 2002), p. 35, the on-field investigation has been developed solely by the Author. Nevertheless, different perspectives of the team members such as Ms Wint Latt and of the local participants have been taken into consideration to understand the Bagan cultural, social and economic situation.

In the following paragraphs, indirect and direct research findings are presented.

Indirect research consisted of an analysis of the main sources and documents available. The main problems faced in this phase were related to inconsistencies among different sources. These sources differ in terms of documents' format (monographies, reports, books, inscriptions, etc.), authors' provenance (local, non-local, visitors, travelers or foreign residents in Bagan or in Myanmar[35], etc.) and period of publication (i.e. colonial time, post-WWII era). These differences in the sources of indirect research presented, in some cases, contradictions in the interpretation of architectural features (such as contrasting information on material provenance, different meanings and histories associated with patterns and figures in the stucco decorations and in wall paintings topics and subjects, different interpretations of structural buildings behaviours and of geometry and shape of architectural elements and spatial arrangement) as well as in dating issues (diverse information on the date or period of buildings' construction) and terminology used (words and associated meanings).

Despite the specificity of the case study, the adopted methodology can be extended to other living built heritage sites that present ongoing change, living knowledge and know-how associated with the conservation and maintenance of built structures.

Indirect research

The starting point of the indirect research was the inventory developed between the 1982 and 1991 by the French archeologist Pierre Pichard. The inventory, as already noted in Chapter 6, was developed within the framework of an UNDP project and

[35] Foreigners resided in Bagan or in Myanmar mainly during the British rule from 1885 to 1948.

published in eight volumes between 1992 and 1995. It contains information about each Bagan monument organized as follows: Inventory Number; Name of the Monument; Broad location referenced to a prominent monument, landmark or village; Coordinates and a Short Description of each monument (Pichard, 1992).

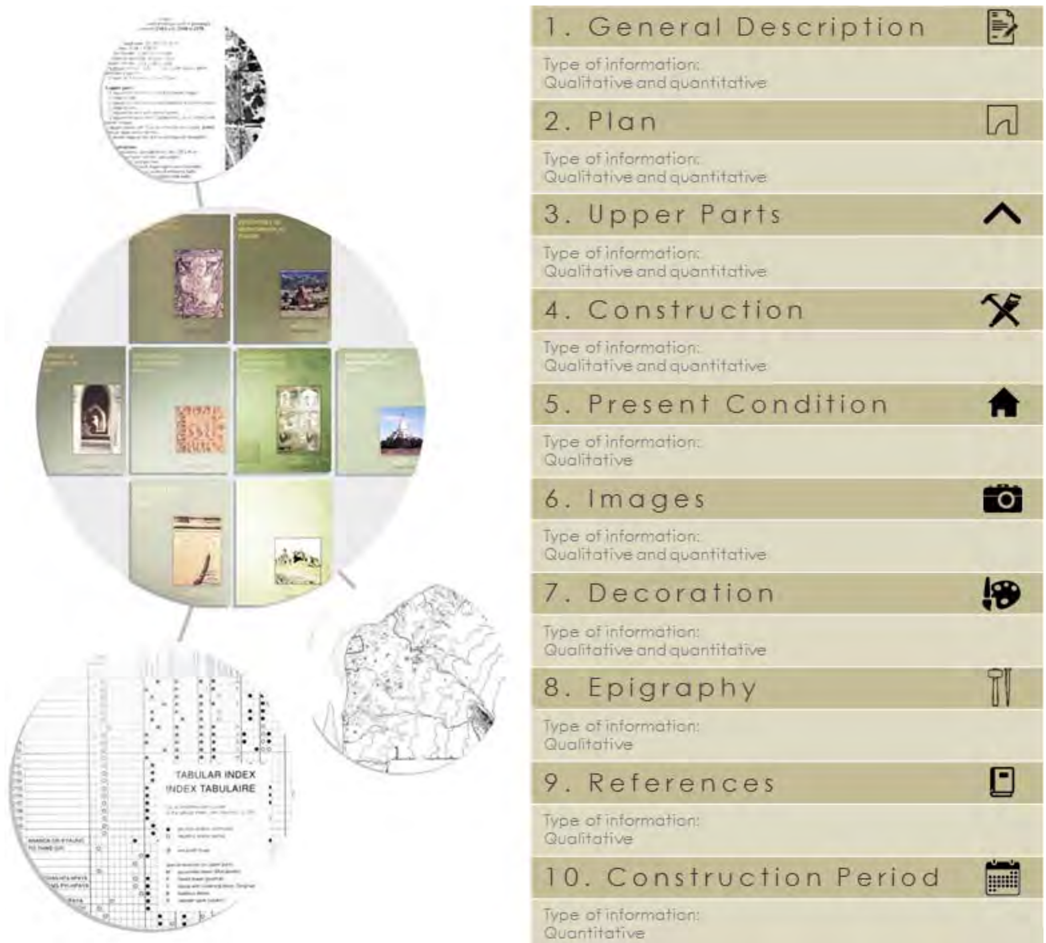

Figure 53 UNESCO inventory structure. Image source (Mezzino, Quintero, Pwint, Latt, & Rellensmann, 2016).

Direct research

Because of time and budget limitations, four qualitative methods of the REAP methodology were used: direct observation, transect walks, behavioral mapping and personal communications.These methods allowed to document unknown aspects related to the value (or non-value) recognition of Bagan historic structures according to different groups representing a cross-section of the local population. Besides, through this qualitative analysis, it was possible to discover relevant local-making products and techniques that characterize construction and conservation practices that were not recorded in written sources.

In order to provide a significant overview of local perceptions about the cultural built heritage of Bagan, local people with different profiles, background and roles were selected.

First of all, the REAP evidenced conflicting information coming from actors involved at different levels and with different roles in the conservation or reconstruction of Bagan historic structures. Furthermore, it also allowed to grasp different and contradictory points of view, feelings and opinions towards Bagan built heritage.

In particular, some the local population showed limited interest in the maintenance of Bagan religious monuments. This was unexpected but at the same time relevant for the objectives of the research (see chapter 1 *New interpretation paradigms in the conservation field, Paragraph* 1.3 *Conceptual framework*). The REAP outcomes validate the research initial assumptions stressing the role of the documentation of intangible aspects to make conservation of tangible assets effective, more inclusive and relevant to local actors so as to ensure the sustainability of conservation efforts.

In particular, in terms of values, the REAP outcomes underlined that the majority of the local population who do not possess a secondary school degree and, in some, cases, not even a primary school degree, perceive the ancient Bagan monuments mainly as tourist attractions and possible source of income. Indeed, most of the farmers, peasants and workers pray in the temple (or neighbor temple) close by their home, recognizing only that one as place of worship. Usually, these temples are new structures and thus attract fewer tourists. Personal communication with locals and visitors have shown that the Bagan temples in the monumental area are mostly places of pilgrimage and tourist destinations, rather than places of worship for local communities.

The results of the REAP carried out in Bagan seem to indicate a correlation between the level of interest by local actors in the history of Bagan tangible assets and their conservation, and their level of education. Dissemination and education actions should thus integrate tangible conservation actions, as they appear relevant in order to share heritage values and transform them in shared and socially sustainable impacts.

Secondly, the REAP provided relevant information also of technical aspects of Bagan structures. This information fulfilled the second aim of the research, pursuing the understanding of intangible aspects associated with materials and techniques of historic buildings.

The REAP outcomes proved very useful in terms of integrating the technical information on building and maintenance techniques involving 'traditional' materials, based on local knowledge[36] and skills. From the DoA staff and local masons involved in Bagan monuments repairs, interesting information on bricks assembly, mortar, stucco composition and wall paintings emerged. Relevant information included, but was not limited to composition of materials, manufacturing processes of building components and construction materials, availability of primary sources (i.e. clay, stone, wood), traditional and current construction techniques, symbolism of

[36] Builders, masons and craftsmen traditionally transmit their knowledge father to son or to neighbors and/or relatives.

architectural and decorative buildings' elements, buildings uses, local natural resources employed for construction materials (i.e. neim or acacia resins as glue for plaster).

The knowledge of specific aspects associated with material, techniques, manufacturing processes and skills of the actual makers (craftsmen, masons, etc.) can integrate, enrich and allow the development of informative conservation actions, by stressing the connections between heritage values and conservation impacts (i.e. masonry conservation made by local masons or plaster restoration using local materials and traditional know-how).Therefore, the REAP evidenced important aspects to be taken into account in the specific conservation workflows. This is particularly evident in the case of Bagan built heritage, where its brick masonry structures derive from the knowledge of the subtle relationship among climate, vegetation, earth, uses of the structures as well the knowledge of the climate and weather conditions (such as high humidity, range of temperatures, rain periods, etc.).

This information was collected and structured in the developed BIM model, using the Loka-hteik-pan temple as a case study. Collected information was used to characterize the geometric 3D model. This aimed at making this information relevant in the different design phases of a conservation/reconstruction process, structuring them in the employed design tools, trying, in this way, to ensure that this information would not be ignored as often happens (i.e. historic relation/research seldom taken into account in the final proposal and executive phase).

Workflows and associated issues regarding the semantic characterization of the model are addressed in Chapter 8 *Combined uses of BIM systems and Wiki approaches to archive and collect quantitative and qualitative information.*

7.5 Strategies to document intangible knowledge related to building materials and constructive techniques

To grasp information on embodied knowledge of Bagan built structures, several documentation strategies to collect information were tested. The direct investigations on the ground provided relevant information on building techniques, traditional workflows, materials provenance, meanings and values associated with shapes, buildings' design and decorative elements. From the REAP emerged that, despite local professionals (masons, craftsmen, builders, etc.) developed mainly spoken means in the codification of traditional building practice, transferring knowledge and know-how relying on practical demonstration and oral instructions.

In a first phase, due to difficulties in finding and localizing information keepers on the site, only few interviews were carried out. Indeed, even with the support of DoA staff, relevant information arose randomly because of the lack of a centralized and shared database, also within the same DoA office[37]. Even if the information gathered was relevant, this approach was very time-consuming and needed further structuring.

Therefore, in a second phase, direct analysis followed the Rapid Ethnographic Assessment Procedures (REAP) methodology. This allowed to proceed with a more systematic organization of information gathering and contributed to significantly reducing the time required for the completion of data collection.

Having tested the effectiveness of this consolidated method, chapter 8 will analyze the characteristics and implications of alternative approaches to developing and

[37] This problem was confirmed by the UNESCO officer Nuno Vasco Oliveira, a member of the UNESCO Bangkok technical unit, who was stationed in Bagan at the time of the fieldwork.

systematically using direct observation on the intangible aspects of heritage as a method integrating conventional forms of data gathering on the tangible aspects of cultural heritage. Sources of inspiration came from the IT technology field and from the analysis of the rapid development and spread of social media and web platforms as systems to collect and share data, as discussed in chapter 4 *The potential of the 'Digital Revolution' for the conservation, documentation and management of Cultural Built Heritage* and chapter 5 *The Epistemic object: WikiBIM as a participatory documentation approach to managing design choices in built heritage contexts.*

Considering the developed strategy to collect information through the REAP methodology, chapter 8 will also address the challenge of gaining and systematizing similar information also from informants, consultants and experts with different social and cultural backgrounds and different conservation approaches. Hence, the availability of mobile communication devices, access to internet connections and level of user-friendliness by local communities will be considered to define an effective approach. Finally, chapter 8 will also outline a strategy to set up an efficient method of organizing information drawn from heterogeneous sources that could be integrated into the pre-set database logic of Building Information Model (BIM) system.

The proposed documentation strategies stress the role of shared intangible aspects to ensure cultural diversity and to generally increase the value and consequently the positive impacts of conservation processes on a site in terms of theoretical approaches and technical solutions.

8 Chapter: Combined uses of BIM systems and Wiki approaches to collect and archive quantitative and qualitative information

8.1 Proposed workflow to build a BIM model

In the creation of geometrical information from the generated pointcloud, a BIM model has been developed. The purpose of the BIM, or in this case HBIM (Historic Building Information Modelling), according to the current literature review (Murphy, McGovern, & Pavia, 2013), aims at increasing the level of knowledge of a building integrating metric and descriptive information. The choice of a comprehensive model to collect and store all gained information consisted in its recognized potential in the design, construction and maintenance processes (Banfi, 2016). Further, the main purpose of the BIM model consisted in collecting such information in a 3D database to document and safeguard traditional workflows for the stewardship of the Loka-hteik-pan temple's features. Indeed, what is perceived as merely decorative – such as the exterior decorated plaster, used to protect the bricks masonry from the rain (particularly during the rainy season) - can be determined as functional.

In order to structure the collected quantitative and qualitative information, through direct and indirect analysis, a 3D model employing the Autodesk Revit application has been developed. The choice of Autodesk Revit software has been oriented by the capability of formulating object libraries and families with parametric constraints and properties offered by the software (Oriel & Clare, 2016).

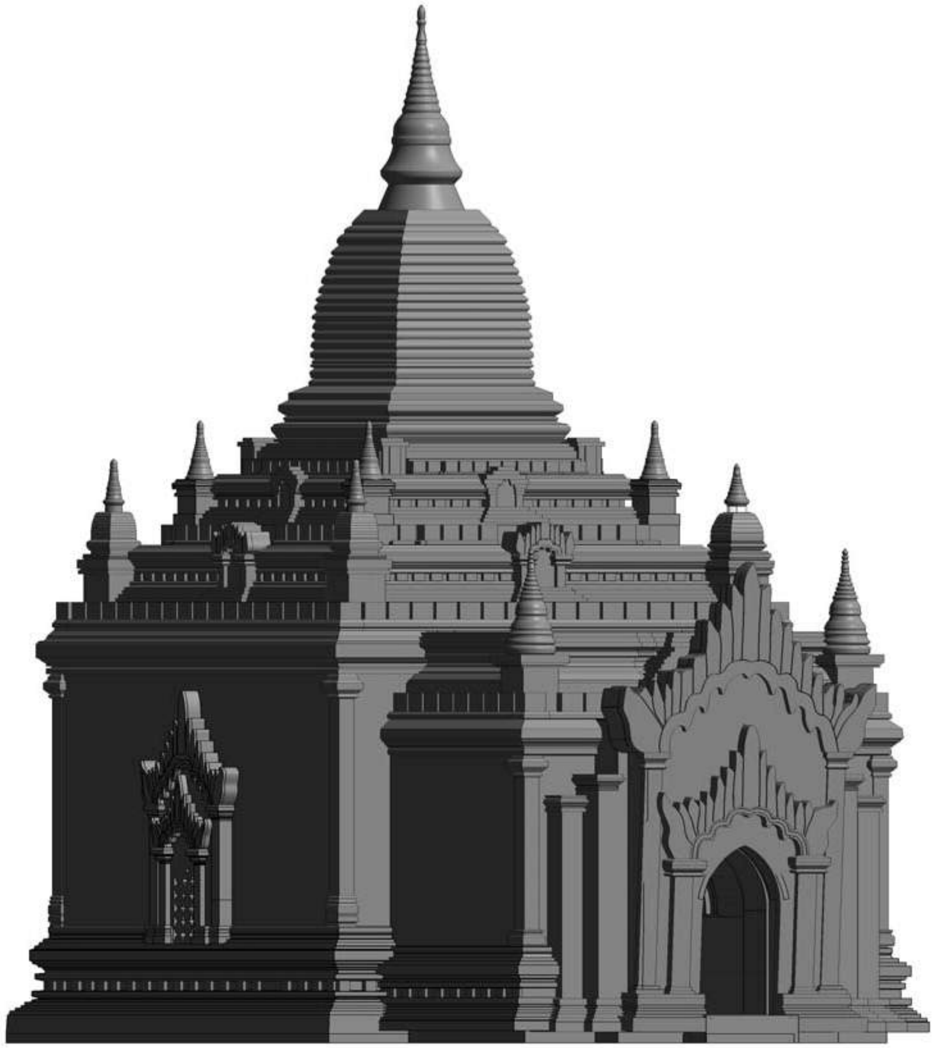

Figure 1 Screenshot of the completed BIM model of the Loka-hteik-pan temple. Software employed Autodesk Revit 2016. Source: Author.

Indeed, Revit is characterized by *"an internal structure made up of a database with families of objects. These objects represent the architectural elements that form a building"* (Banfi, 2016). Nevertheless, the choice of a parametric software provided several challenges in its application on an ancient heritage building characterized by the heterogeneity of each of its building components. Some applications of Historic Building Information Modelling (HBIM) have already been tested by Murphy for the reconstruction of heritage buildings from XVIII century in Dublin and Prague, by Oreni, Brumana, Barazzetti and Banfi for the modelling of layered Italian historic buildings (Oriel & Clare, 2016), and by Fai et al. in the modelling of the Bata building in Batawa, Ontario, Canada as well as the Canadian Parlament in Ottawa (Fai et al., 2011).

Many of these applications showed the limits of BIM, particularly in terms of modelling complex shapes. Concerning these limits, Apollonio, Gaiani and Sun evidenced three main constraints of the application of BIM on built heritage: semantic characterization challenges for unsegmented data, limits in the representation of irregular shapes and geometries that characterize historic architecture (i.e. handcrafted decorative elements or differences in object sections due to material consumption in the time or to other pathologies or damages such as weathering), and parametric constraints in the modelling of irregular geometries of historic structures with a high level of detail, avoiding oversimplifications (Apollonio, Gaiani, & Sun, 2017).

The modelling process has been developed in line with the principles illustrated at the beginning of Chapter 7 *The Zètema of the Loka-hteik-pan temple*. Hence, in the modelling phase only Autodesk Revit 2016 was used[1]. The awareness of budget constraints and limitations, that characterize the cultural heritage field, oriented the choice of using only one software in the modelling phase. This choice derived from the consideration of the high costs of BIM software licenses, averaging between € 2000[2] and € 3500[3] per year. Hence, the cost of additional 3D modelling software applications, such as Rhinoceros, 3DsMax, etc., to support and integrate the 3D

[1] Even if, in the modelling phase, Autodesk Revit 2016 was predominantly used, AutoCAD 2016 was used to test and support alternative modelling strategies and to develop 2D drawings.
[2] According to the Autodesk website a licence for a Revit software costs € 2659,60 per year (Autodesk, 2016b). The licence of the BIM software Edificius, provided by ACCA software S.p.A., has instead an annual cost of € 2148 (ACCA software, n.d.).
[3] The annual cost of a licence of the BIM software ArchiCAD, produced by Graphisoft, is € 3480.00 (ArchiEDU, n.d.).

modelling phase of the model, would be too onerous and potentially unsustainable from an economic point of view.

The choice of Autodesk Revit 2016 instead of other BIM software was justified by its huge diffusion and its interface similar to the one of AutoCAD, already used by most of the Architectural and Engineer studios and firms worldwide. Hence, the familiarity with its interface was considered a strength of the software, reducing training efforts, thus optimizing time and costs of the software employment. More generally, the choice of employing exclusively one 3D modelling software was also oriented at reducing the required skills and consequently the training activities needed to learn others 3D modelling software such as Rhinoceros, 3ds Max, Softplan, AutoCAD Architecture, ArchiCAD, Vectorworks Architecture, Solidworks or Allplan, just to mention some available 3D modelling software.

Furthermore, Autodesk provides an educational license of Revit that can be downloaded and used for free by students (Autodesk, 2016a). This additional aspect oriented the choice of employing a software that is (and will be) used by emerging professionals in the architectural and engineering field. The model generation relied on the previously acquired information captured through IT supported techniques as well as direct and indirect analysis. The modelling phase consisted of two main parts: geometric modelling and semantic characterization of the model.

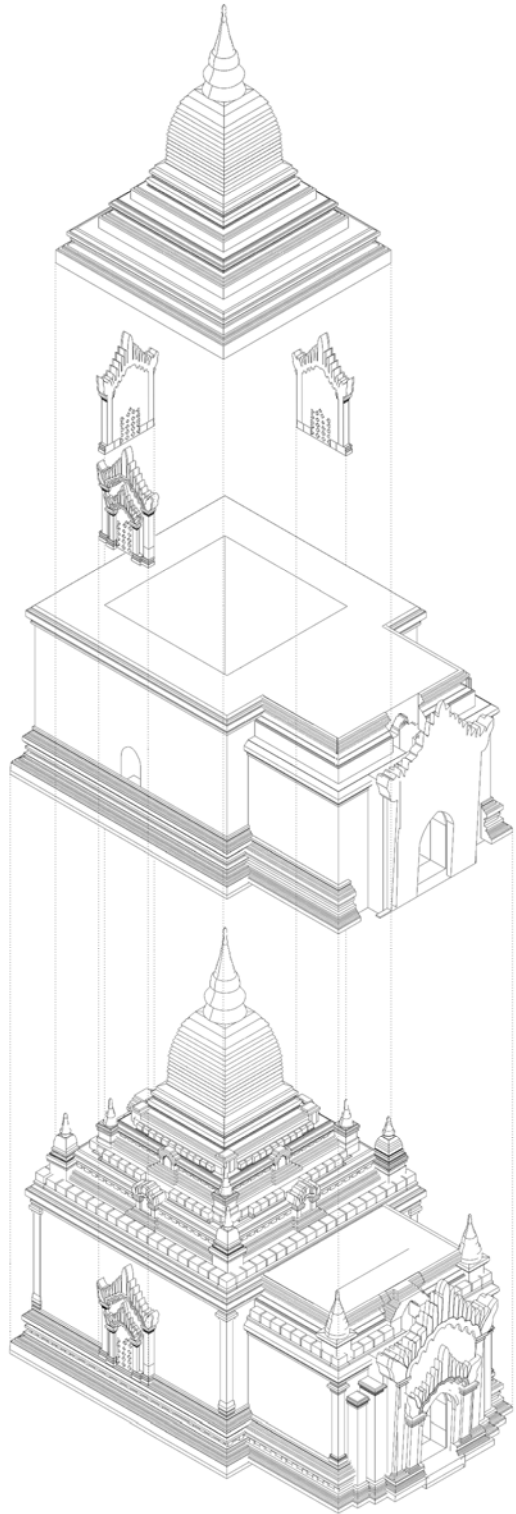

Figure 2 Exploded diagram of the axonometric model of the Loka-hteik-pan temple. Software employed: Autodesk Revit 2016. Image source: Author.

Concerning the modelling workflow, time effective solutions were preferred compatibly to the accuracy requirements. Nevertheless, alternative solutions were also tested and are illustrated in this chapter.

8.1.1 The 3D modelling phase

The development of the model involved three main stages: data processing, 3D modelling and semantic characterization of the model. Firstly, the consolidated pointcloud was generated by combining data coming from two sources: photogrammetry (aerial and terrestrial) and laser scanning. Such data were combined into Autodesk ReCap 360.

The surveyed points on the building, measured with a Leica Total Station TS11, allowed to reference and combine the different pointclouds into a comprehensive pointcloud of both the inside and outside of the building.

Secondly, the pointcloud was imported into Autodesk Revit 2016 in order to start the modeling phase by employing the pointcloud as reference to build the geometric model.

Figure 3 Perspective view of the consolidated pointcloud of the Loka-hteik-pan temple combined into Autodesk ReCap 360. Source: Author.

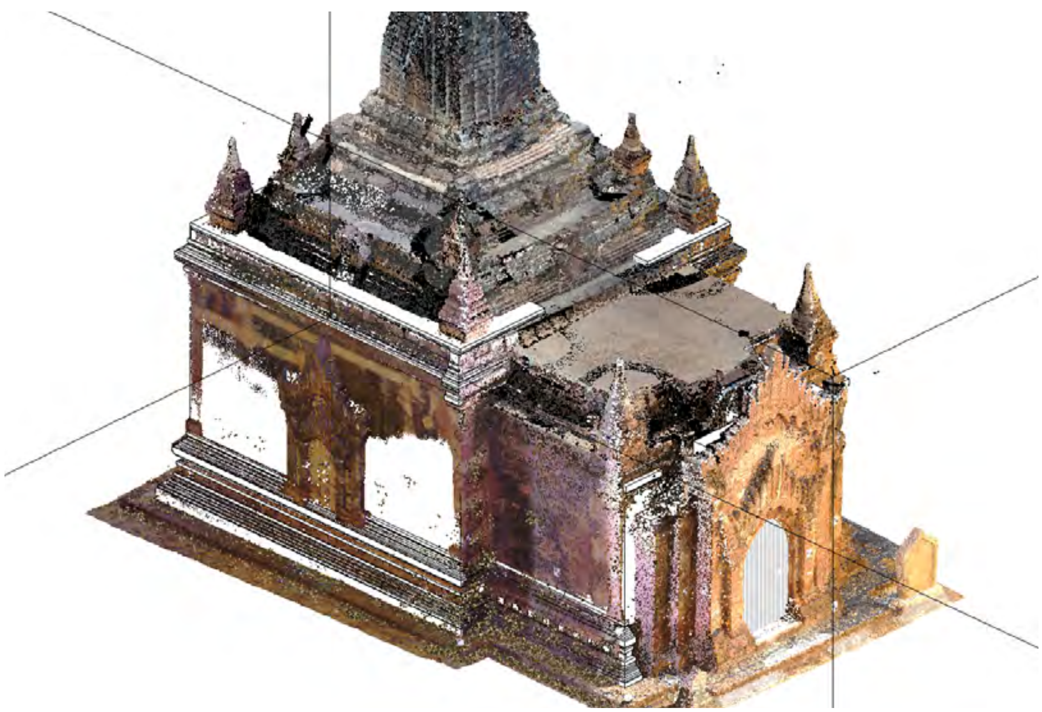

Figure 4 Loka-hteik-pan temple point cloud imported into Autodesk Revit 2016. Source: Author.

The pointcloud was referenced to the predefined views and was scaled according to the project unit (meters). After that, all the levels were set up in order to be able to start the modelling phase. Levels were used as reference to model the different heights and sections of the temple's walls.

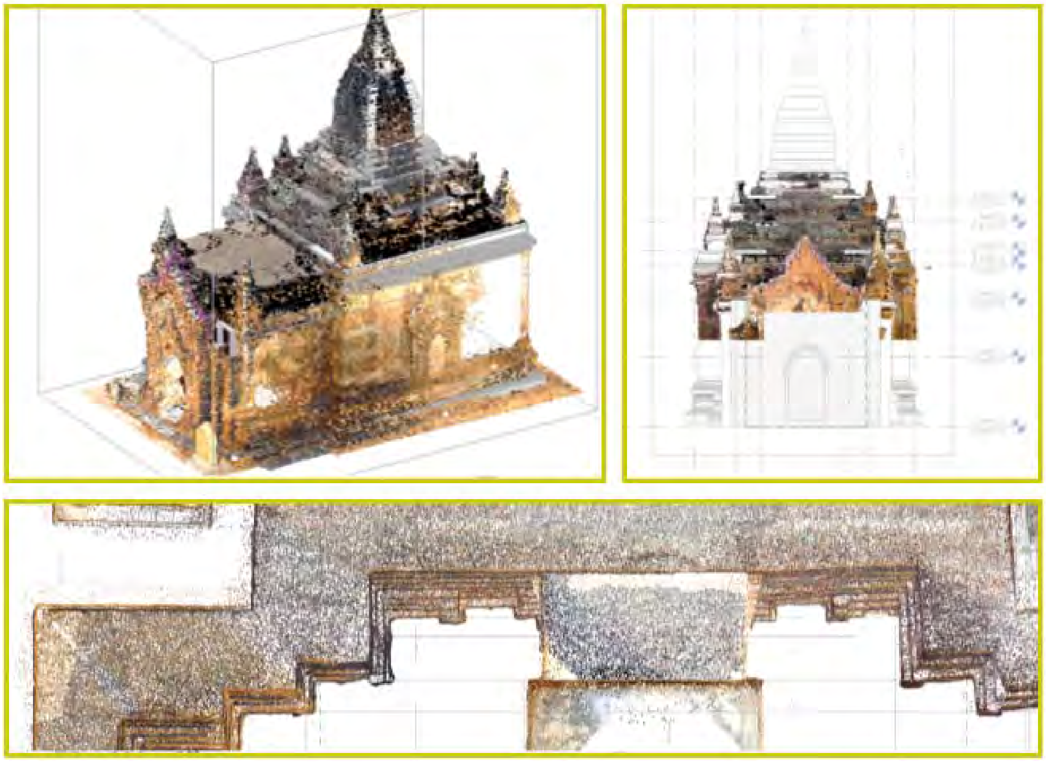

Figure 5 Image illustrating the use of the levels as reference to model the temple from the pointcloud. Software employed Autodesk Revit2016. Source: Author.

The choice of working with the pointcloud directly in Autodesk Revit 2016 – instead of creating orthophotos, trace them in AutoCAD and then import the line drawings into Revit - was aimed at reducing accuracy errors in the passage from one software to the other one.

The generative workflow for the geometric model included several steps particularly considering the complexity and the irregularity of the building.

The first element modelled were the walls. In this step the main challenges consisted in setting up a methodology to represent all the walls in line with the established level of detail. Hence, different modelling strategies were tested. The first one consisted in using the 'wall' command to model the wall profiles, using the pointcloud as reference.

In terms of modelling, due to the discontinuity of the walls size, an average between the bigger and the smaller wall's width was taken as reference for the width of the wall to be modelled.

Although efficient in terms of time needed for completion of the procedure, this modelling workflow did not provide a high level of accuracy. Trying to address this issue, a different strategy to model the walls was tested. It consisted in modelling the wall as '*In-Place Mass' (*Under the 'Massing & Site' tab).

This method consisted in dividing the wall into different sections (in this case one every 30 cm) drawing the profile of each section and then joining the different 'slices' in order to have a wall responding to the real wall trend with a level of accuracy proportional to the number of 'slices' and to the distance among them.

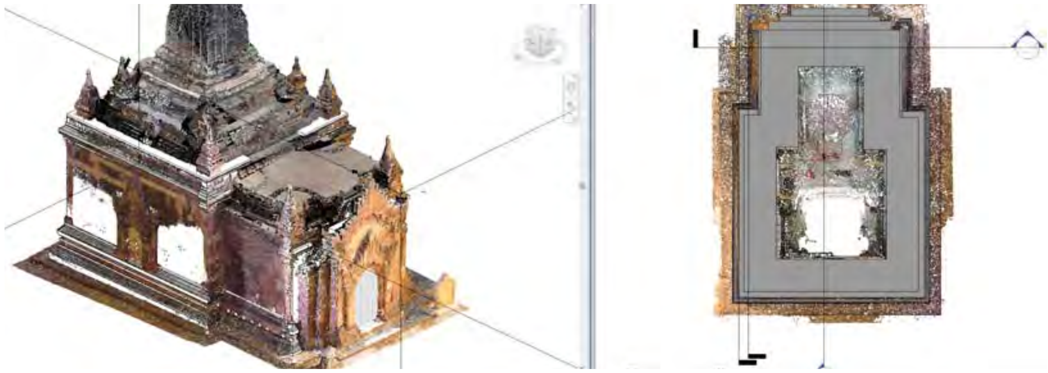

Figure 6 Screenshot illustrating the modelling process of the temple's walls. Software employed Autodesk Revit2016. Source: Author.

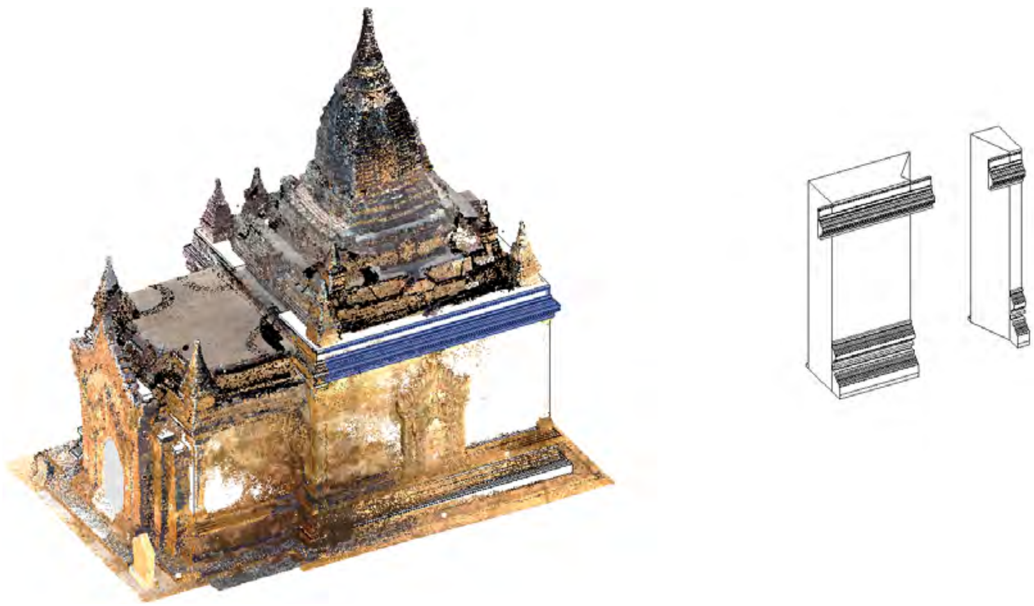

Figure 7 Screenshot illustrating the upper moulding and the basement of the temple modelled with the 'sweep' function, using the wall as reference. Software employed Autodesk Revit2016. Source: Author.

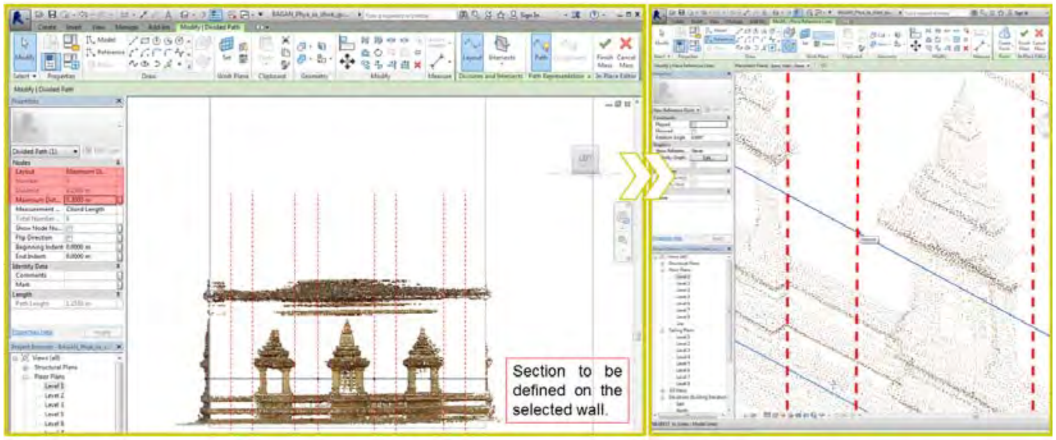

Figure 8 Screenshot illustrating one of the tested workflows to model a wall with higher accuracy. The wall was sectioned with a regular range in order to represent the irregular shape and the out of plumb of the wall with a pre-set level of accuracy. Software employed Autodesk Revit2016. Source: Author.

More specifically the workflow included two steps:

1. Create a new *In-Place Mass*. Under the "Massing & Site" tab, click the "In-Place Mass" button. The mass was named with a specific term according to the wall orientation (i.e. "South_wall_Loka_temple_Massing").
2. Iterate sectional analysis of the wall and consolidate the results. The south wall of the Loka-hteik-pan temple was sectioned every 30 cm. The profile of the different sections was traced with the 'spline' tool. This process was repeated for all sections. Afterward, all the traced wall's profiles were selected and combined through the function 'Create form> Solid' to convert them in masses and then joined through the 'Join' command to connect all the wall masses. Then, through the command 'Architecture>wall>wall by face' the selected wall type was associated with the created wall profile.

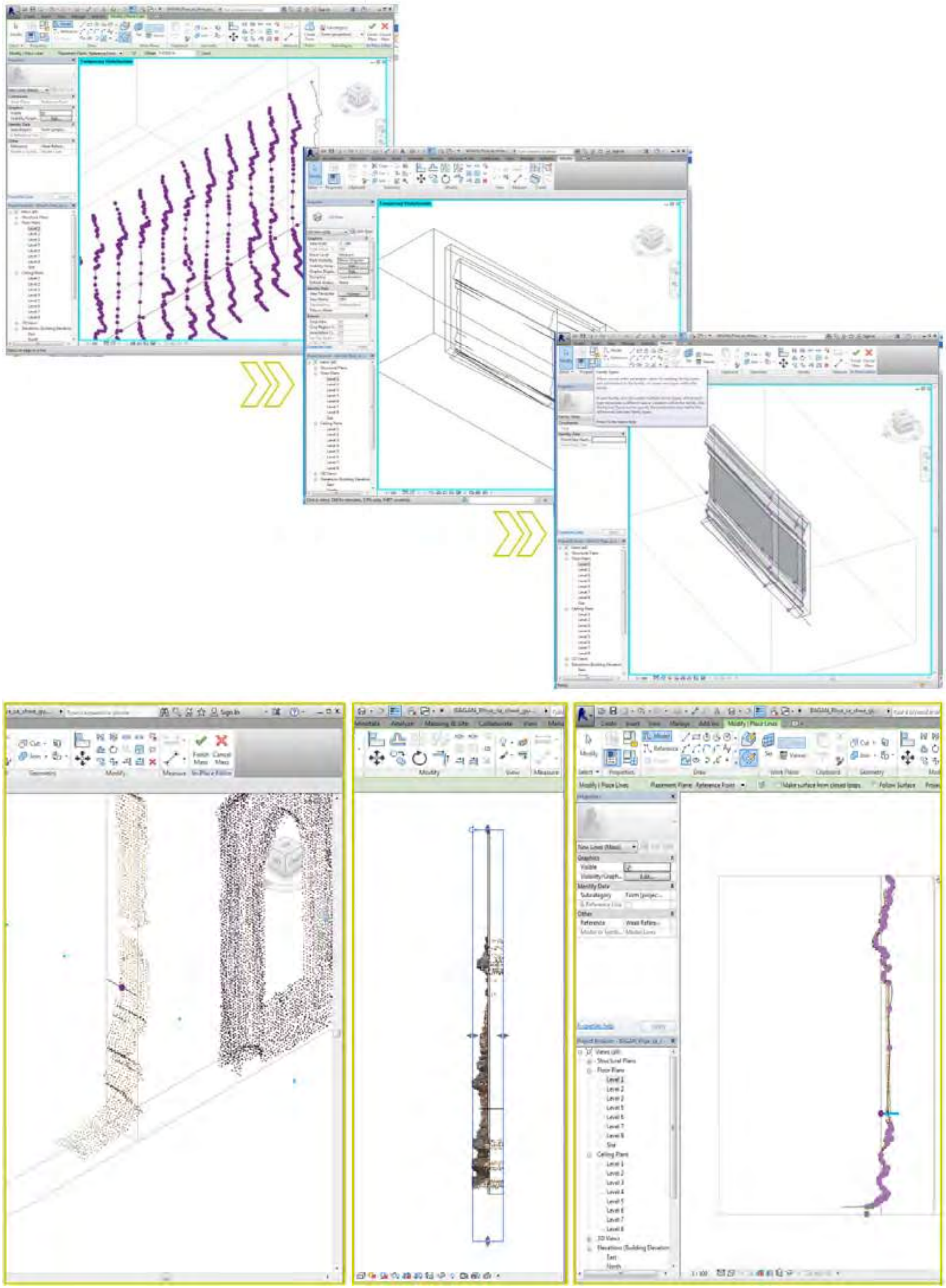

Figure 9 Screenshots illustrating one of the tested workflows to model the temple's walls. Software employed Autodesk Revit2016. Source: Author.

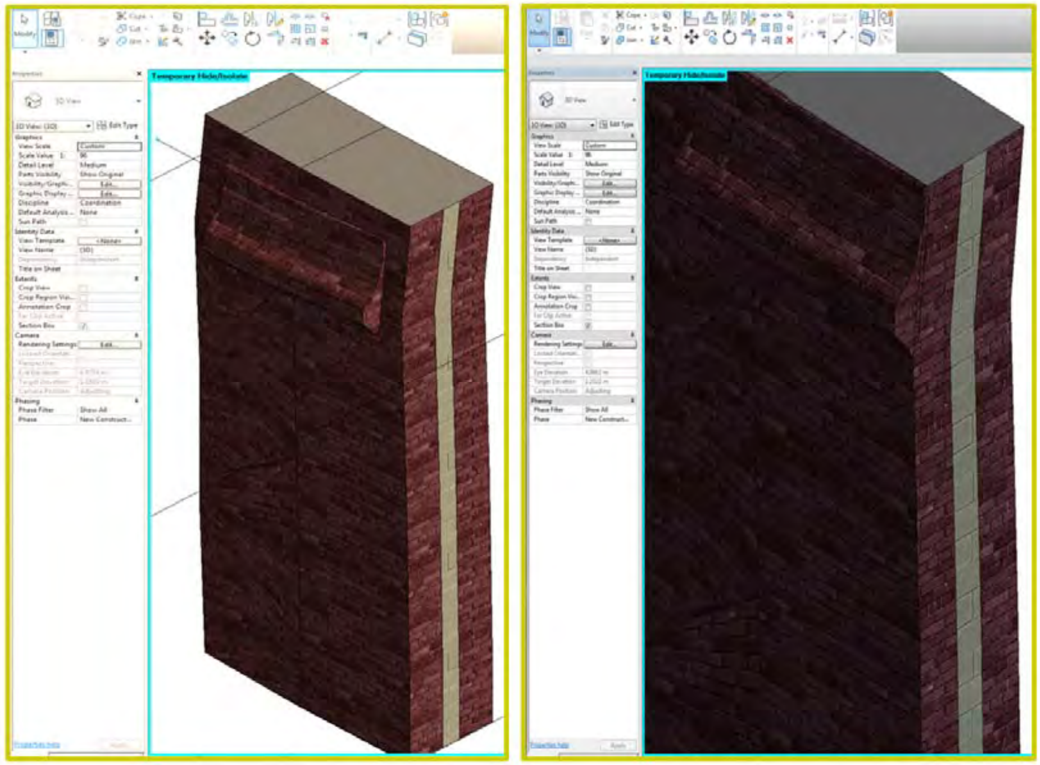

Figure 10 Screenshot illustrating the outcomes of the tested workflow to model the temple's walls as mass. Software employed Autodesk Revit2016. Source: Author.

This workflow, even if more accurate, presents several limitations in terms of semantic modelling. Indeed, the wall created as mass and not as wall component was limited to the characterization through the mass including only 'identity data[4]' and 'phasing[5]'. Since, through the employed workflow the wall was created as mass. Hence, information on construction[6], graphics[7], material and finishes[8], analytical properties[9] and identity data[10], all fundamental data for using the model in the

[4] This consists of three parameters: image, comments and mark. For each of them is it possible to insert associated values.

[5] This information indicates if the modelled wall is an existing wall or an addition and if it needs to be created (phase created) or demolished (phase demolished).

[6] Construction information are divided into parameters and values including structure, wrapping at inserts, wrapping at ends, width and function. These parameters allow to define the different layers of the wall and to associate with each of them a material characterizing it with its thermal and physical features as well as to define its appearance, graphics properties as well as its identity features including descriptive information, product information and Revit annotation Information.

[7] Information on graphics is divided into parameters and values including coarse scale fill pattern and coarse scale fill color. This information allow to graphically characterize the drawn wall associating with each material a different geometric pattern with a specific colour.

[8] Information is structured into parameter and value describing the structural properties associated to the selected material.

[9] Information is structured into parameter and value defining heat transfer coefficient (U), thermal resistance (R), thermal mass, absorbance and roughness of the wall.

development of economic as well as energetic assessments and reports, are lost due to the Autodesk Revit software constraints.

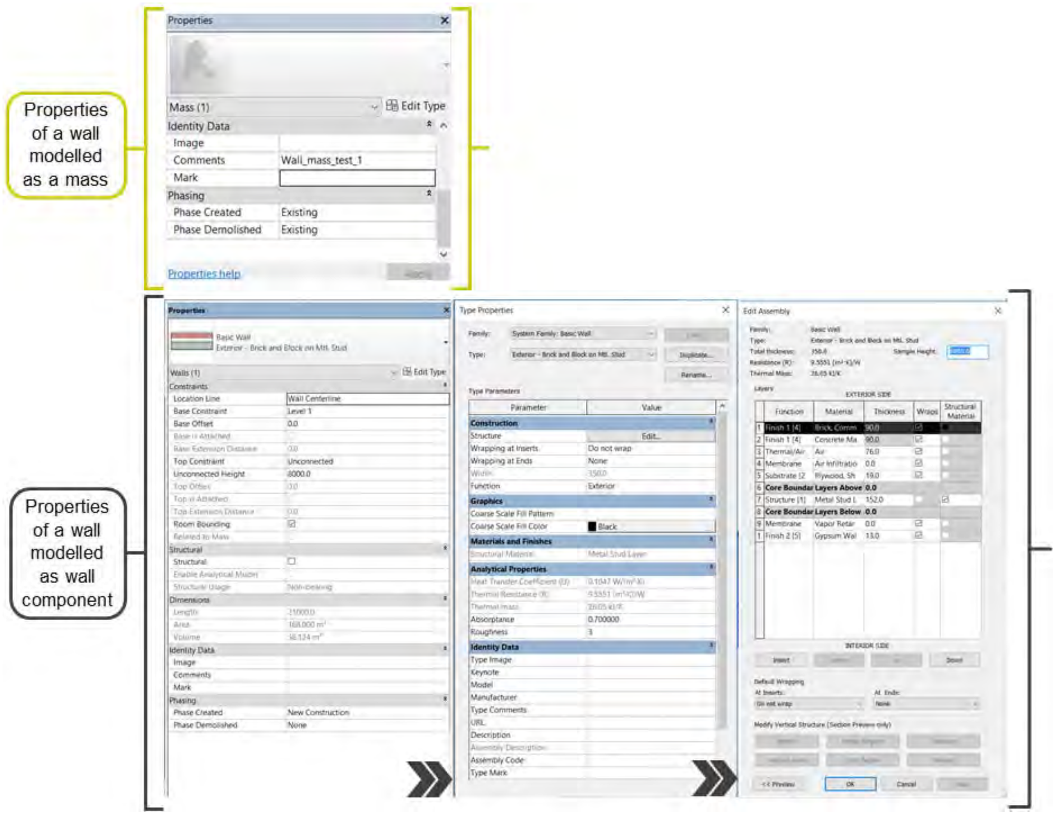

Figure 11 Image illustrating the different properties options allowed by the Revit software to model a wall as 'mass' and as 'wall component'. Source: Author.

In line with the initial premises, this study assumes that a BIM model – although time and cost consuming - should exploit its geometric as well as its descriptive (semantic) properties.

Therefore, the author decided to follow a workflow that would allow the characterization of building components even if this implied, in some cases, to approximate geometrical accuracy of the modelled elements, due to the software constraints. In addition to the modelling of the walls, the adopted workflow is

[10] Including type, image, keynote, model, manufacturer, type comments, url, description, assembly description, assembly code, type mark, fire rating and cost. The information is structured into parameter and value.

described in the following paragraphs. The modelling description is organized illustrating the main building components, according to the Revit logic.

Modeling the Stupas

The Loka-hteik-pan temple has four different types of *stupas*, one for each level of the roof terrace. Accordingly, four families were generated:

- Type 1: 2 for the front entrance;
- Type 2: 4 for the first terrace;
- Type 3: 4 for the second terrace;
- Type 4: 1 large central stupa.

The inner rod and walls of the *stupas* were first modelled to represent the structure of the real-life *stupa* construction.

Afterward, a sweep was applied to generate the correct *stupa* profiles of Loka-hteik-pan temple. Sweeps were made by tracing the profile of the pointcloud and by saving it as a profile. These profiles were then applied as a wall sweep to the surface of the inner rod.

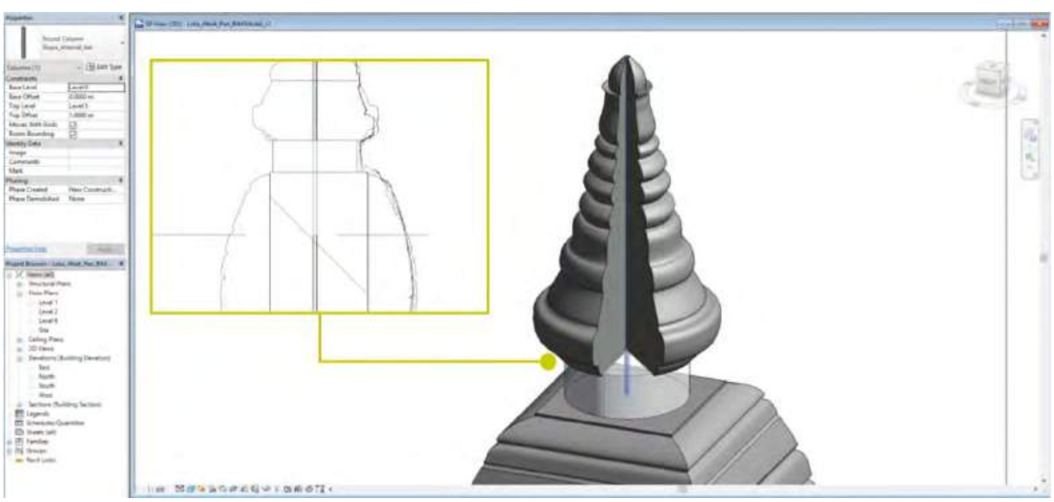

Figure 12 Image illustrating the applied wall sweep and the structure of the stupa. Software employed Autodesk Revit2016. Image source: Author.

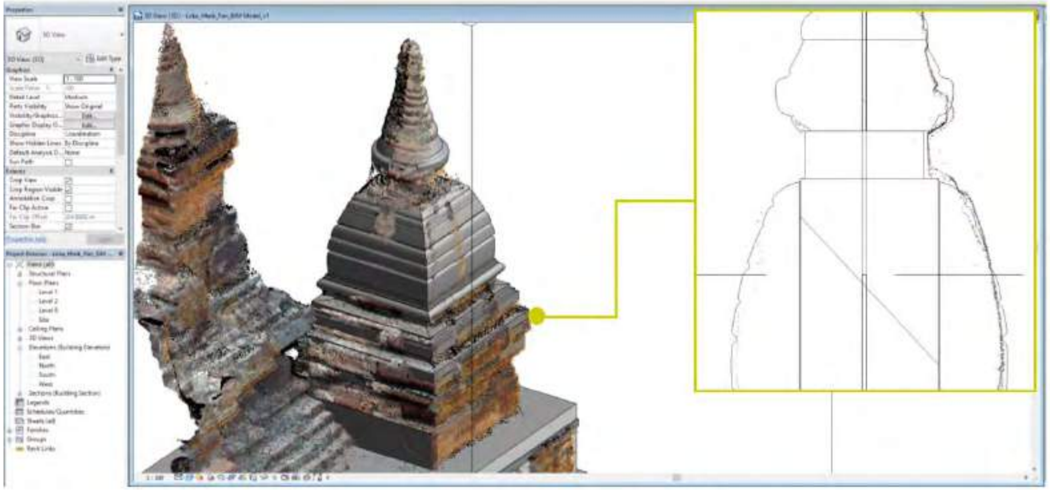

Figure 13 Image illustrating the adjacent pointcloud overlay over the modeled stupa and the structure of the stupa. Software employed Autodesk Revit2016. Image source: Author.

Modeling the Interior Barrel Vaults

The entrance of Loka-hteik-pan temple has a vestibule and a hall (leading to the main shrine), overarched by a barrel vaults. There were four different heights corresponding to five barrel vaults. These were modelled by:

- First taking a section of the model to see the appropriate view, setting the “far clip offset” to a low distance to clearly see the pointcloud outline;
- Using the ‘roof’ command; (click on the view and trace the outline of the barrel vault arch then click finish);
- Set a horizontal section view; (click into view and extrude the roof for the length of the barrel vault);
- Create a “model in-place” component and set it into appropriate view. Create a void, and trace the outline of the roof and the wall borders. Use the cut-geometry command to create the hallway.

These steps were replicated four times for the 4 varying barrel vault heights. (note: the barrel vault in the hall is not level and actually slants down).

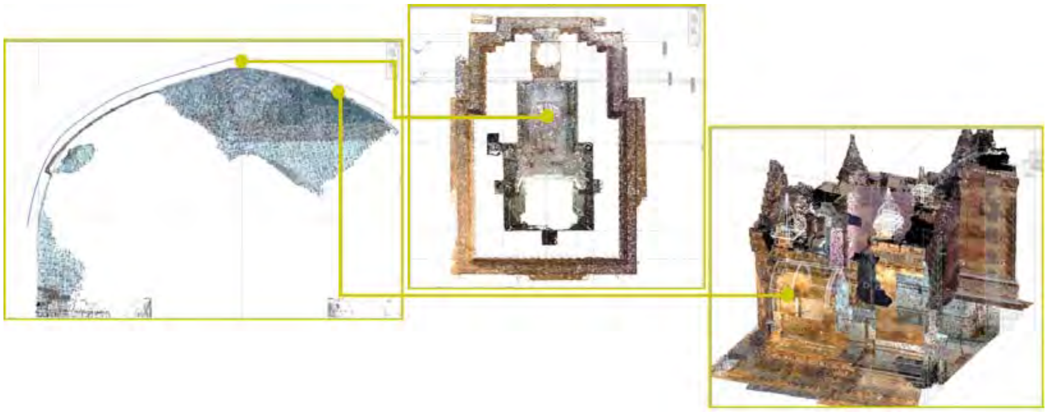

Figure 14 Image illustrating the sections created and the outline of the entrance barrel vault. Software employed Autodesk Revit2016.Image source: Author.

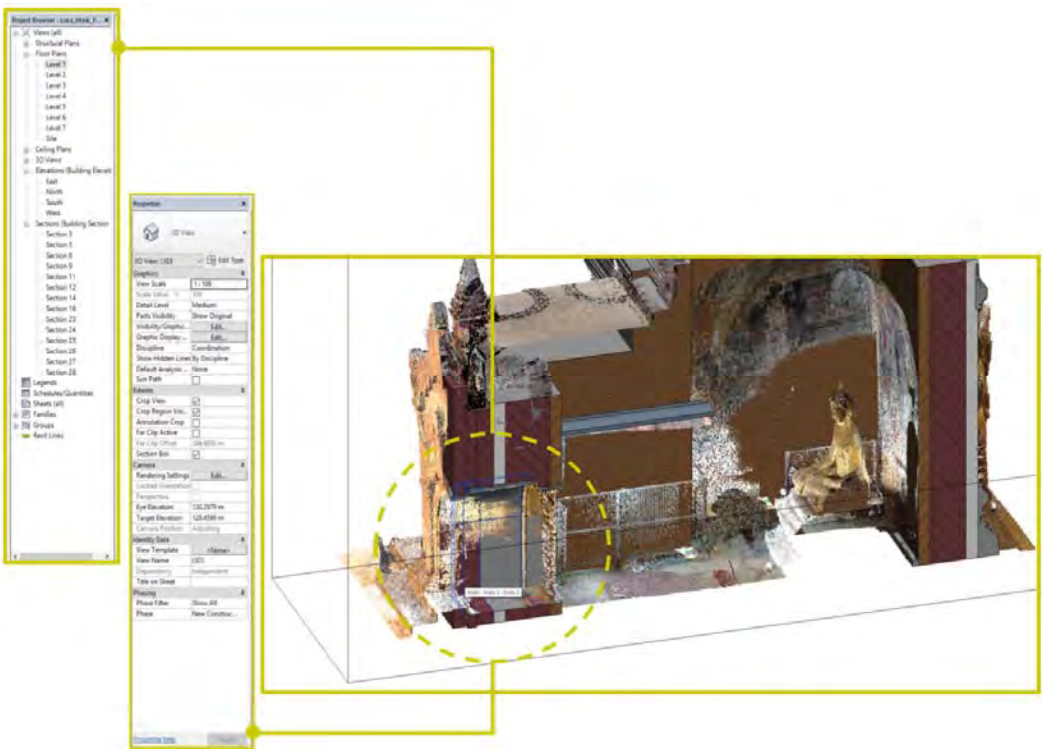

Figure 15 Image illustrating the entrance voids in section view. Software employed Autodesk Revit2016. Image source: Author.

Window and Stair Voids

Using a similar method employed for the vaults, voids were made with the "in-place component" function. Afterward, the appropriate sections were created (one horizontal and another transverse). The profiles of the stairs and windows were traced to make the void.

However, later on in the modelling of the temple, these voids were removed because it was better to include the voids as part of the window family to ensure that they aligned perfectly with the window on the exterior.

Figure 16 Image illustrating the voids behind the windows and the modelled window void. Software employed Autodesk Revit2016. Image source: Author.

Fixing the Front Wall Profile

The first attempt to make the front wall of the temple consisted in creating a new wall type (setting appropriate thickness, etc.) and then creating the wall profile by tracing the pointcloud. However, it was evident that the wall at the front was not straight. It is slanted at a 3° angle measured from the developed AutoCAD drawing[11] of the west elevation.

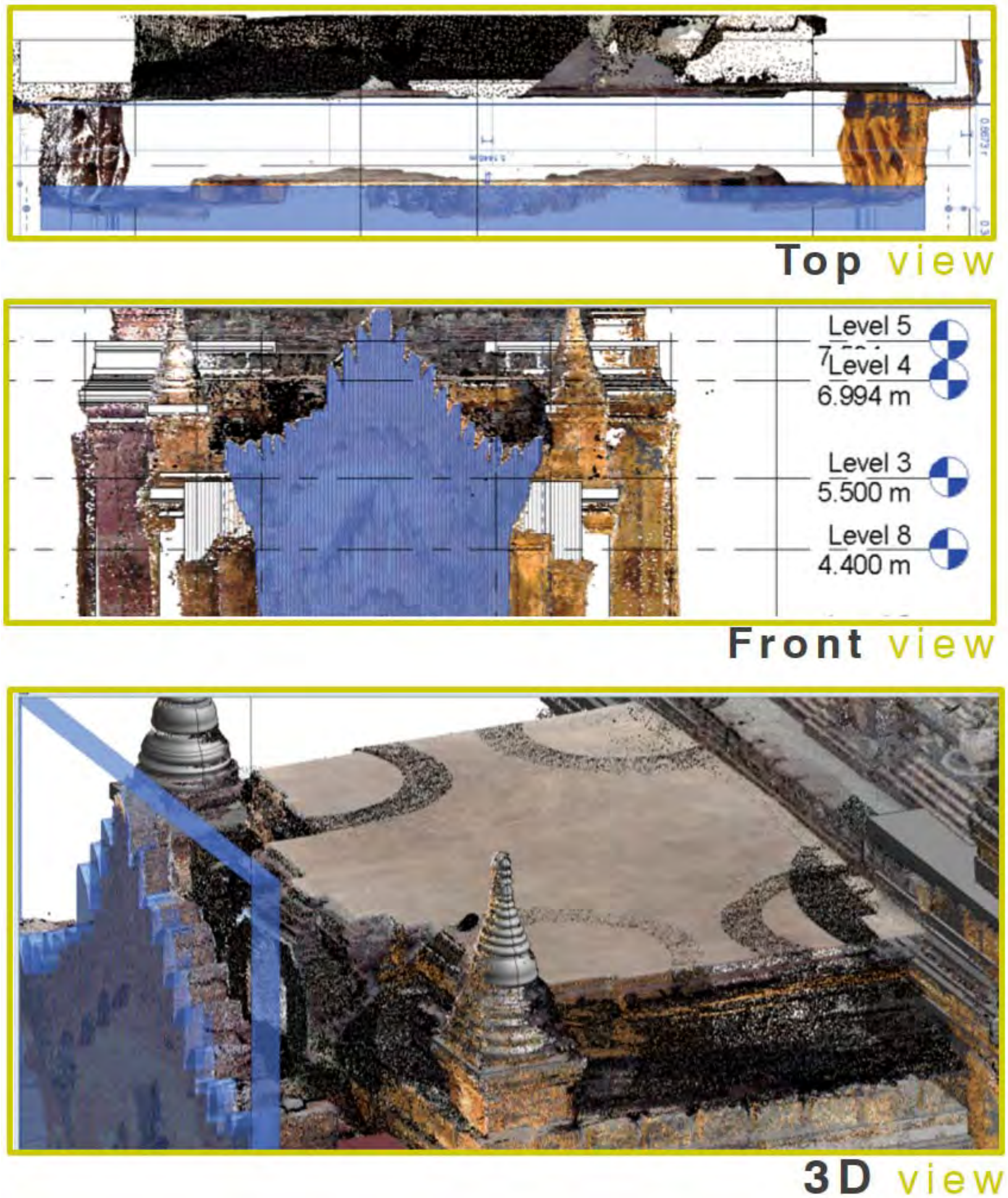

Figure 17 Image illustrating the first attempt at modelling the front wall; the wall was evidently too straight. Software employed Autodesk Revit2016. Image source: Author.

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[11] Even if not object of this thesis, AutoCAD drawings of the temple in scale 1:100 and 1:50 were also developed. The set of measured line drawings included: site plan, roof plan, floor plan, east –west cross section and north-south cross section as well as four elevations.

In the second attempt, the slanted profile of the wall was traced from the west elevation. This wall was pulled to fit the width of the front wall.

Afterward, a void extrusion was made on the north elevation tracing the negative space of the wall. The command “cut-geometry” was used to select the void and the wall, resulting in the desired slanted wall. This is a base wall with no extrusions or details on it.

Next, the extrusions on the front of the wall were modelled on a face-based generic model family.

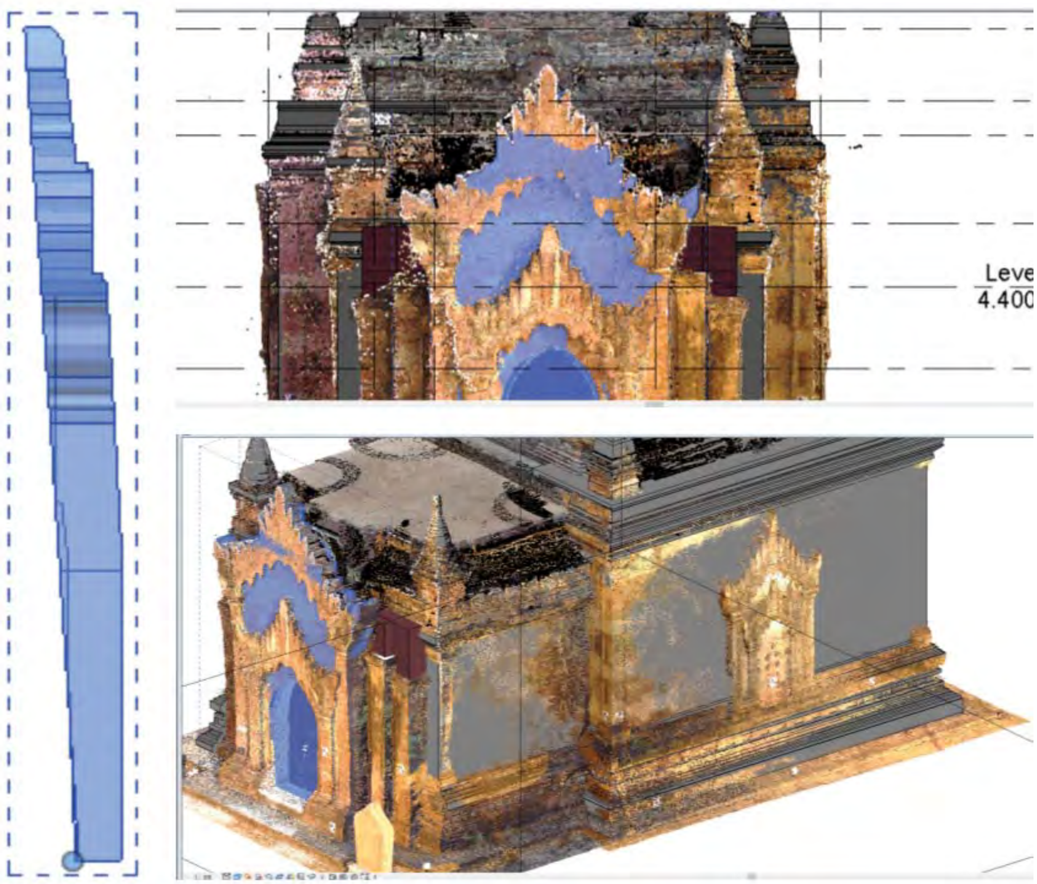

Figure 18 Image illustrating the wall at a slanted angle of 3°. Software employed Autodesk Revit2016. Image source: Author.

The front view was firstly traced from the point cloud on AutoCAD 2016 to make the outline. To determine the depth of the extrusions, measurements were taken from the pointcloud profile.

The exterior outline was taken from the base wall, already in the Revit project. Because of the pilasters on the front, the capitals were created by tracing the pointcloud profile, modeled in a generic model family as a sweep, and then nested into the family.

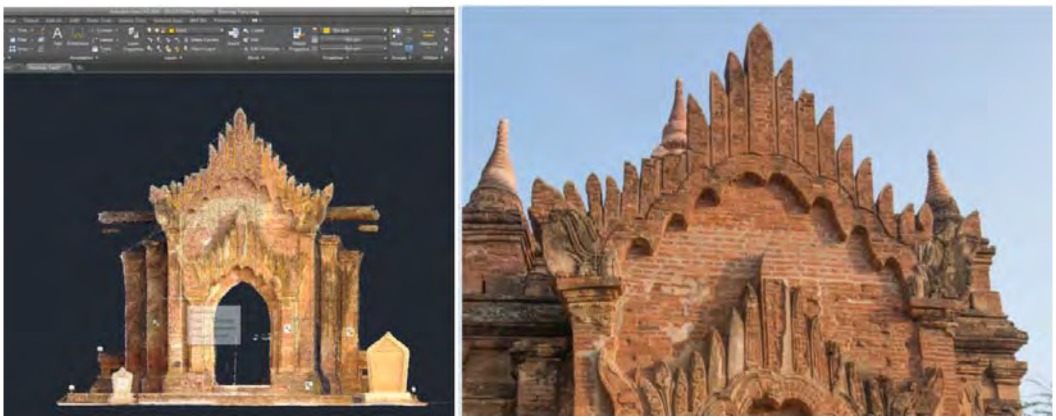

Figure 19 Tracing the extrusions on CAD and using a photo for reference. Software employed Autodesk AutoCAD2016. Image source: Author.

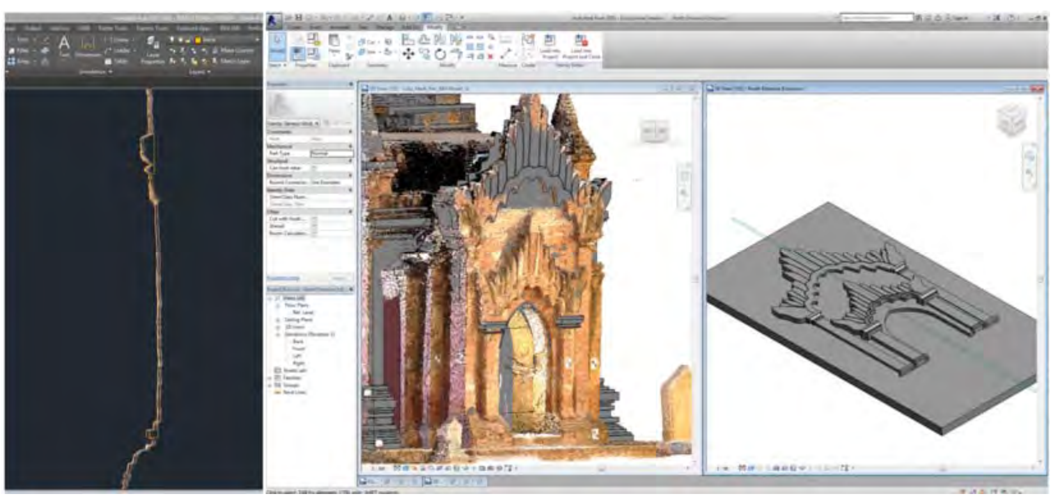

Figure 20 Tracing the capital and base profiles of the pilasters to create on the face-based generic family. The image on the right shows the final result of the extrusions being placed on the slanted wall base. Software employed Autodesk AutoCAD2016 and Autodesk Revit2016. Image source: Author.

The front wall extrusions, after the family was finished, were then placed on the model.

Creating the Window Typology

Loka-hteik-pan temple has three windows, one each on the east, west, and south facades. They originally were likely constructed as the same typology, since they are the same size and have similar detailing.

Henceforth, one window family was made for the three windows. Due to the complex details, the front profile and east profile were traced on AutoCAD 2016. Then, the traced profile was imported into Autodesk Revit2016 before importing the lines into Revit. The pane of glass was deleted and the openings were created by tracing their profiles.

Measurements were taken off of the Recap model to adjust the extrusion distances (however, note that measurements can also be taken off of CAD or Revit, but it was easier to navigate the pointcloud on Recap).

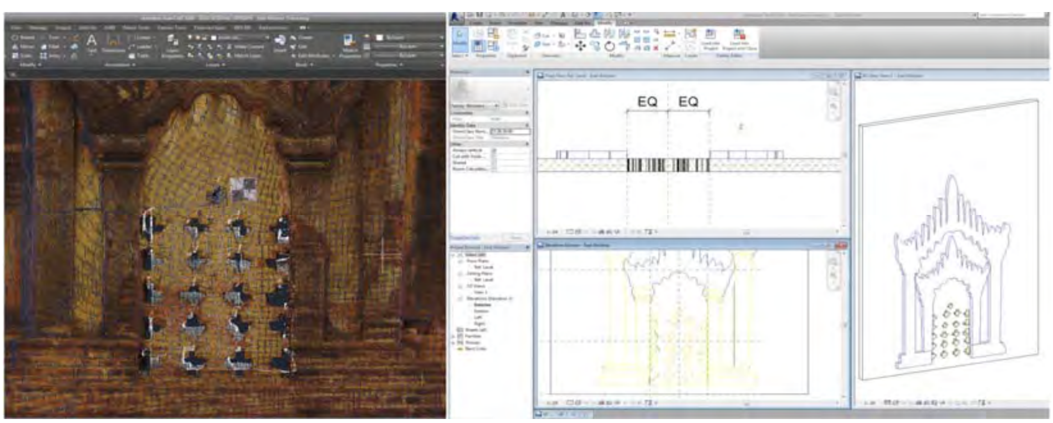

Figure 21 Tracing the window profile on CAD and modelling it as a window family in Revit. Software employed Autodesk AutoCAD2016 and Autodesk Revit2016. Image source: Author.

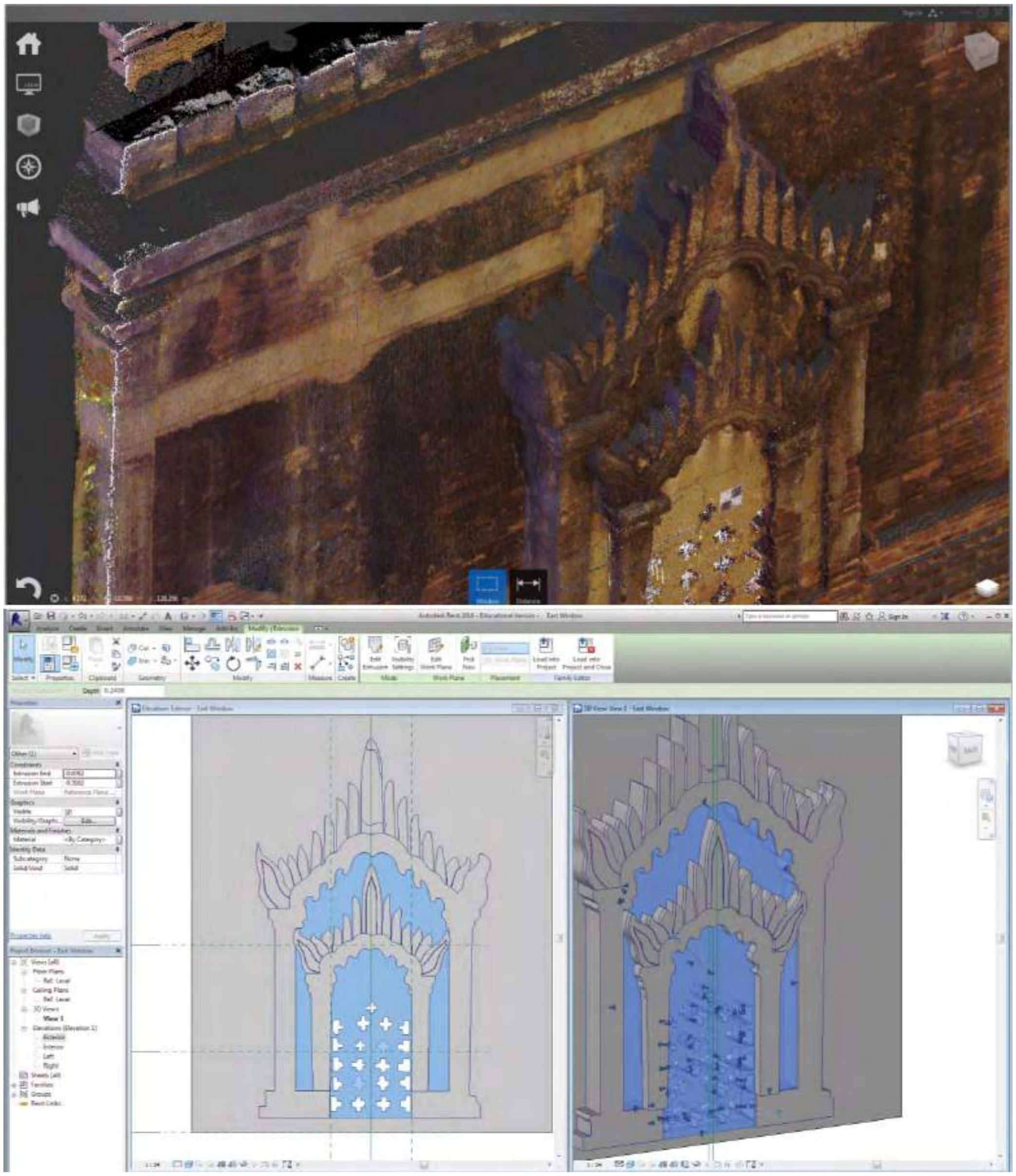

Figure 22 The window profile traced in CAD is then modelled as a window family in Revit. Software employed Autodesk AutoCAD2016, Autodesk Recap 2016 and Autodesk Revit2016. Image source: Author.

Because the window had column pilasters, the capitals of the columns were created as separate generic models and then nested into the window family. There were two different capitals and their profiles were traced from a pointcloud section, imported into a generic model, and made into a sweep.

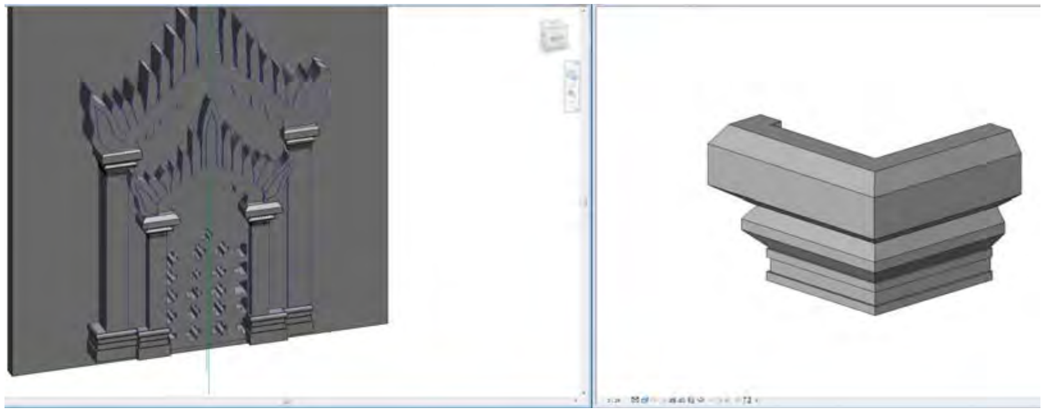

Figure 23 The created capital of the column and its nesting in the window family. Software employed Autodesk Revit2016. Image source: Author.

Once completed the window family, the wall thickness had to be adjusted to match the thickness of the existing wall of the Revit BIM model. Otherwise, the window would not rest on the surface of the wall, but within it (the procedure ought also to ensure that the reference lines are in the correct spot so that the window rests above the line towards the exterior side).

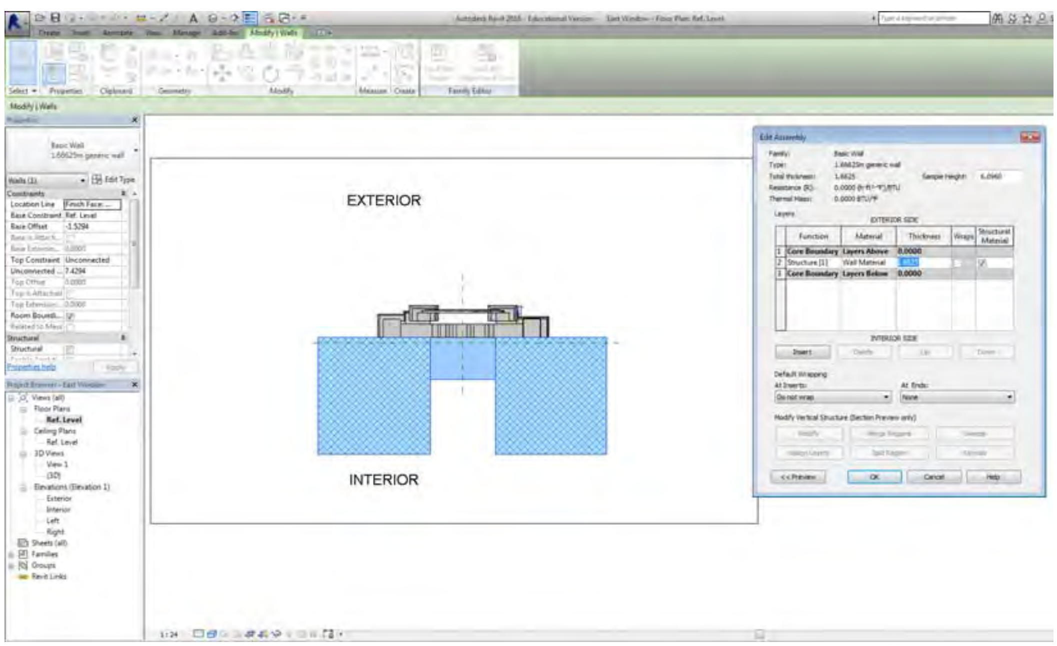

Figure 24 Thickness of walls changed to match the created wall typology of the Loka-hteik-pan model. Software employed Autodesk Revit2016. Image source: Author.

It was not possible to apply the window within the wall in the project, because of the existing stair void in the wall, because the window would not rest in front of the stairs. Therefore, the stair void was deleted in the BIM model and then recreated within the window typology. This ensured the perfect alignment of the stairs leading to the window.

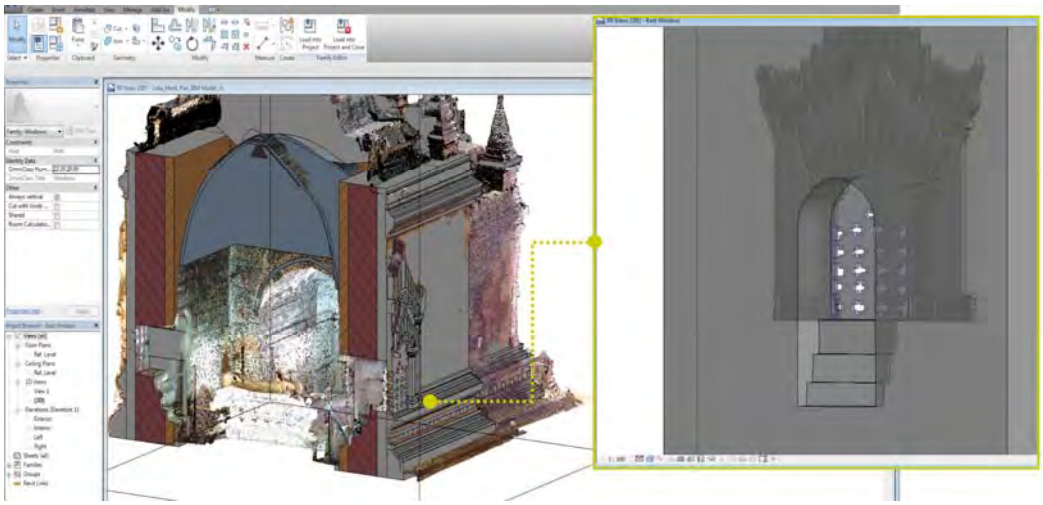

Figure 25 Image illustrating the window typology in the model, as well as the window family with the stair void behind it. Software employed Autodesk Revit2016. Image source: Author.

Modeling the Tiered Terrace

To model the upper terrace beneath the *stupa*, the profile of the steps was traced from the pointcloud (allotting space for the dentils to rest on top of).

Measurements were taken to ensure its appropriate height and size. The traced profile was used to create a sweep that would become the stepped terrace.

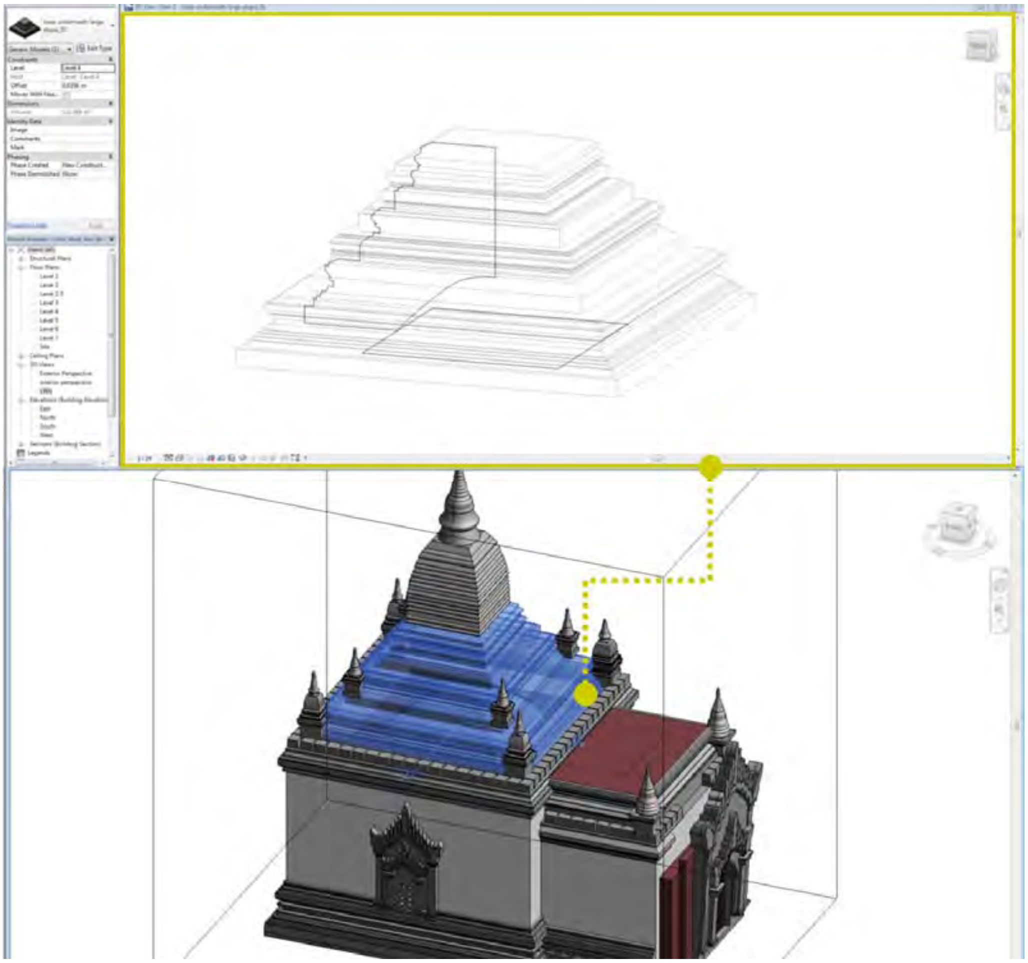

Figure 26 Image showing the upper terrace sweep and afterwards its insertion into the project. Software employed Autodesk Revit2016. Image source: Author.

Parametric Array Dentil Family

The Loka-hteik-pan temple has different dentils used to outline its exterior walls and upon its terraces. In the model, there are four different types of dentils used.

The dentils were made in a parametric array family that could easily be pulled to fit the length of the wall. Measurements were taken off the pointcloud to determine the width, length, and depth of the dentil block as well as the spacing between the blocks.

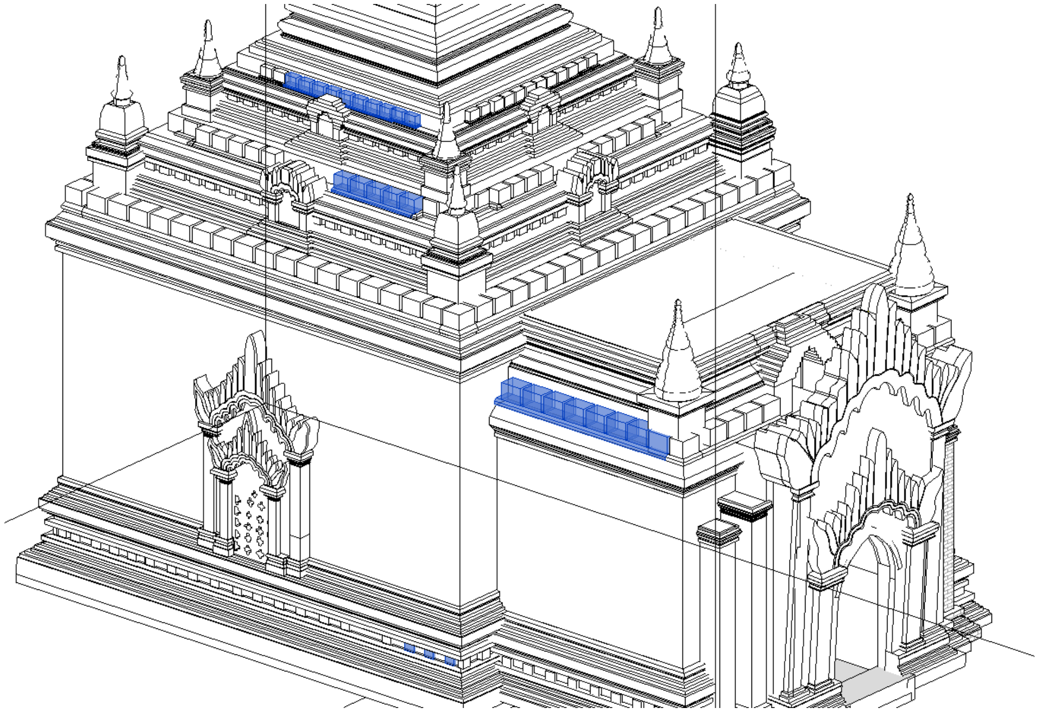

Figure 27 Image of the BIM model with the four highlighted dentil families. Software employed Autodesk Revit2016. Image source: Author.

The dentil block was made as a generic-model family and then nested into another generic-model family with the parametric array. This was done to ensure that the blocks wouldn't change size. A parameter was added denoting the "dentil distance" from one another and the other for "length". The dentil block was arrayed, and the parameter added was called "# of dentils", which was made by putting the equation as "length/dentil distance". This would allow the family to stretch in the model.

Looking at photographs and the pointcloud were methods to check that the amount of dentils made were accurate.

Corner pieces were modelled separately in generic-model family to connect the dentils together. When placed in the model, they were aligned and locked together.

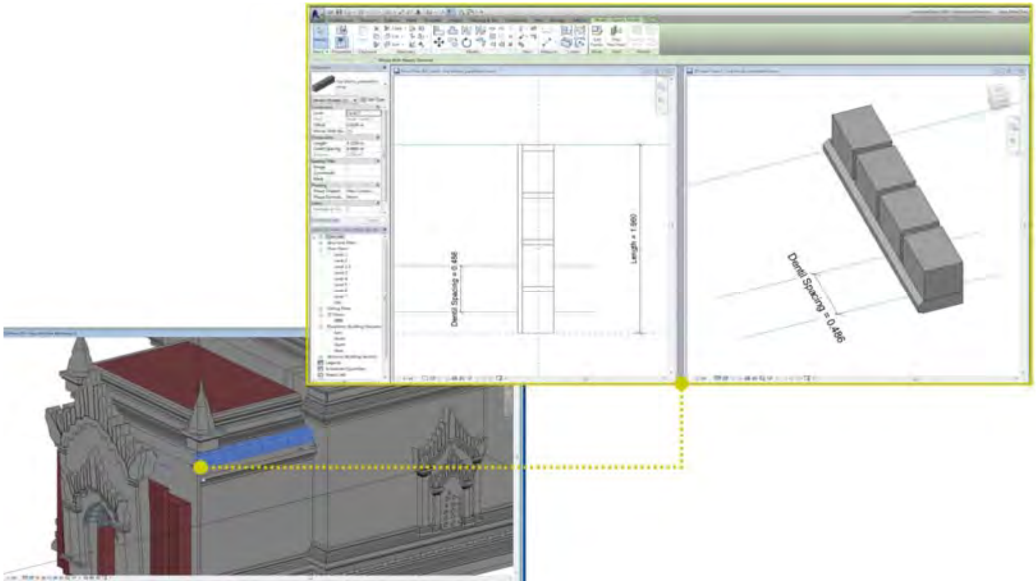

Figure 28 Image illustrating the parametric array family and its insertion into the BIM model. Software employed Autodesk Revit2016. Image source: Author.

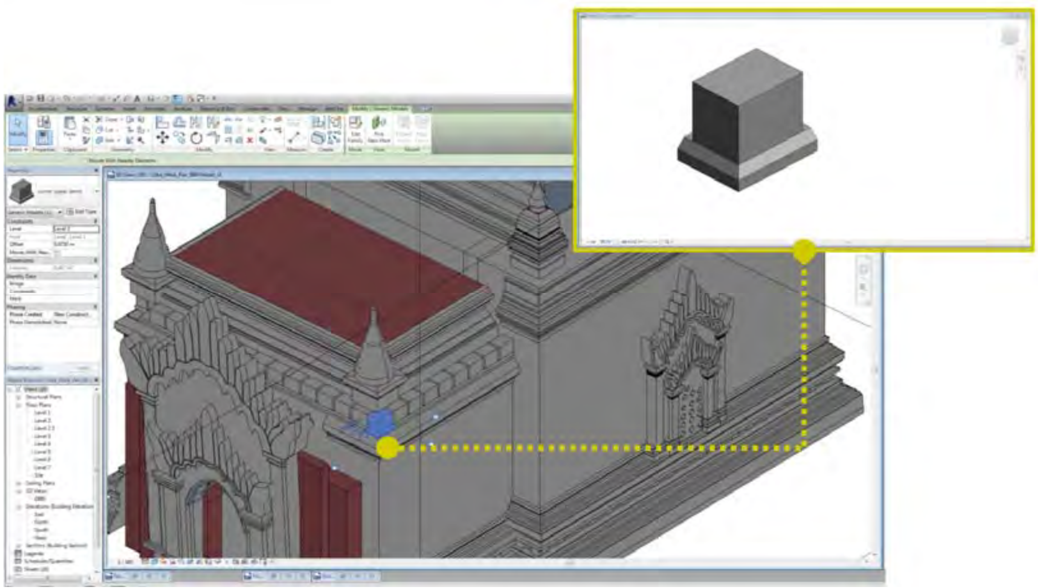

Figure 29 Image of the dentil corner piece locked into place. Software employed Autodesk Revit2016. Image source: Author.

Modeling the Upper Niches

The temple has several arch components on its terraces, with two different types. There are four on the first level, and another four on the second level. These were made in similar style as the windows and to the north wall entrance door. The front and the plan views were traced from the pointcloud, and then imported into a generic-model family.

The base sweep was taken from the upper terrace steps, to guarantee the component would perfectly fit in the upper terrace.

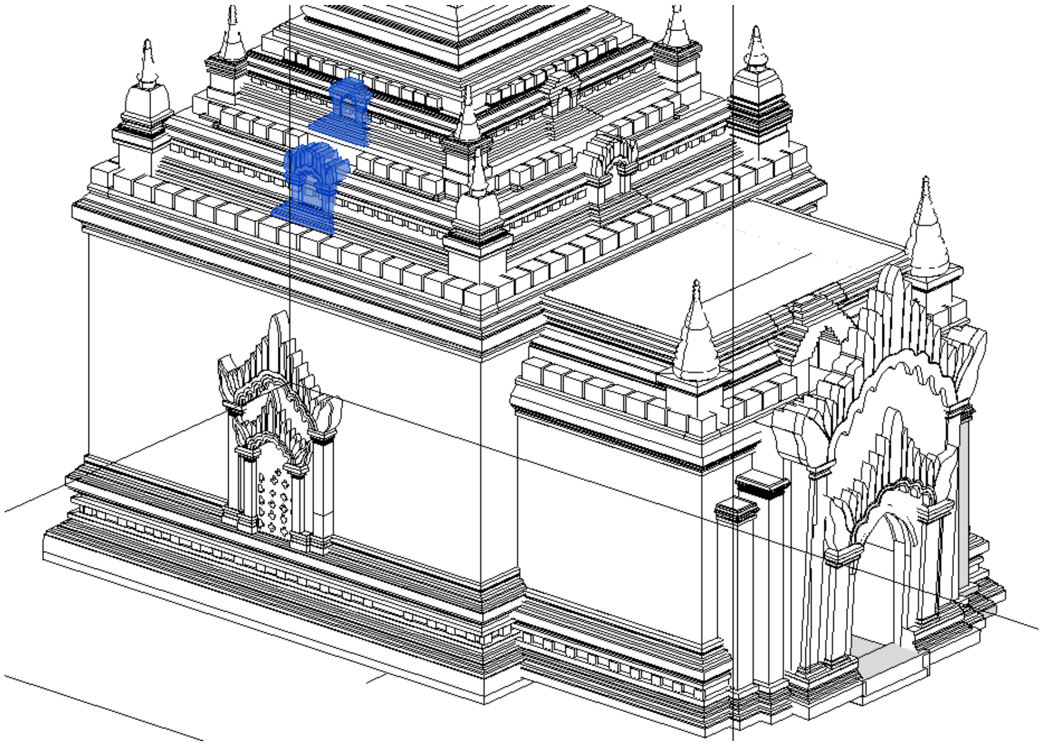

Figure 30 Image of the two niches components on the upper terrace. Software employed Autodesk Revit2016. Image source: Author.

The arch components were aligned and locked into place on the terrace[12].

[12] Despite the arch components on the north-east and south-west looked different (one looks new and is flush brick, the other has the original shape with remains of stucco on it) they are modelled with the same workflow.

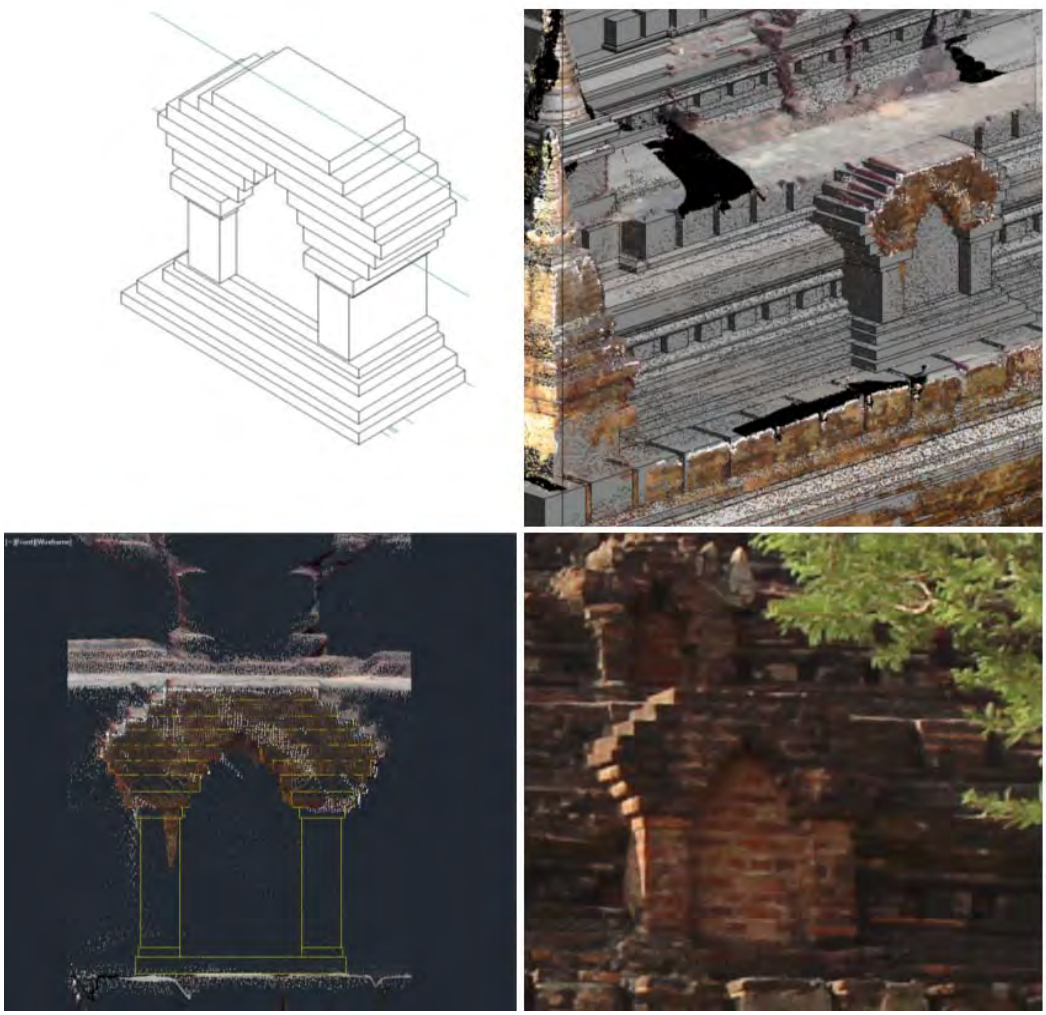

Figure 31 South niche component made and placed. Traced profile and plan view on AutoCAD 216 and bottom of column traced from existing sweep, imported and made Revit family, placed in model and adjusted (photograph used as reference). Software employed Autodesk Revit2016. Image source: Author.

Placing Room Tags

Room tags were added to the porch, vestibule and central shrine to determine the indoor temple's area, perimeter, and volume. This command can be found under the 'Architecture' tab (→Room and Area → Tag Room or Room Separator). Each room had to be first divided by room separators before the room tag could be created. The heights of the tag of the central shrine, vestibule and porch were adjusted to fit the interior space.

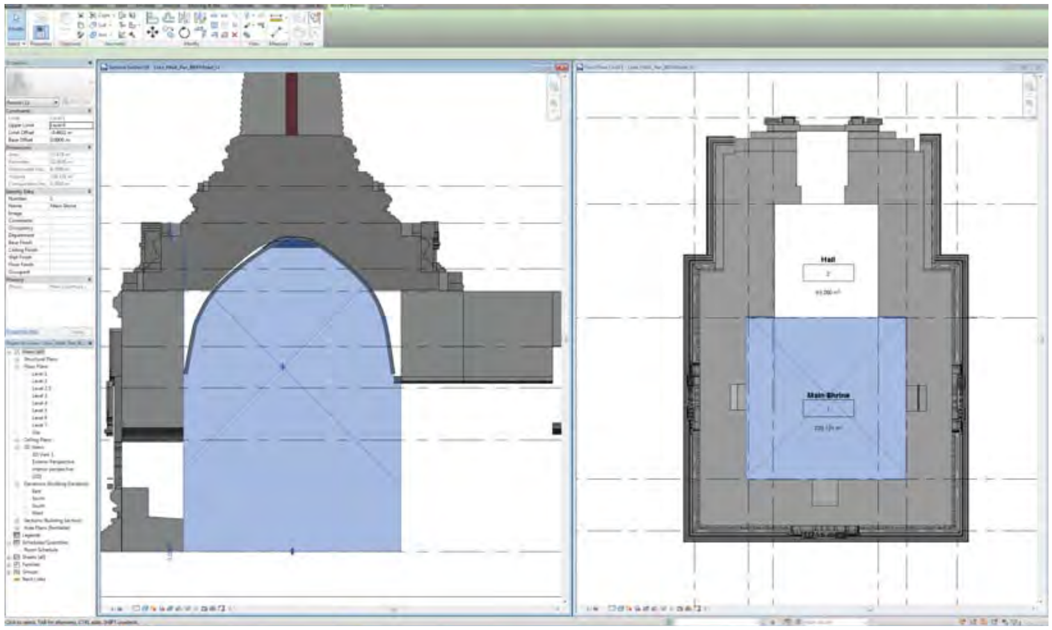

Figure 32 Editing and Placing Room Tags; Rooms outlined in room schedule with their calculated area, perimeter, and volume. Software employed Autodesk Revit2016. Image source: Author.

Creating Pilaster Columns

The exterior of the temple has three types of column pilasters; six on its main body, two shorter ones on the north facade, and two taller ones on the north facade.

The pilaster columns were created under the column family of Revit. The measurements of height, depth, and width were taken off of the pointcloud. In addition, the profile of the sweeps were traced from the pointcloud, and the profile for the base was taken from the existing wall base sweep.

The parameters were set for the height, width, and depth, and they have been locked to the upper reference level[13].

[13] Otherwise when importing to the model, the column height would shift and the sweep would not be aligned to the top.

After their insertion into the model, the "join geometry" command was used to insert the column into the wall as a pilaster.

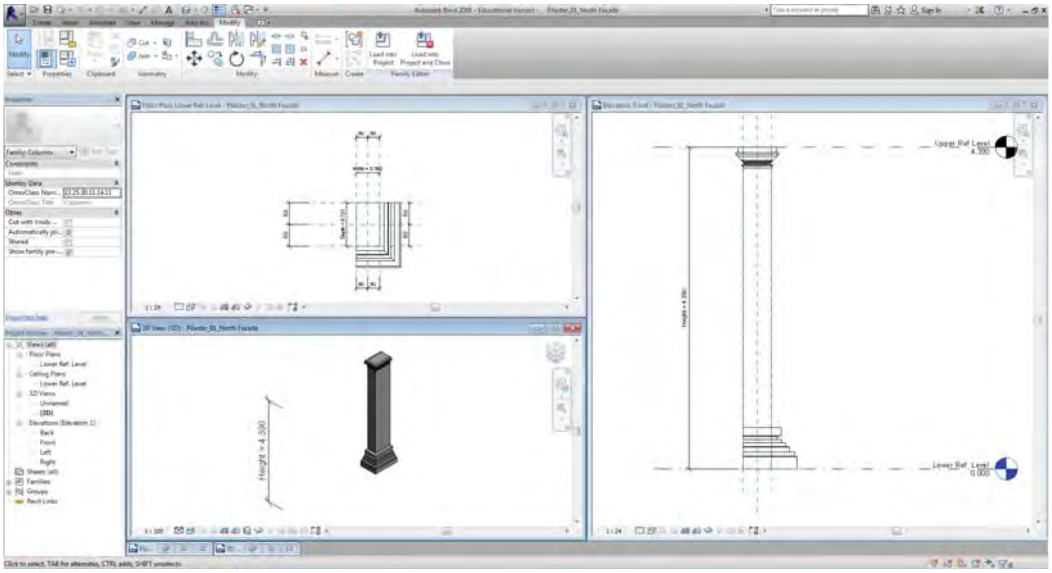

Figure 33 The column family with the height parameter. Software employed Autodesk Revit2016. Image source: Author.

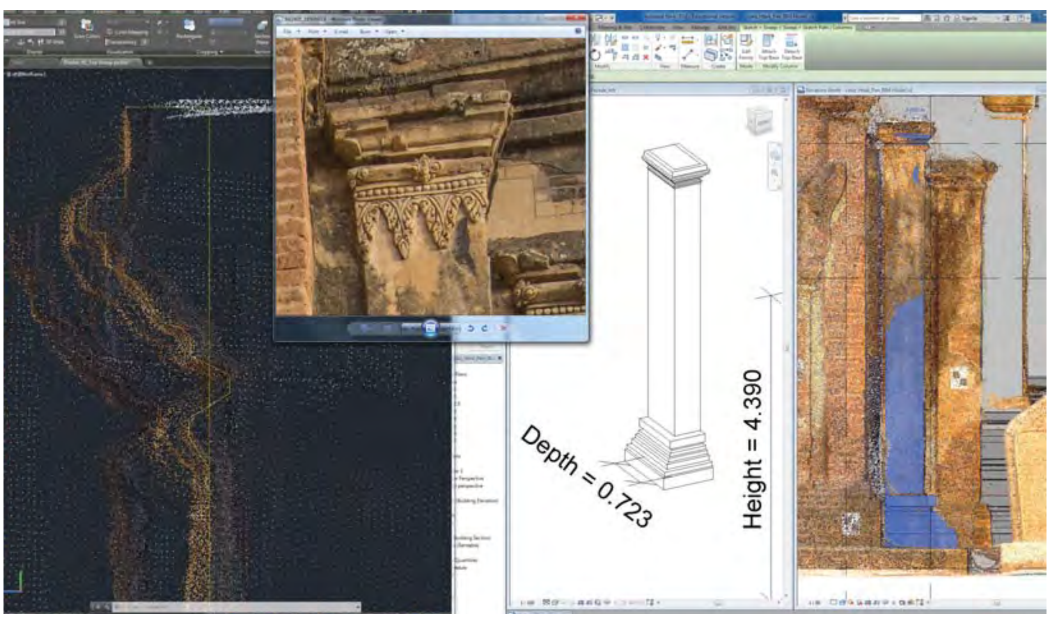

Figure 34 Front Pilaster; top sweep traced from CAD, bottom sweep the same as the previous existing wall sweep. Stucco ornament on the column has been omitted. In the point cloud, the column is slanted at a 3 ° angle. Software employed Autodesk Revit2016. Image source: Author.

Interior Stair Void

The Loka-hteik-pan is a single-storey temple, with access to the upper terrace by a set of stairs. The different elevations and plan view of the stairs have been traced from the point cloud on AutoCAD and then imported into Revit. Using the generic model family, the stairs have been modeled as a void.

After the stairs have been imported into the final project. With the command 'cut geometry', void and wall have been selected. This created the void opening for the stairs.

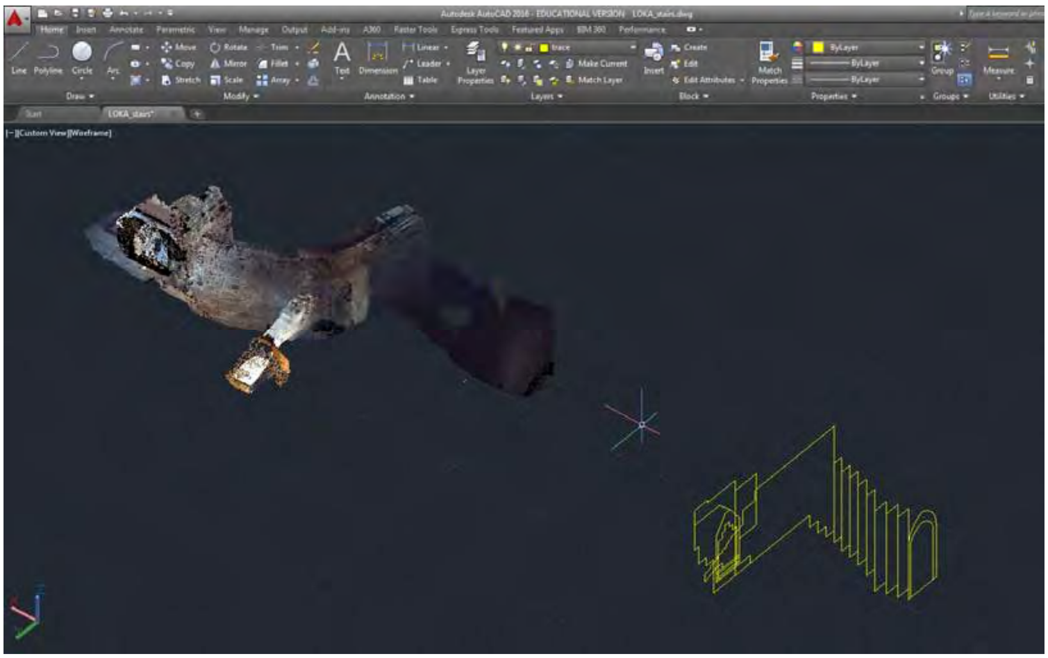

Figure 35 Pointcloud of interior stairs and its traced profile. Software employed Autodesk AutoCAD2016. Image source: Author.

Addition of Floor Slabs

The interior floor of the temple has been covered with concrete, while the below structure is made of bricks. This stratigraphy was used to characterize the floor layers[14]. The heights of the floor were measured from the pointcloud.

[14] The floor of the temple was modelled with the command "floor" (Architecture Tab> Build panel> floors).

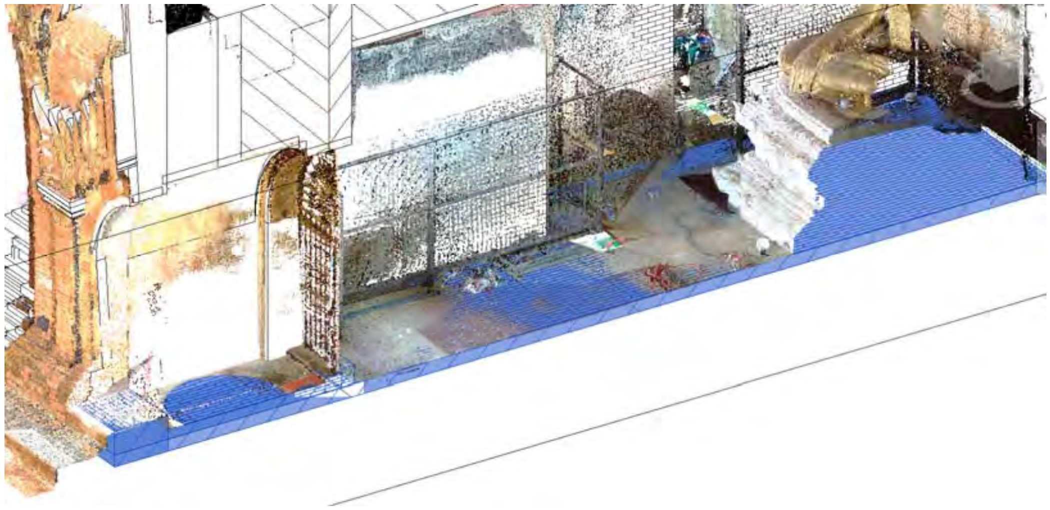

Figure 36 Cross-section showing the added floor slabs; thickness was measured from the pointcloud model. Software employed Autodesk Revit2016. Image source: Author.

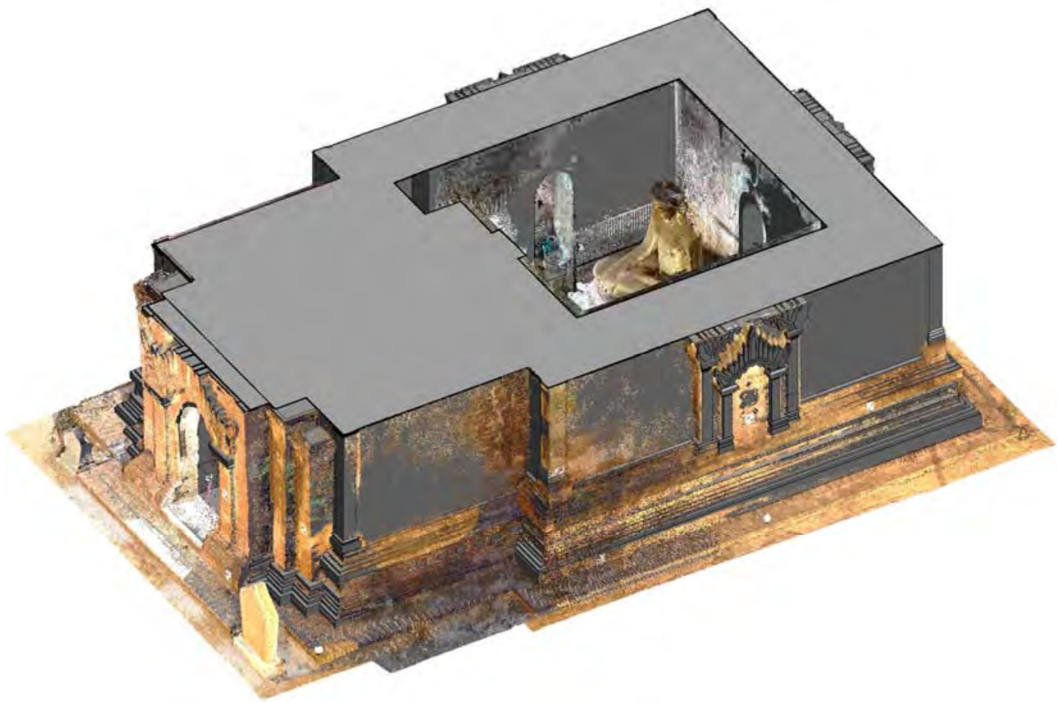

Figure 37 Screenshot of the sectioned Revit model of the temple. Software employed Autodesk Revit2016. Image source: Author.

Figure 38 Screenshot of the sectioned Revit model of the temple. Software employed Autodesk Revit2016. Image source: Author.

The model has been developed with a LoD of 300. This level of detail is internationally considered to support a detailed design able to manage (new) buildings (Banfi, 2016).

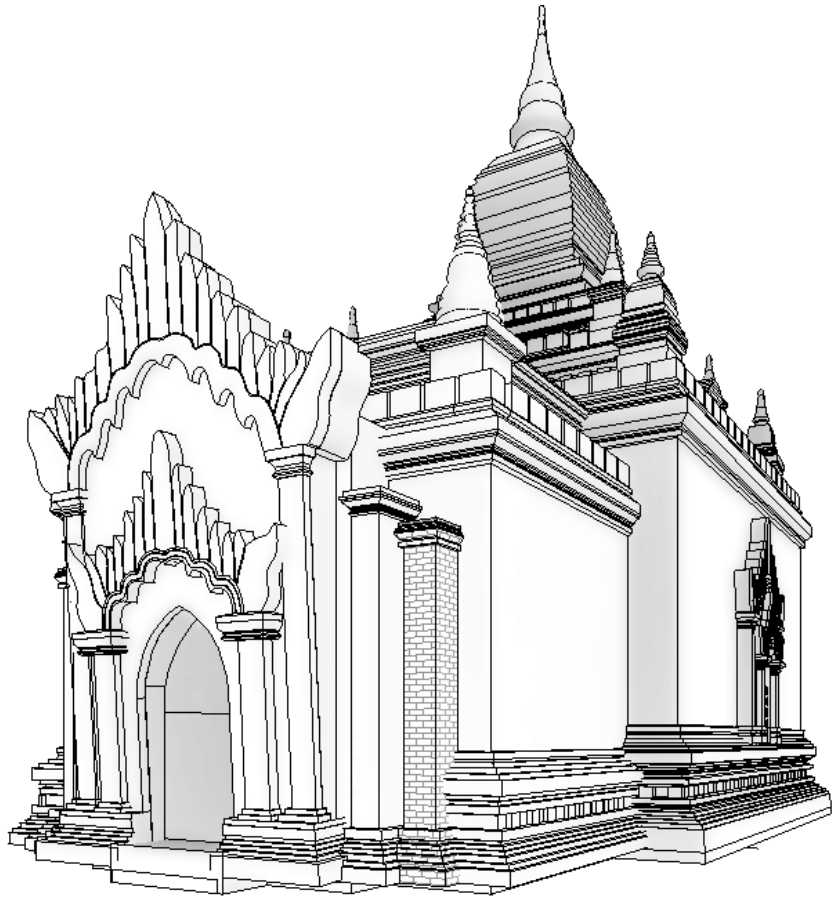

Figure 39 Perspective view of the modelled temple. Software employed Autodesk Revit2016. Image source: Author.

Nevertheless, since construction and heritage applicants tend to require precise geometric reconstructions[15], additional attempts to reach higher levels of detail were tested. It is worth to briefly reflect on this issue, even if it is not object of this research. According to Banfi, it is impossible to define a correct LoD for existing buildings. He justifies his position by considering the changing requirements of a conservation process over the years. Henceforth, he claims the need to integrate different LoDs (Banfi, 2016).

[15] While models containing generalization for simulation and operational management do not require high accuracy.

This approach was followed in the research by presenting different modelling scenarios to reach different levels of accuracy.

The results showed that, in terms of modelling, the only use of Revit, in the modelling phase, presents several constraints, particularly if dealing with complex shapes. This was a limit in the development of the 3D model.

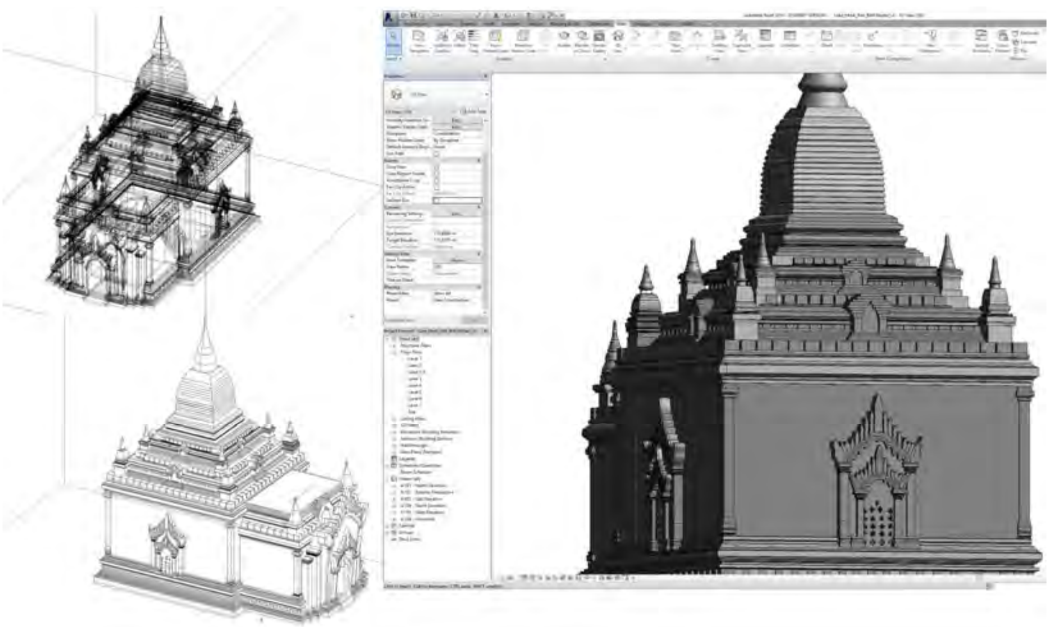

Figure 40 Different visualizations of the modelled temple. Software employed Autodesk Revit2016. Image source: Author.

Finally, in order to quantify the level of accuracy of the generated BIM model, different data were compared. These included:

a) 3D pointcloud;

b) 2D measured drawings, generated into AutoCAD 2016;

c) 3D Revit model.

Comparing different building elements drawn and modelled from the pointcloud emerged an overall level of accuracy of +/- 10 mm for the AutoCAD drawings and an accuracy level of +/- 15 mm for the Revit model.

The table below reports the results of one of the West columns of the temple. The reported measurements evidence different level of accuracy associated with these three types of data.

Table 1 Accuracy level of the different data generated from the pointcloud. Table Source: Author.

	Measurements from the point cloud	Measurements from the AutoCAD drawings	Measurements from the Revit model
Column base	0.394 m	0.403 m	0.455 m
Column section 1 (at 1.80 m from the ground level)	0.325	0.326 m	0.375 m
Column trunk (section at 2.10 m from the ground level)	0.318 m	0.314 m	0.300 m
Column trunk (section at 2.80 m from the ground level)	0.283 m	0.292 m	0.300 m
Capital	0.533 m	0.531	0.520
Capital cornice	0.412 m	0.410	0.408
Accuracy	+/- 4 mm	+/- 6 mm	+/- 35 mm

From the table emerges the lower level of accuracy of the BIM model in comparison with the pointcloud and with the AutoCAD drawings. A possible explanation relies on the constraints of the parametric features of the Revit software in modelling complex and irregular architectural elements with a high level of accuracy.

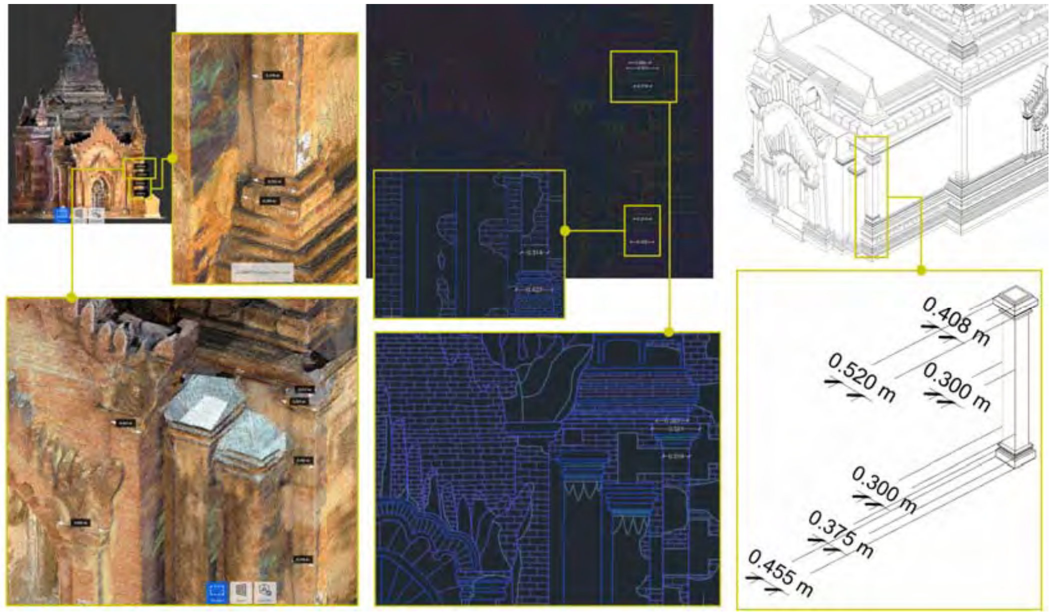

Figure 41 Image illustrating the measurement of one of the West columns taken from the pointcloud, from the 2D AutoCAD drawings (developed from orthophotos generated from the pointcloud) and from the 3D Revit model. Image Source: Author.

8.1.2 Automation and future perspectives of BIM for built heritage

Future developments in modelling built structures in BIM environments could concern the generation of geometries from pointcloud. Effective and reliable automated processes of geometrical reconstruction directly from the pointcloud are therefore one of the challenges that innovation in this field would need to address.

In terms of automation, there are some software applications allowing for automated processing from scans to geometries that can be exported into BIM environments. This section analyzes and assesses three possible software solutions with different levels of automation[16].

[16] The following information is mainly derived from a personal communication with Peter Afshar from Cansel, a firm specialized in selling software and hardware applications and services to provide tailored solutions improving recording and modelling workflows of built architectural components (Cansel, 2017).

The first software application is VirtuSurv. It allows very simple automation processes from scans taken with a FARO laser scanner. Basic architectural elements can be reconstructed directly from the scans by employing automated processing. VirtuSurv works directly with Revit, by importing the selected components in the scans into Revit. Such components can be characterized by the Revit families and database components.

Despite its easy workflow and pretty user-friendly routines, this application is not suitable for complex shapes and highly detailed geometries. Therefore, its application in the built heritage field would not be significant or useful for speeding up and supporting geometric 3D modelling in Revit.

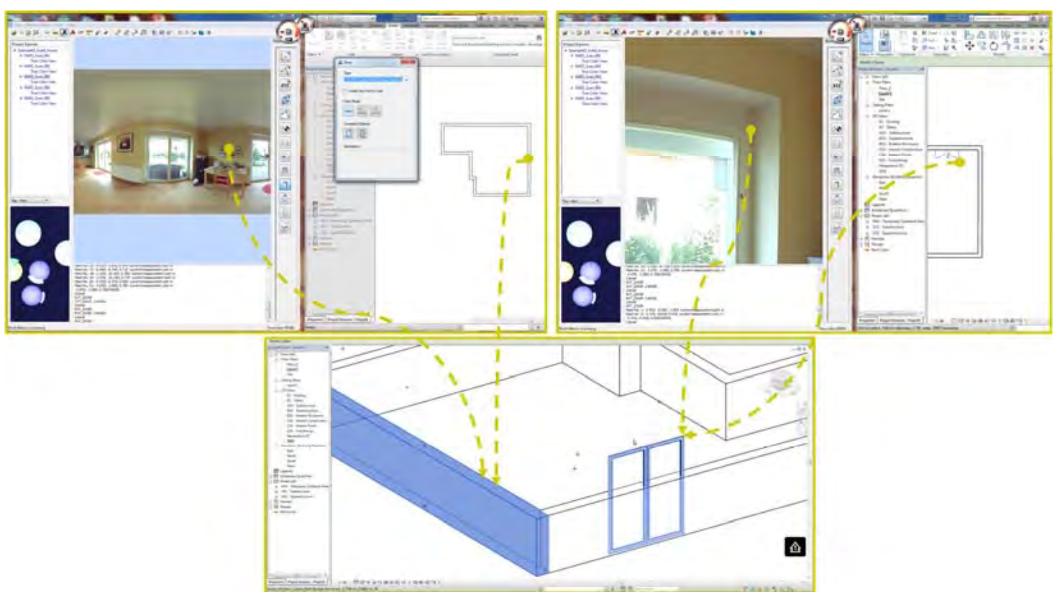

Figure 42 Reconstruction process of the geometry in a BIM environment through a semi-automatic process employing VirtuSurv software. The images are taken from a tutorial by Peter Afshar, elaboration by Author.

The second example of software application is Point Sense. This works directly in Revit as a plugin. It exports pointcloud in Revit allowing automatic reconstruction of regular elements (such as beams, windows, columns, etc.) from the pointcloud into geometries. Nevertheless, the software does not work well with irregular or complex geometries.

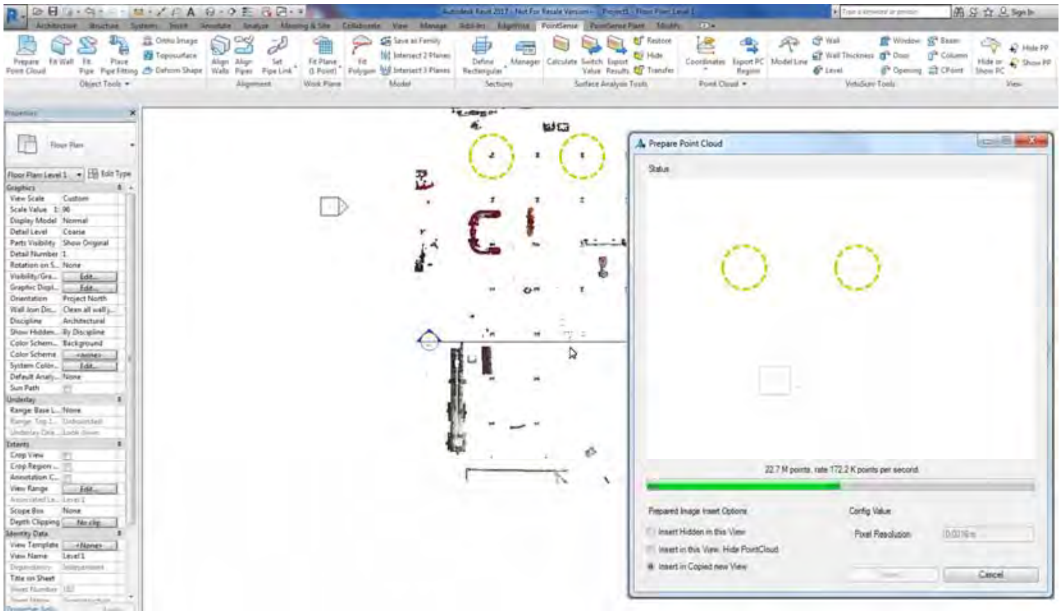

Figure 43 Example of automatic reconstruction of architectural components from the pointcloud directly in Revit using the Point Sense plugin. The images are taken from a tutorial by Peter Afshar, elaboration by Author.

The third software is EdgeWise, which allows a fully automated reconstruction of the pointcloud into geometries.

Nevertheless, problems can occur in the case of incomplete pointclouds (holes in the pointclouds) or pointclouds that are not dense enough. Geometries can then be modified in the software and imported into a BIM environment.

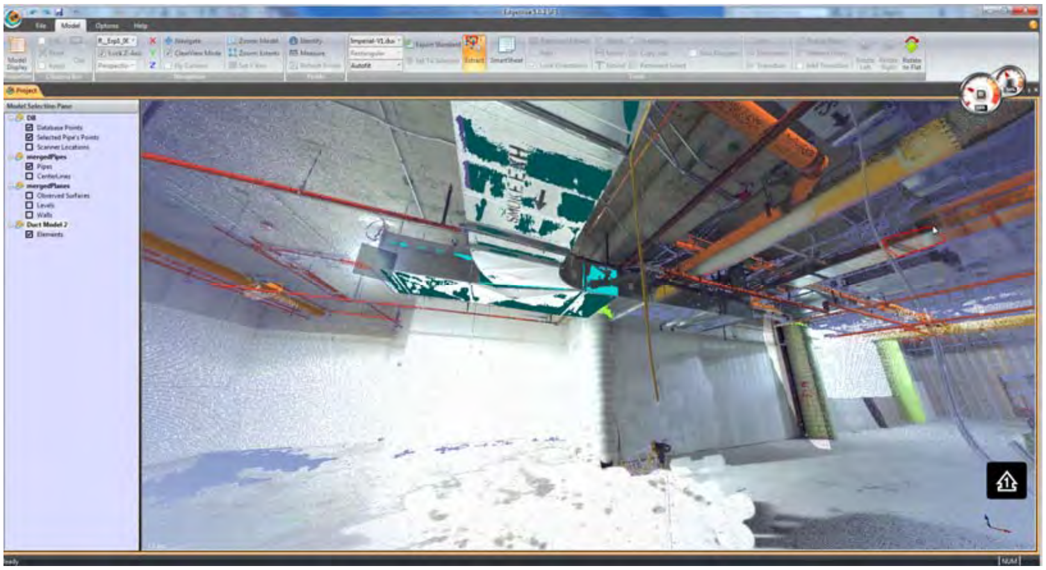

Figure 44 Examples of primitive geometries (pipelines) that can be extracted from the point cloud through a fully automated process. The image is taken from a tutorial by Peter Afshar.

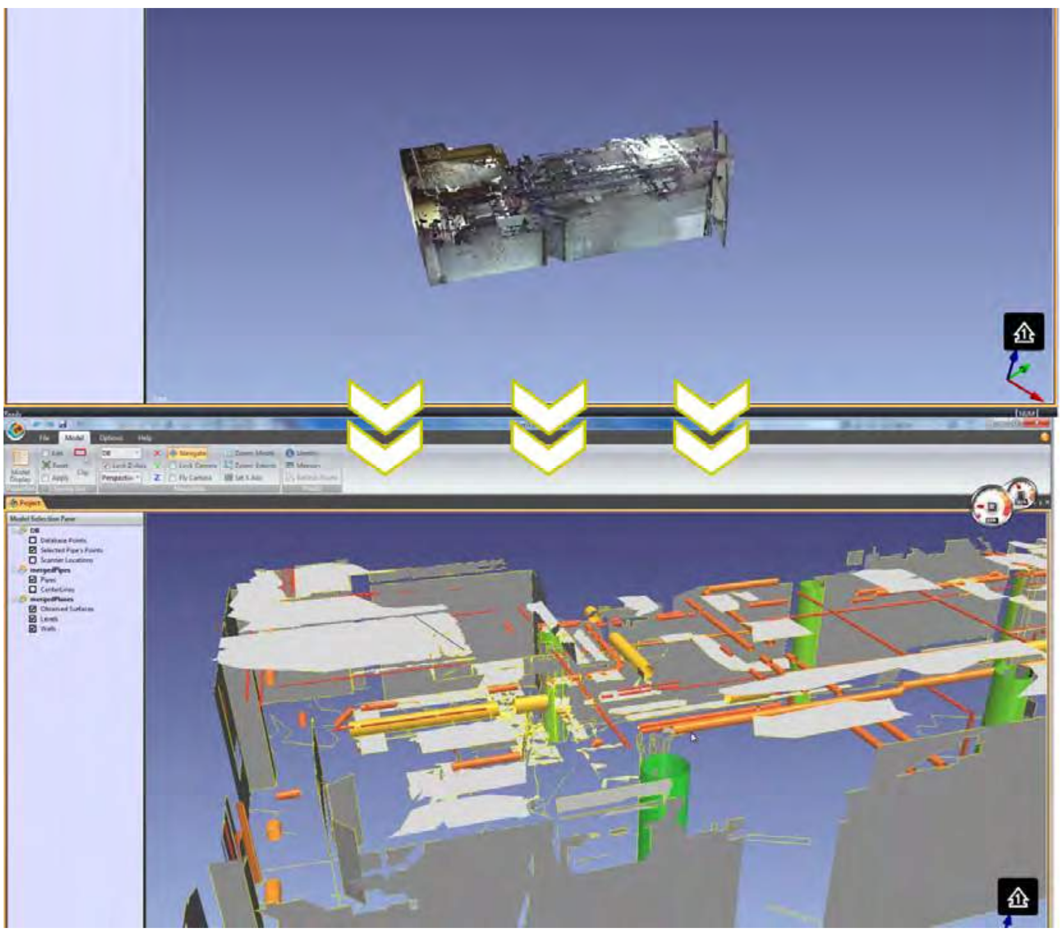

Figure 45 Example of fully automated reconstruction from the pointcloud through a fully automated process. The images are taken from a tutorial by Peter Afshar, elaboration by Author.

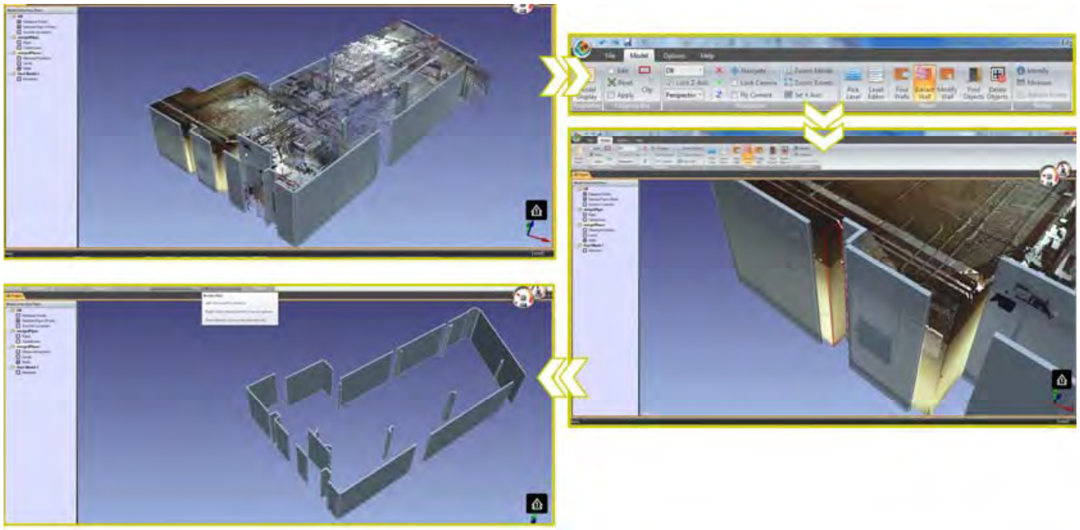

Figure 46 Example of fully automated reconstruction of a wall from the pointcloud, dimensions and thickness of the reconstructed wall can then be characterized through a fully automated process. The images are taken from a tutorial by Peter Afshar, elaboration by Author.

The following table reports the level of automation of each of the described software applications and the associated costs[17].

Table 2 Level of automation and cost of software application to generate geometries from scans and pointclouds that are compatible with BIM environments. Information source: Peter Afshar and Amar Kalsi. Information elaboration by Author.

AUTOMATION LEVEL	SOFTWARE APPLICATION	COSTS
Low automation level	VirtuSurv	PointSense for Revit (includes VirtuSurv for Revit) Educational Bundle (for ten seats total), network version about $6500, including training.
Medium automation level	Point Sense	
High automation level	EdgeWise	Edgewise Full Suite, Educational offer (for ten seats total), network version about $9500 including training.

[17]From the table the high cost of these new applications is also evident.

8.2 Proposed workflow for the semantic characterization of the BIM model

Once completed the model, each element was characterized with a semantic description. Information came from the direct and indirect researches and investigations carried out. More specifically, information collected in the BIM model can be clustered as follows:

- Information on geometry, dimensions and configuration of the architectural components such as walls, stupas, tower, etc. Knowledge of the inner structure of the temple derived from REAP analysis (mainly from the contribution of experts, masons and workmen) as well as from technical reports (mainly developed by the UNESCO) and visual inspections and direct observation on the site.
- Technical data and properties of the employed materials. In this case, information was derived from documents analysis (including but not limited to library resources and technical reports), non-destructive and destructive tests.
- Awareness of the altered and reconstructed parts, gained through archival research and visual inspections.
- Significance and values of architectural indoor spaces and exterior elements. This information is earned from archival sources as well as direct research.
- Information on local history and recollection of local events not reported in documentary sources. This kind of material was collected through transect walks and personal communications with locals.

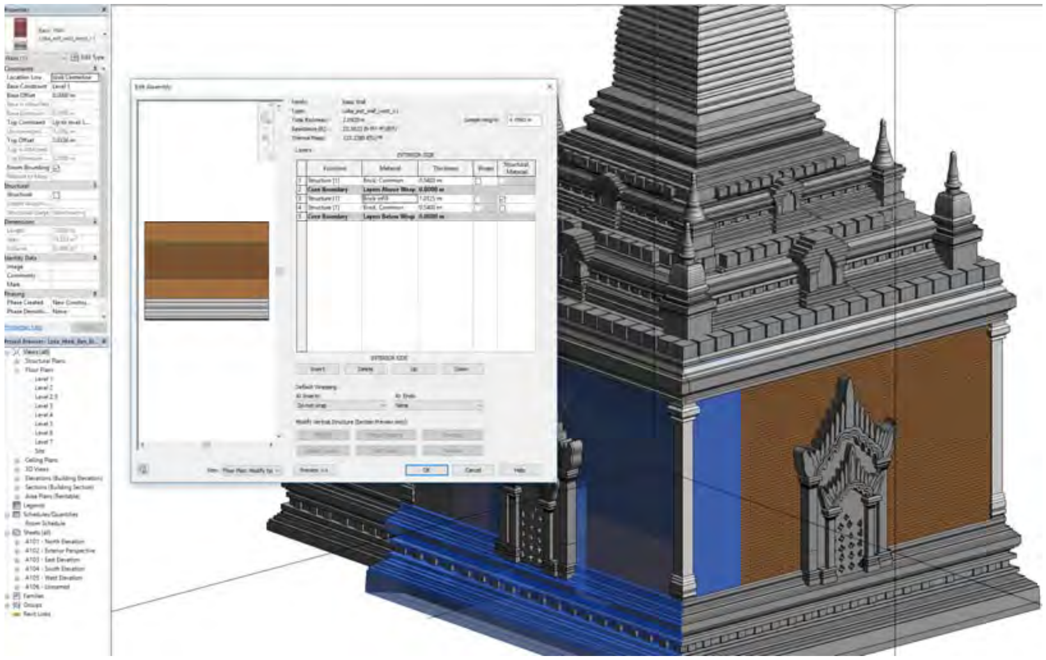

Figure 47 Example of semantic characterization of one of the wall components of the BIM model. Software employed Autodesk Revit2016. Image source: Author.

Figure 48 Production places associated with the maintenance and restoration of Bagan built heritage. Images source: Author.

The characterization of the model, making use of the semantic opportunities of BIM systems, started from the load bearing walls.

The walls were characterized according to the analyzed structure of the walls investigated through direct and indirect analysis on the site. In the specific case of Loka-hteik-pan temple, these parietal load bearing walls' structure consisted of three main layers: two exterior layers made of brick masonry with very thin joints - in order to protect the wall from the water infiltration[18] – and an interior one made of bricks and thick mud mortar joints.

Figure 49 Visual analysis of collapsed Bagan structures. These helped to understand the employed assembly of the construction materials. Images source: Author.

[18] This constructive solution is particularly relevant considering that Bagan is exposed to heavy rains for four months every year, during the rainy season. Furthermore, solutions aimed at protecting built structures from rain infiltrations and related damages becomes even more relevant considering that the mortar is clay based. Hence, if mixed with water, it loses its mechanic properties.

This information was obtained through direct observation, indirect analysis including technical reports, historical essays and researches as well as direct analysis[19]. In the understanding of the inner structure of the parietal load bearing wall, the study of other Bagan temples of the same period has also been useful.

Further, from: a) dialogue with locals masons and constructors b) documental material and visual inspections of Loka-theik-pan walls as well as from c) the visual analysis of inner structures of similar walls of other temples in Bagan, collapsed after the last earthquake (of August 24, 2016) it has been possible to gain information of the wall configuration.

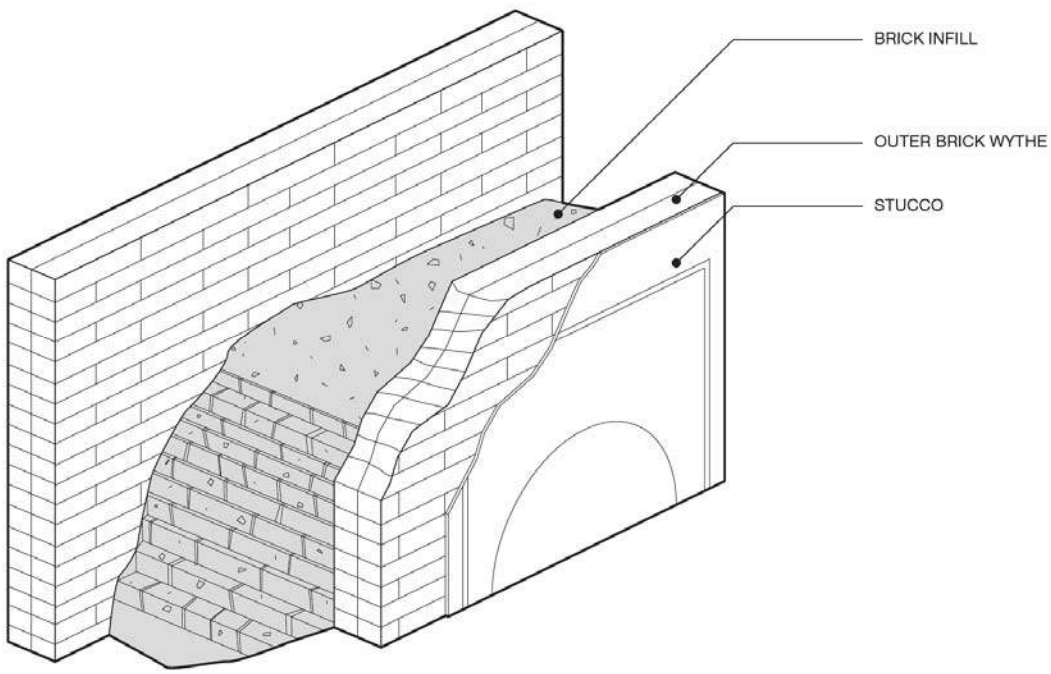

Figure 50 Sketch of the traditional structure of Bagan walls. Image source Author.

The wall structure is composed of three rows of brick for each side (interior and exterior) and of one interior core of brick infill. The interior and exterior bricks wythe have relatively uniform width since it is composed mainly by original bricks with a common average size (36 cm x 18 cm x 6/8 cm) (Yarmola, 1987). Since the

[19] The role of direct analysis was particularly relevant, considering the lack of ancient archives and the scarcity of written sources (only few epigraphy are available and their date is not usually sure).

configuration of the wall consists of three raws it has been possible to calculate the average width of each brick wythe (18 cm +18 cm +18 cm = 54 cm).

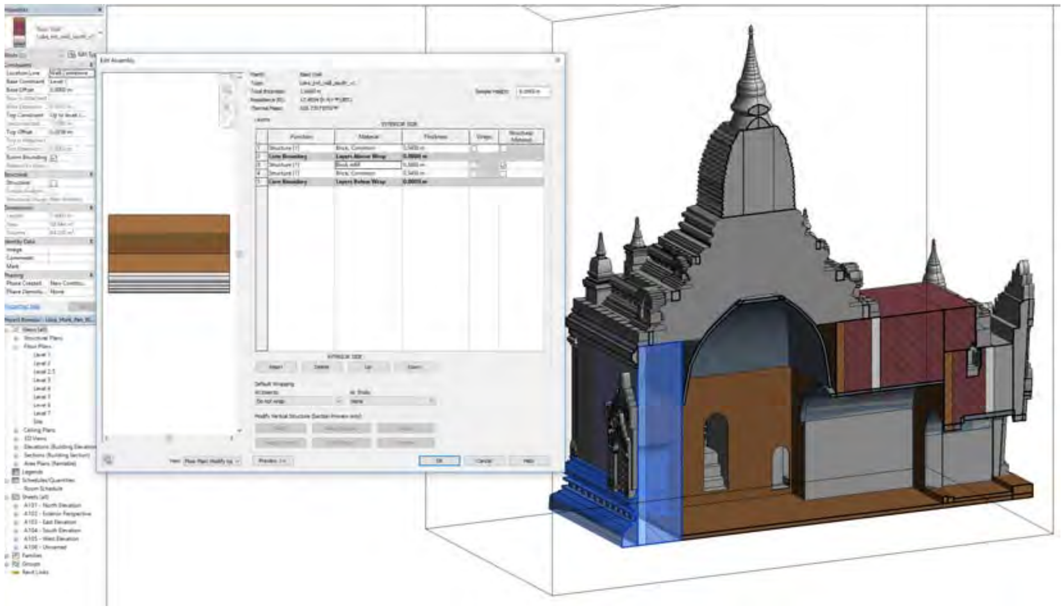

Figure 51 Definition of the stratigraphy of the Loka-hteik pan temple. Software employed Autodesk Revit2016. Image source: Author.

According to Loka-hteik-pan structural specifications, each wall has been characterized as follow:

- exterior brick wythe 54 cm;
- interior brick infill variable according to the wall thickness modelled from the pointcloud;
- interior brick wythe 54 cm.

After this graphic, physical and thermal data as well as identity features have been associated to the wall.

In the definition of a surface pattern, some attempts have been developed to associate a brick pattern respondent to the reality. Nevertheless, the process to import a designed pattern in to the Revit to characterize the surface pattern was particularly complicated.

Reflections on this operation has been developed questioning the meaning of representing 2D information in a 3D environment. Indeed, from the conceptual point of view is it relevant to associate a 2D pattern to a 3D surface, considering the impossibility to associate useful information to it and recognizing its lack of precision and accuracy in the representation of the reality? Hence, established the uselessness of this time consuming operation the default Revit surface pattern for the brick masonry has been preferred.

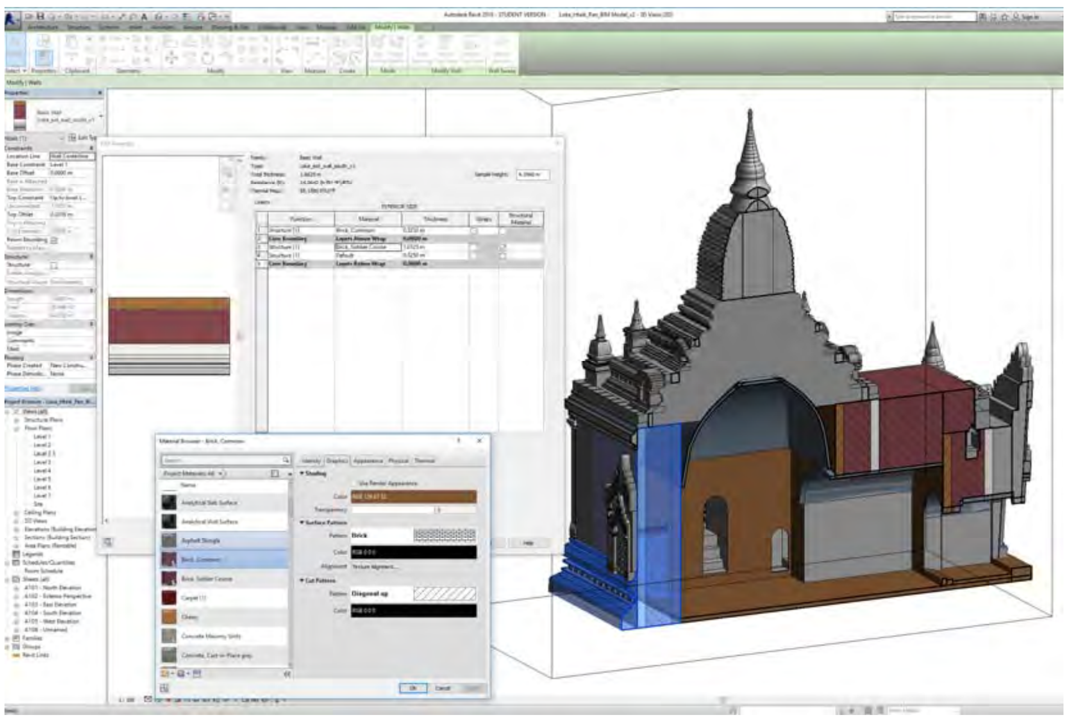

Figure 52 Screenshot illustrating the graphic characterization of the brick masonry of the south wall of the Loka-hteik-pan temple. Software employed Autodesk Revit2016. Image source: Author.

A similar approach has been followed for the appearance of the exterior wall, preferring a default Revit masonry brick texture.

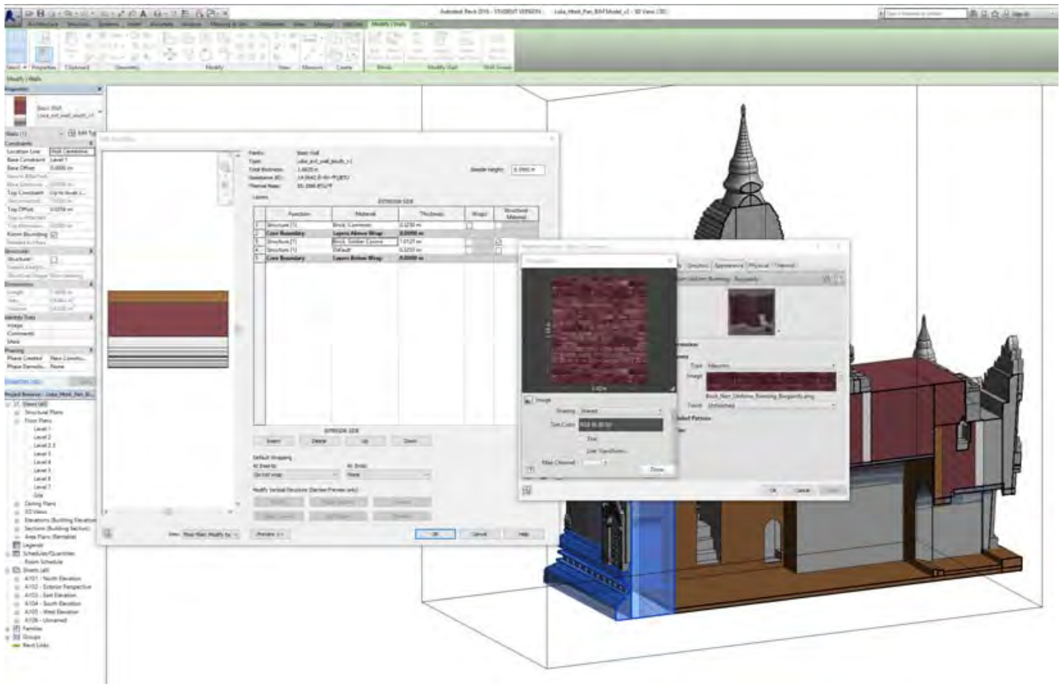

Figure 53 Screenshot illustrating the appearance of south wall of the Loka-hteik pan temple, in brick masonry. Software employed Autodesk Revit2016. Image source: Author.

Then, identity information as well as physical, thermal properties have been associated to the walls. In the “Identity” section, information on material description, manufacturer indicating the location of the brick fabric in the site of Bagan, as well as costs in the local currency, have been included.

This process has been repeated for all the wall types since the thickness of the walls’ sections were all different. This slowed down the modelling process but provided a higher model accuracy.

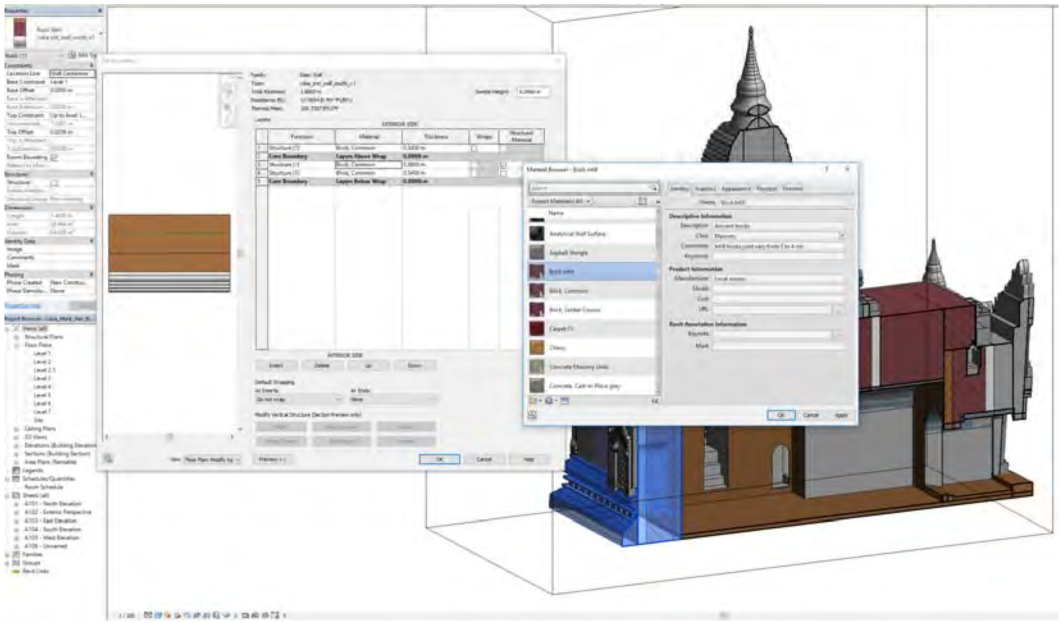

Figure 54 Screenshot illustrating the documentation of the identity feature of south wall of the Loka-hteik pan temple. Information includes data on the basic materials of the wall component such as manufacturers and their location in the site, bricks description, costs, etc. Software employed Autodesk Revit2016. Image source: Author.

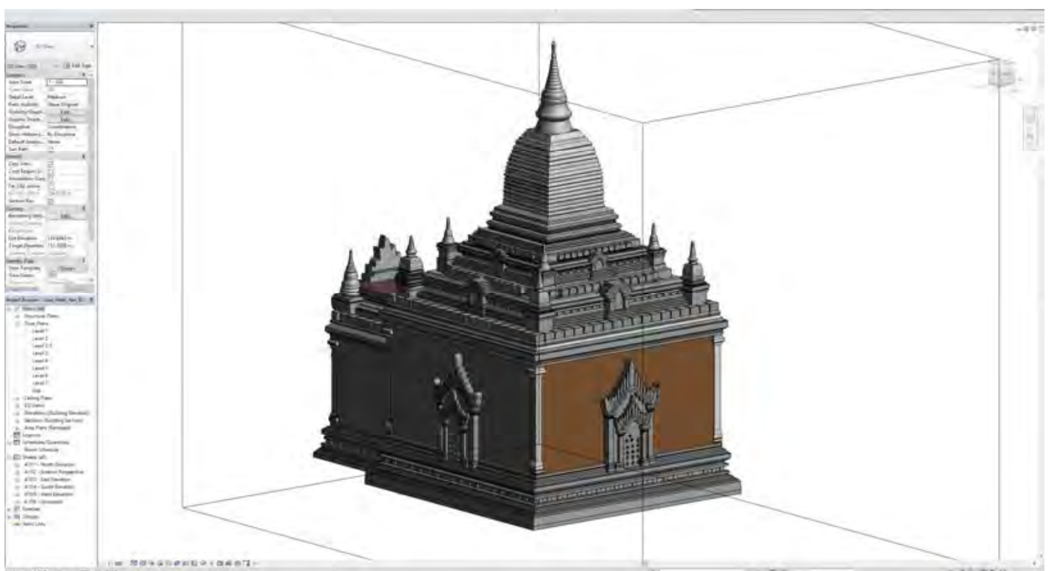

Figure 55 Screenshot illustrating the characterized south wall of the Loka-hteik-pan temple. Software employed Autodesk Revit2016. Image source: Author.

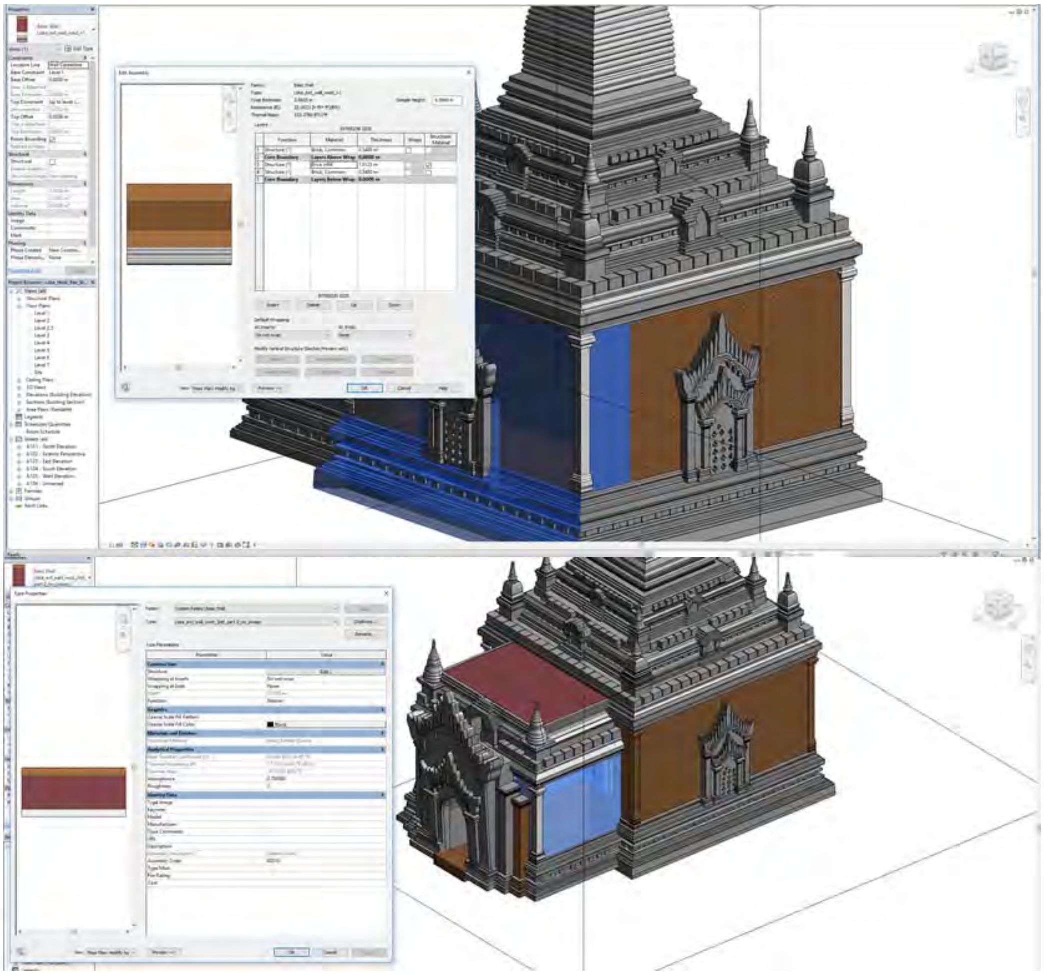

Figure 56 Screenshots illustrating the adopted workflow repeated for all the wall types of the Loka-hteik pan model. Software employed Autodesk Revit2016. Image source: Author.

Apart from the wall all the other architectural components have been characterized.

For instance, the corner stupas have been characterized evidencing the reconstructed ones, in concrete, from the original ones made of bricks. For both types of stupa materials, appearance, physical properties and identity data have been provided.

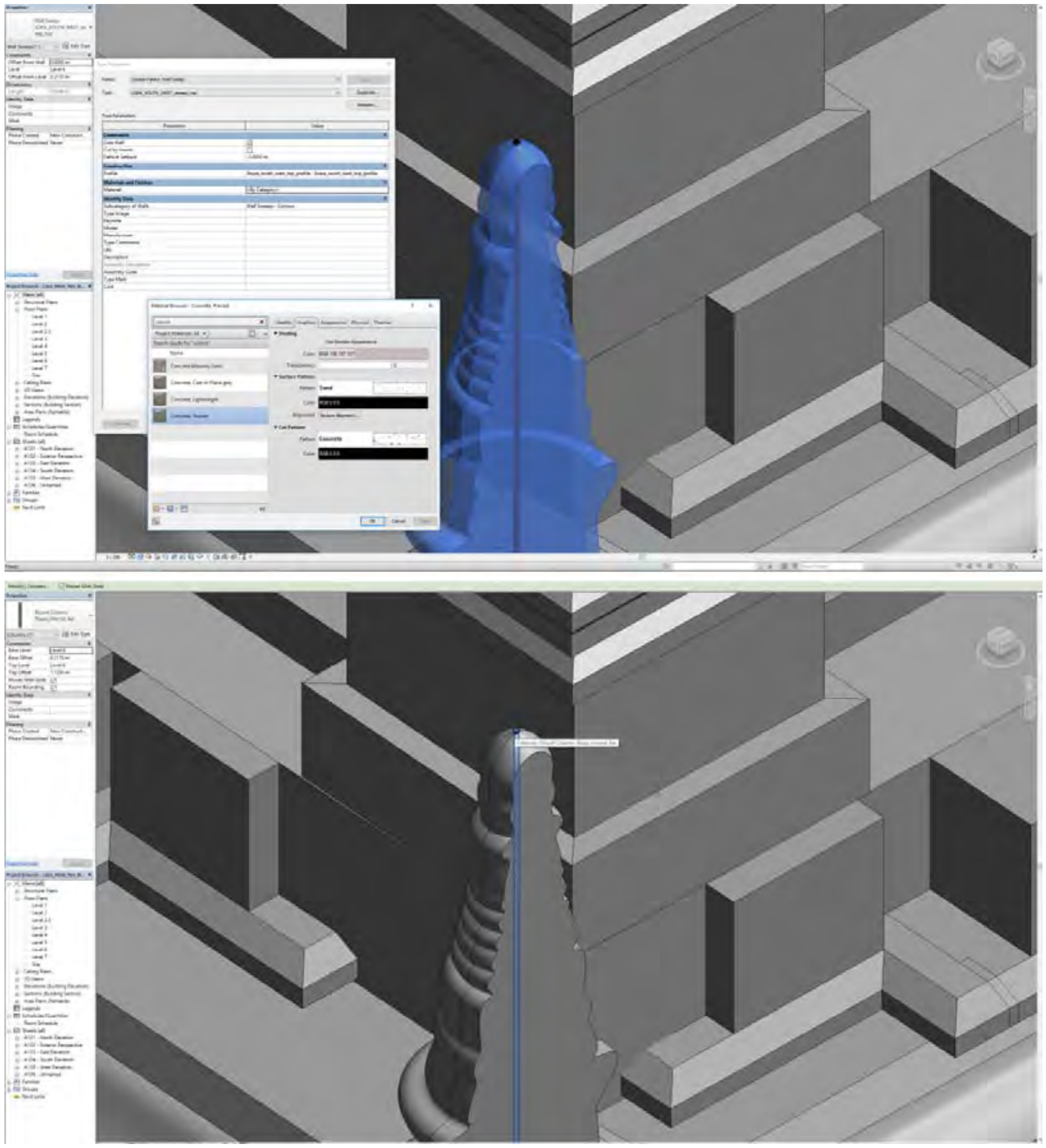

Figure 57 Characterization of the corner stupas of the Revit model. Software employed Autodesk Revit2016. Image source: Author.

Further, information on the significance of these architectural elements documented in the Nara Grid, developed for the temple (see Chapter 7, *The Zetema of the Loka-hteik-pan temple*), has been inserted in the 'Description' (in the Type Properties of the Wall Sweep Family[20]) of each modelled stupa. This workflow allowed to document

[20] The *stupas* reconstructed in concrete have been modelled as wall 'sweep' around an iron bar (modelled as 'column') in order to make the model consistent with the reality.

social, cultural and religious values of this architectural element with functional as well as aesthetic meanings.

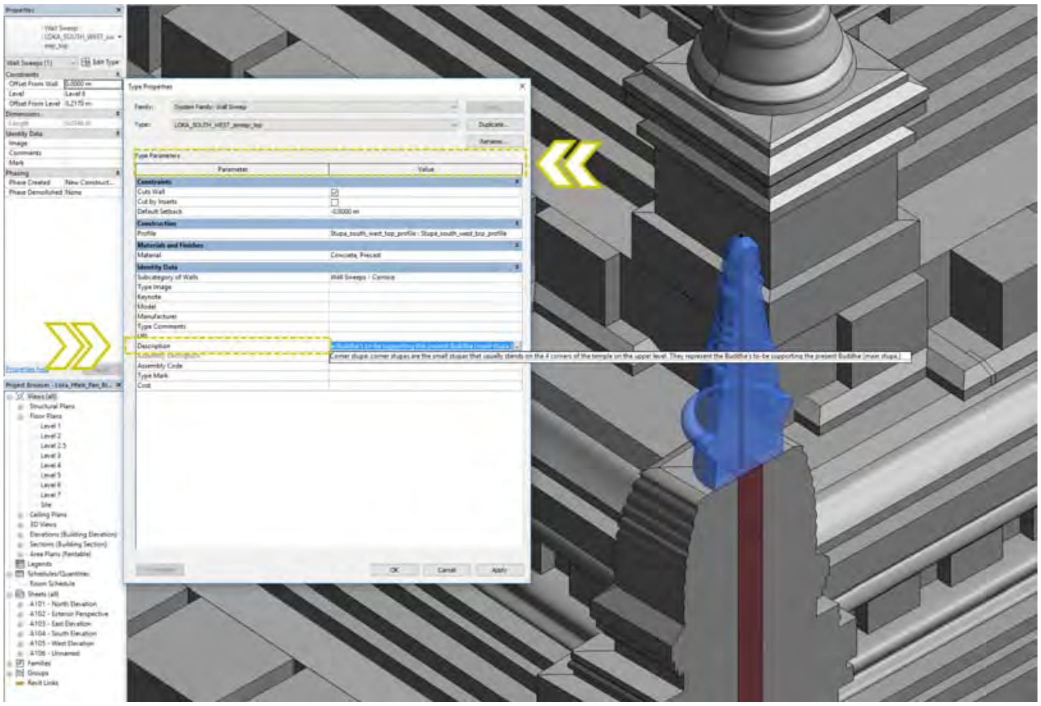

Figure 58 Documentation of the socio-cultural values of one of the modelled corner stupas. Software employed Autodesk Revit2016. Image source: Author.

Openings of the temple have also been characterized introducing in the family properties information on ‘Identity Data’. This information included material characterization, manufacturer identification and location as well as the significance of its shape and design collected in the previously developed Nara Grid. The same workflow was employed for all the openings entrance door and windows.

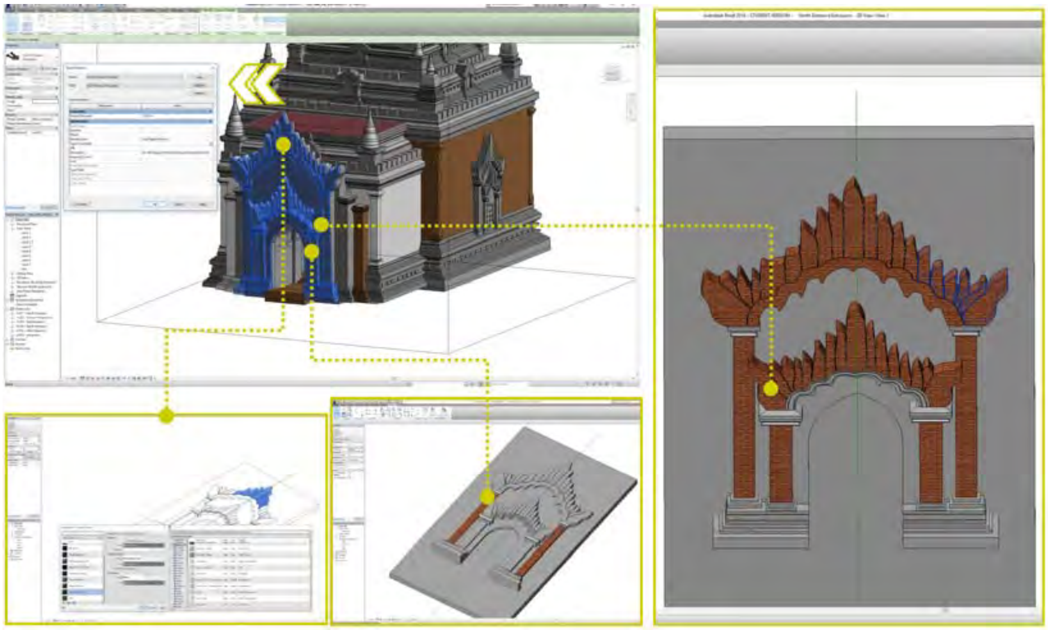

Figure 59 Semantic characterization of the entrance door. Software employed Autodesk Revit2016. Image source: Author.

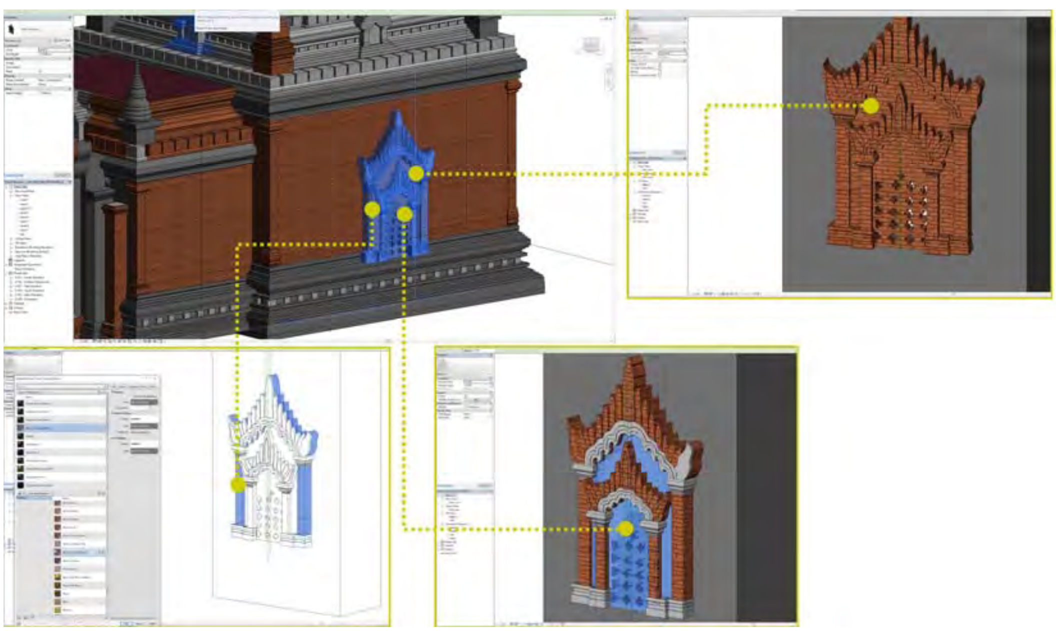

Figure 60 Semantic characterization of the west window. Software employed Autodesk Revit2016. Image source: Author.

The same workflow was adopted for the inside surfaces decorated with wall paintings. For instance, the painted vaults (modelled as basic roof from the pointcloud) were characterized by dividing the vaults into different layers and introducing in the 'Identity' tab the description of wall paintings' techniques and topics and a URL link to the websites containing more detailed description and information of each single decorated surface[21].

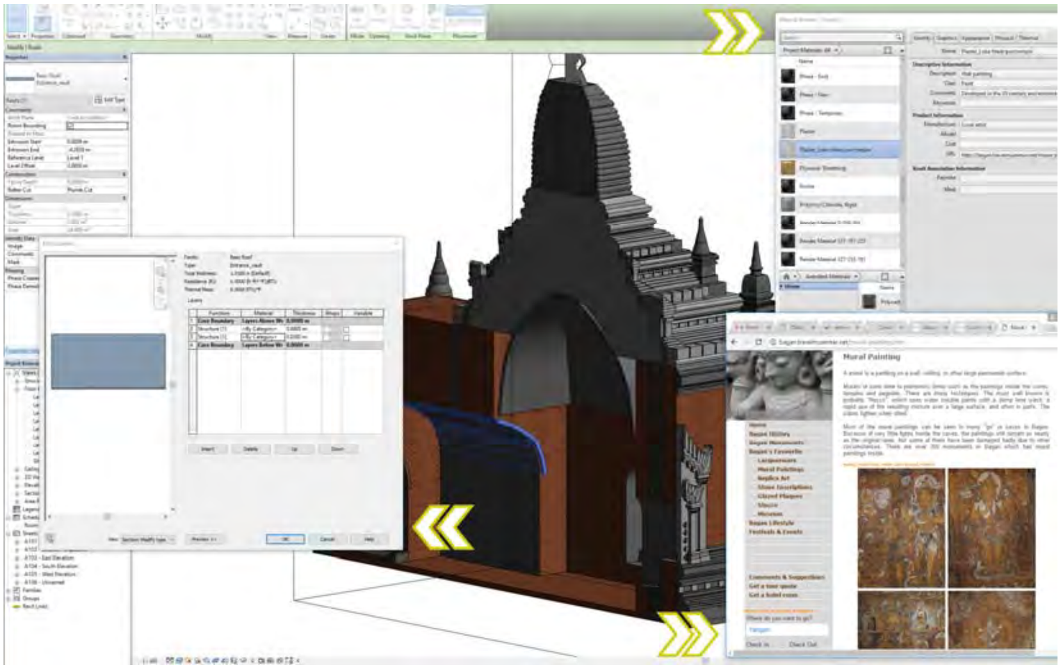

Figure 61 Characterization of the modelled barrel vault of the vestibule. Software employed Autodesk Revit2016. Image source: Author.

8.2.1 Information processing in a BIM environment: challenges, constraints and opportunities

The main constraints faced in the semantic characterization of the model consist in the rigid pre-strucutred information dataset of the Autodesk Revit 2016 software. This data organization did not fit properly to the multiple and heterogenous information collected on the Loka-hteik-pan temple. Further, changes in the data base organization to adjust the database structure to fit the specific documentation needs of the project was very challenging and time consuming, if not impossible.

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[21] Due to the relevance of the temple it was possible to find on-line several websites describing the temple mural paintings.

Nevertheless, the semantic characterization of the model allows to connect different aspects, and therefore enables to consider more holistically different aspects – both tangible and intagible - that would otherwise be considered in isolation.

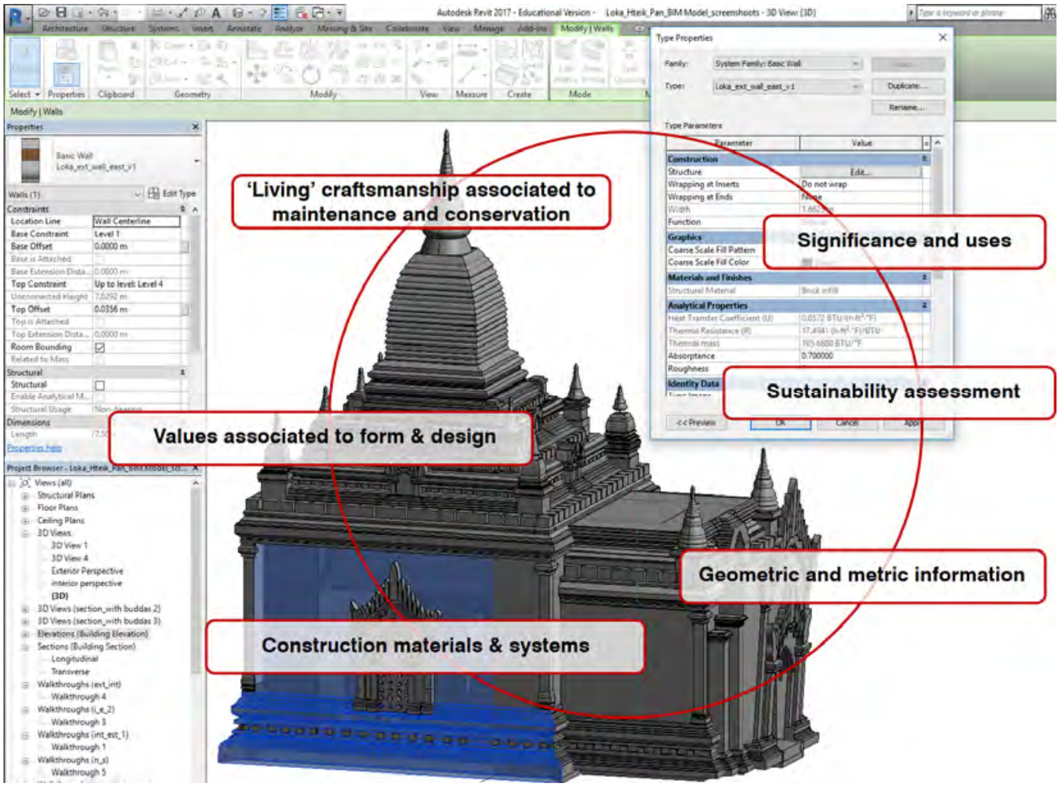

Figure 62 Image showing the aspects that can be documented and managed through the semantic characterization of the BIM model employing the software Autodesk Revit2016. Image source: Author.

These include information on:

- 'Living' craftsmanship associated with maintenance and conservation of the structure;
- Significance and uses;
- Data useful for the development of an LCA analysis, thus providing an evidence-based assessment of the environmental sustainability of the building components;
- Conformation, structure, stratigraphy and material assembly schemes;

- Construction materials and techniques;
- Socio-cultural values associated with form and design of architectural components.

Additionally, to this information, technical data on material technical properties and provenance can be also provided.

8.3 Outlined approach to develop a WikiBIM

Once the BIM model was developed and characterized with semantic information, the research addressed further challenges linked to possible strategies to collect remotely the descriptive information gathered on the field.

In Autodesk Revit2016 the geometry of the visible components of the building was modelled. For the definition of the constructive systems adopted, (i.e. the bricks assembly and conformation, information) was mainly collected through the REAP analysis and only marginally drawn from historical and archival research, due to the scarcity (and in most cases lack) of written records.

The tested REAP methodology showed its strengths in gaining information from local stakeholders and actors involved in the conservation and or reconstruction processes in Bagan and more generally in Myanmar.

Nevertheless, this methodology was time-consuming. It would depend to a large extent to the engagement, support, and ownership of the local department of archeology, that owns the institutional memory of conservation actions as well as the information on, and access to, key informants and data on the different places of production relevant to the conservation of the Bagan monuments, i.e. bricks production centers, bamboo firms for the scaffoldings, plaster makers, etc.

Furthermore, knowledge of the language is essential for qualitative data gathering and processing. The REAP would not have been possible without the support of a translator, from Burmese to English, found in the person of Ms. Wint Latt.

Due to the complexity of the built structure, to the layered interventions over the years and to the systems of values associated with the temple, the time invested in the survey (two weeks exclusively dedicated to the REAP analysis) allowed to collect only part of the information required to develop a precise, accurate and comprehensive[22] 3D model.

Therefore, web supported strategies were taken into consideration to develop the semantic characterization of the BIM 3D database through a participatory logic. As reported in chapter 4 *The potential of the 'Digital Revolution' for the conservation, documentation and management of Cultural Built Heritage* and in chapter 5 *The Epistemic object: WikiBIM as a participatory documentation approach to managing design choices in built heritage contexts*, the increasing diffusion of web platforms for sharing, and managing information is becoming a global phenomenon, rapidly expanding its applications.

In line with this trend, a participatory strategy to allow information collection relevant for conservation purposes could be outlined.

The first step consists in the definition of a web platform. The concept at the basis of the platform should address five main principles:

[22] The term comprehensive here indicates a model that from the geometrical point of view illustrates the shape of the building components, including its inner parts, and from the descriptive point of view presents a complete semantic description of the technical aspects as well as the social meanings associated with each part of the building.

- *User-friendliness,* in order to make the platform accessible to a broad public. The graphic interface of the platform should be designed in order to provide an easy understanding also by non-expert and non-skilled users.

- *Simple workflow:* to assure platform's usability and effectiveness to upload as well as collect information, a simple, intuitive and schematic workflow should be designed.

- *Inclusion:* Accessibility to the platform from different social media and web pages should make the participation as simple and democratic[23] as possible.

- *Transparency:* the identification of the *information providers*, user registration should be requested to avoid spreading fake information.

- *Versatility:* Capabilities of *sharing graphic* as well as *audio and multimedia items* should enable recording and integrating information on intangible elements, such as building component manufacturing processes and oral histories describing social and technical values of built structures.

The second step requires effective strategies to stimulate the participation of experts and non-experts in information-sharing through an interactive platform.

The third step should face the issues of information collection and data structuring to insert them in a pre-set database structure of a BIM software application such as AutoDesk Revit 2016.

A proposal of the design of the Wiki component of the WikiBIM approach is illustrated in the following paragraph.

[23] Limitations of the democratization process in the use of web platforms was considered. Constraints due to the need of IT tools (and the related costs), internet connection and basic knowledge of informatics tools to access the platform were taken into account.

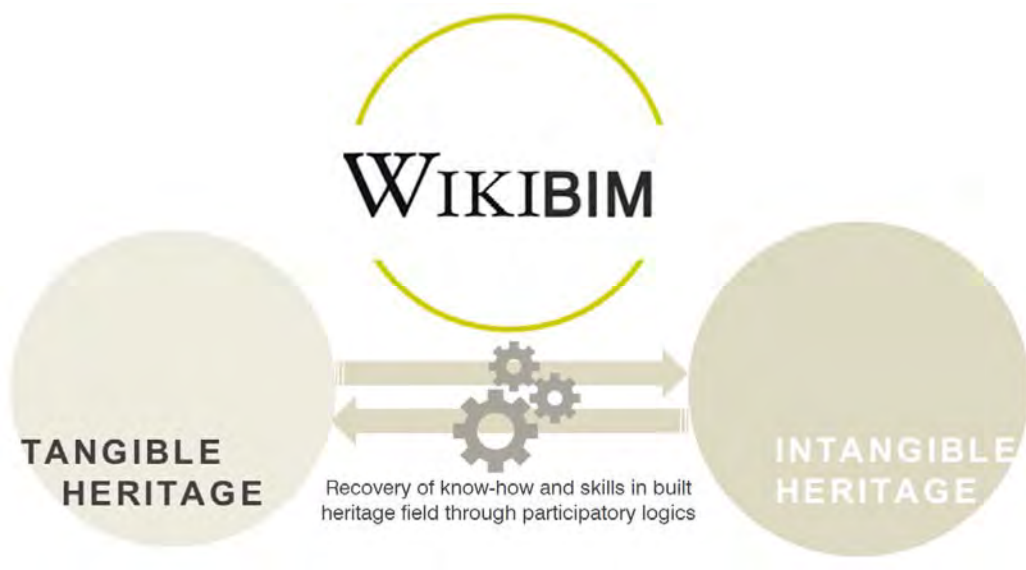

Figure 63 Schematic diagram of the main functions of the WikiBIM approach. Source: Author.

8.3.1 Design of the Wiki component of a BIM model

Inspiration for the design of the Wiki platform proposed to characterize the BIM model of a cultural heritage building comes from the logic employed in different fields where a platform is used to gain information through a knowledge sharing approach.

An interesting example from a different field is provided by the ACE Practioners' Network. The Electoral Knowledge Network ACE is an online resource that shares electoral expertise, experience and knowledge (ACE The Electoral Knowledge Network, n.d.). This platform allows to ask experts questions on electoral reform and management issues, on the condition of user's registration through identification of the user profile, affiliation, and job. It also allows to browse through the consolidated replies to find out if the question was already addressed (ACE The Electoral Knowledge Network, n.d.).

In the built heritage field a similar approach can support two kinds of interactions:

1) Expert to expert;

2) Non-expert/general public to expert.

The proposed Wiki platform could rely on similar principles, and be structured as follows:

1) Engage users on a voluntary basis in any of the following activities:

- Post and answer questions, both from other network members and from the 'Ask the Experts' function.
- Post and engage in discussions.
- Contact and interact with fellow members directly of the network.
- View heritage related announcements, upcoming events, and job vacancies.

2) Provide incentives to share information and to participate in the web platform, like:

- Benefits from sharing experiences and knowledge from the field.
- The sense of belonging to a community of practice, i.e. a reputable global community of experienced preservationists (heritage practitioners/experts).
- Expand professional networks.
- Increase visibility through the personal profile.
- Receive peer advice from other experts.
- Access expert information, job vacancies and announcements.

3) Benefits from finding the experts able to solve public institution/private owner problem.

- The 'Ask the Experts' function is the bridge between the client (either public or private) and heritage professional networks, as well as the bridge between heritage professionals and specialists in other disciplines. Users of the web platform can submit a question related to general conservation issues and raise issues of technical nature. According to the topic of the questions, they may be addressed to the heritage experts in the platform. The answers provided are then published in a database that can be accessed in order to support future users with similar problems.

- Although the language used in the platform could be an issue, at least in the starting phase English could be used as default language.
- Furthermore, to make the platform as democratic as possible, membership fees should not be considered, allowing free participation to the restricted network of the experts as well as to the one open to the wider public.

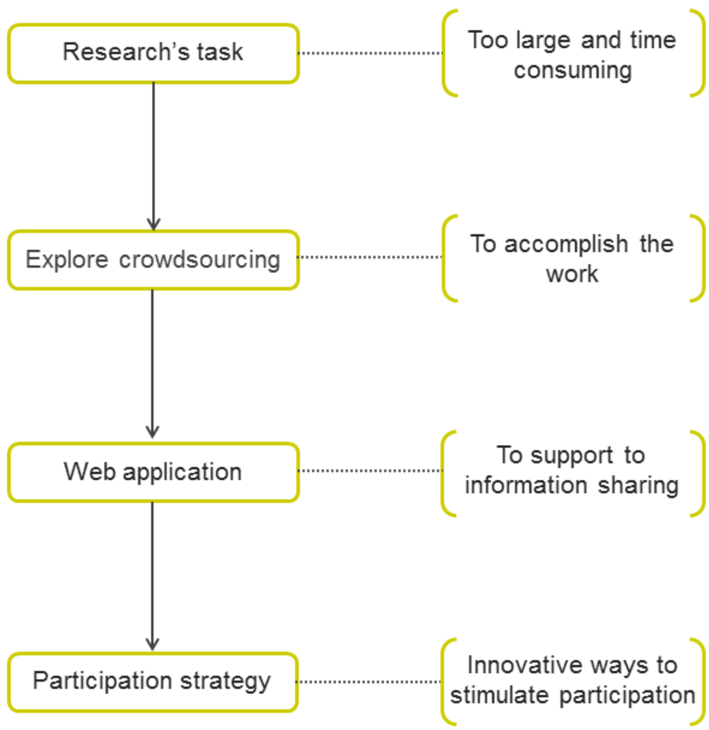

Figure 64 Diagram of the proposed wiki approach workflow designed to engage information sharing in built heritage documentation. Source: Author.

Therefore the proposed application is addressed at two main categories of users:

1. Heritage experts;
2. General public.

Concerning the first one, the proposal aims at pro-actively engaging skilled professionals in networking on heritage conservation approaches and practices. To promote their participation, the basic idea consists in creating an experts' community for experience sharing and learning. The concept consists in linking who has a problem with someone who can solve it.

In the heritage conservation field this can be intended, for instance, as an expert in buildings' structure that needs an expert in documentation and survey to study and analyze an historic structure. Therefore, conservation agents would employ participation to gain info on specific architectural constructive techniques and or solutions. Their participation would be promoted in two ways:

- Expert users become part of a broad web community on heritage conservation.
- Expert users can access information on technical solutions and techniques that can be employed into different contexts.

In relation to the second one, the Wiki logic would employ people ideas and opinions for value assessment and the analysis of character-defining elements of historic structures in the present socio-economic and cultural context.

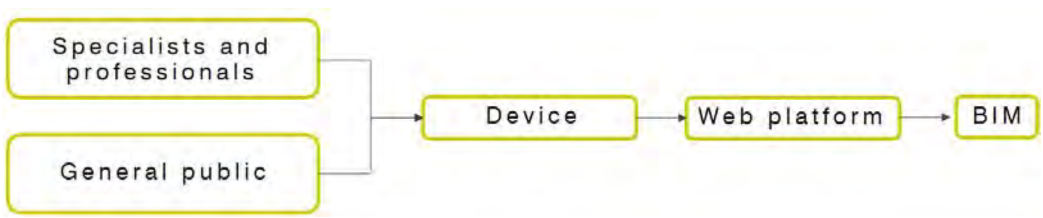

Figure 65 Diagram of the workflow of the outlined wiki approach. Source: Author.

Two levels of information should be associated with these two different users' categories:

1) For heritage experts.

The issue of *"How to promote info sharing"* should be addressed. For instance, information providers can be interested in being part of this network since they can use others' information on technical problems related to heritage conservation - used in different contexts (e.g. Angkor Wat, Cambodia and Bagan, Myanmar) - in their own projects and/or researchers. The motivation for their participation would be knowledge sharing to gain information generated by other experts and heritage professionals. This approach is similar to the one at the basis of the web platform Academia.edu. Therefore, information and knowledge shared at this level would be of a technical and specific nature, including not only texts but also multimedia file and specific files formats (i.e. .dwg, .dxf, .pdf, .xlsx, .ai, .psd, etc.).

2) For the general public.

Information shared with the broad public and experts or professionals differ from that one shared between experts in terms of: data dimension, technical focus, formats heterogeneity, and complexity. Information should be limited to textual and multimedia formats.

In relation to these considerations and to the presented case study, a web application to collect information, according to the above-mentioned principles, could be developed. A web app would allow end users to collect information in a bottom-up logic, advantaging from the support of mobile devices (owned by the majority of the local population in Bagan[24], including low-income people) and internet connection

[24] Recently, the diffusion of ICT has strongly determined the way Myanmar people currently access information, changing at the same time human interaction modalities. As reported by the study "Mobile phones, internet, and gender in Myanmar", developed by the GSMA Association, 40% of the Myanmar population own a mobile phone and 58% of Myanmar households have an active mobile SIM (GSMA Association, 2015).

(considering that, for example in Bagan, most of the owners of mobile devices also have internet connection[25]).

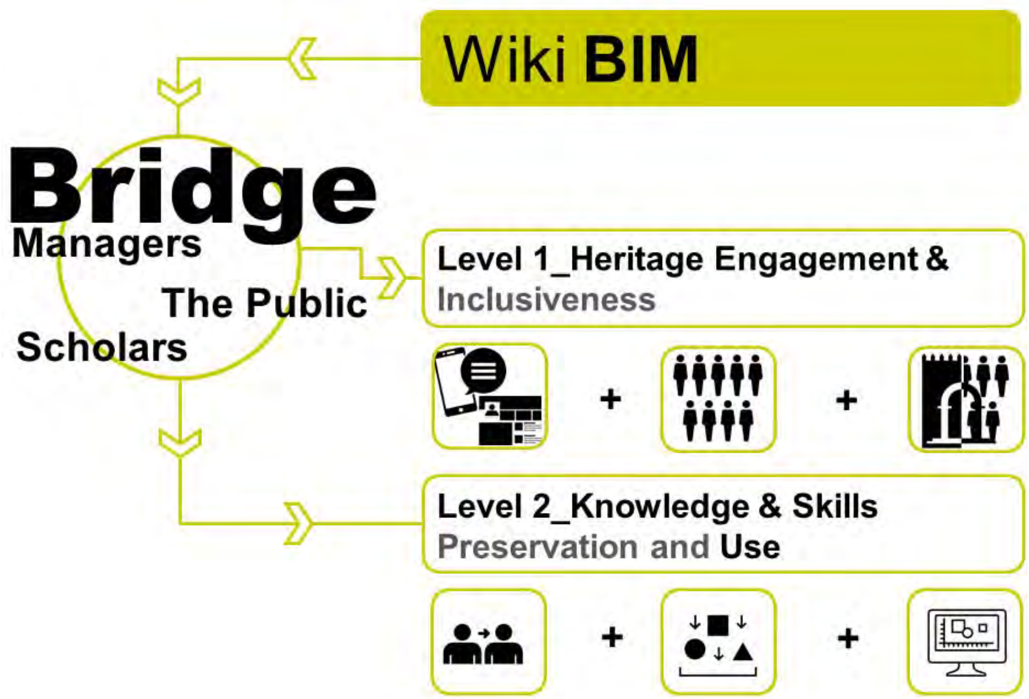

Figure 66 Schematic diagram of the main functions of the WikiBIM approach. Source: Author.

8.3.2 Further developments: Virtual Reality and Digital Fabrication

In the digitalization of the tangible and intangible aspects of the built heritage, some additional applications can be derived from the outcomes of the research.

For instance, immersive environments can be generated through virtual reality applications for education, promotion and dissemination purposes. From the records gathered on the ground in the data acquisition phase, it is possible to recreate virtual environments and sharing information through engaging modalities.

[25] Even if connection can not be very stable or fast.

Virtual reality combines two main senses[26], hearing and sight. These can guide the exploration of virtual reconstructed places recreating an environment that stimulates emotional and physical closeness to the site. This kind of experience stimulates, at the same time, the user's consciousness on the recreated environment, of its features and values.

Further, these applications can allow to experience remote places (far away from users and sometimes not reachable or destructed) making anywhere and anyone feeling local (Milk, 2016).

The experiential nature of virtual reality, would allow a broad communication of the research achievements and of the information gathered on the ground providing a better understanding of a site supporting more informed and respectful forms of tourism.

Additionally, virtual reconstructions can be a useful tool in participatory decision-making processes providing multiple virtual scenarios of possible future interventions on built heritage sites. This kind of audio-visual and scientific[27] platform would potentially enable informative decisions also for a broad (and non-expert) public/audience. For instance, in case of restorations, repairs and reconstructions, communities would be able to visualize, in an immersive environment, the outcomes of these kinds of interventions and express their opinion about it.

[26] Tomasz Mazuryk and Michael Gervautz considered the different contribution of the five senses in relation to the significance and quality of the stimuli transmitted to human brain. They reported that sight contributes to most of the information passed to our brain (70%), capturing most of human attention, it is followed by the hearing (20%) while the other senses - smell (5%), touch (4%) and taste (1%) - contribute only marginally to the stimulation of human brain (Mazuryk & Gervautz, 1996).

[27] Depending on the methodology and on the workflow adopted (and on the metadata provided) in the development of the virtual tour.

Even if not object of this research, the limits and constraints of virtual reality applications should be considered. These concern, for example, tools required for the development of virtual environments (i.e. software applications, head mounted devices (HMD), cameras to capture existing places to be recreated, etc.), skills (trained people able to generate and manage virtual environments), costs (in terms of initial investments for the tools, both software and hardware, as well as for the generation, maintenance and update of the created virtual reality projects) and time required to create virtual environments (such as the time for the animations, audio recordings, transition effects, etc.).

Therefore, a virtual reality test on the Loka-hteik-pan temple has been carried out[28]. The test was developed employing two different applications (Panotour and Wonda) in order to test the versatility and potentialities to produce virtual reality projects to be visualized from mobile devices that can be inserted in head mounted devices (HMD)[29].

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[28] The adopted workflow, included four main phases:

- Data acquisition; a set of eight High Dynamic Range (HDR) photos was taken using a fish eye lens to capture panoramic photos. These photos are then used to generate full spherical panoramic photographs of the selected exterior and interior locations. The images were taken using a Nikon D300 DSLR camera (12.3 megapixel DX format CMOS sensor) equipped with a fisheye Nikkor lens of 10.5mm that covers a field of view of approximately 180º diagonals.
- Data processing; the HDR images taken were processed in Adobe Photoshop 2016. The panoramas were prepared by stitching eight overlapping images for a complete coverage of 360º of the captured scenes (six horizontal, a bottom and a top view). The taken images were then processed in the PTGui Prov9.0 software to merge the eight photos in a panoramic one. In this process the software Adobe Photoshop 2016 was used to adjust and edit exposure and saturation of the images.
- Virtual reality project generation. This phase included several steps: importing the panoramic photos in the software, creating links among the panoramic images, setting up transition points (from one panorama location to another one), adding context information related to the panoramic photos, inserting audio tracks to support the user to understand and follow the storytelling of the site, attaching images to illustrate details and additional information. The integration of different multimedia elements to interact with users, allowed to disseminate values embedded in the site, including the intangible ones.
- Project dissemination; this last phase consists in publishing the project, accessible from a QR code, on different social media and communication platforms.

[29] This choice was oriented by economic sustainability reasons. Indeed, the cost of portable HMD to allow users to visualize virtual reality projects, from their mobile phone, are affordable for single users and institutions such as museums, schools, NGOs, etc. (according to the HMD specification the cost range from 20 $ to 90 $). Due to the possibilities of offered by Wonda in terms of effects and audio-video animations this software was preferred to develop virtual tours accessible by mobile.

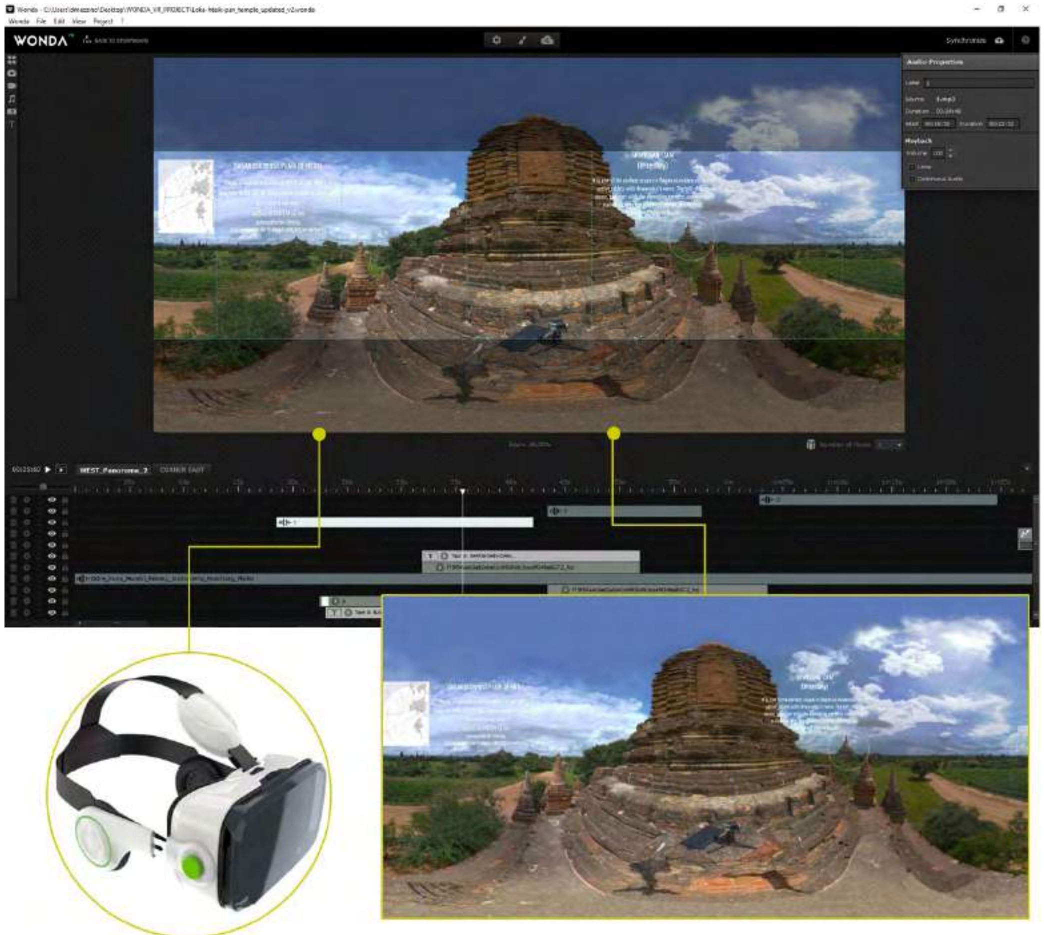

Figure 67 Image illustrating the work in progress of the Virtual Reality test carried out on the Loka-hteik-pan temple. Software employed: Wonda VR. Image source: Author.

Further, an additional tangible outcome of the digital workflows tested by the research, can be the fabrication of scaled models through 3D printers. This kind of application, within the so called 'digital fabrication' field could be significant for dissemination, communication and promotion actions. Despite a scaled reproduction of a digitally recorded building is not relevant for scientific purposes in the conservation field, it can be a useful product in the decision-making phase i.e. providing a tangible scaled model that can illustrate different scenarios of the possible interventions with a good level of detail.

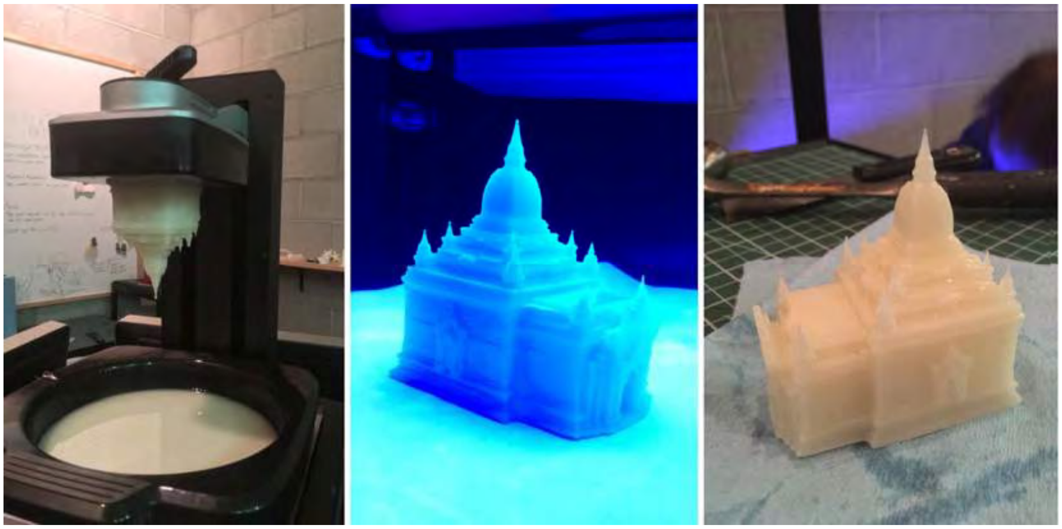

Figure 68 Images illustrating the fabrication process of the 3D scaled model of the Loka-hteik-pan temple coming from the BIM model. Images source: Author.

Furthermore, digital fabricated models can be used in museums as gadgets for promotion and dissemination purposes[30].

[30] In line with these considerations, the fabrication process of a digital model was tested using the Revit model of the Loka-hteik-pan temple. The adopted workflow consisted in the following steps. The BIM model was exported from Autodesk Revit 2016 into FBX format and then imported in Rhino 5 to repair the mesh of some parts of the model and get rid of the duplicate phase/surfaces then the model was scaled and put into the origin and exported as .stl and .obj file. After that the model was imported in the MoonRay RayWar: Ver2.23 software connected to the MoonRay 3D printer to start the printing process. In terms of costs the printing process (excluding the software licenses required to generate the model and the cost of the working hours for a person to create the model) included 5000 $ for the MoonRay 3D printer and associated software to open, visualize and print the model and 100 $ for 3D printing resin to fabricate the model. Concerning time issue the model fabrication time required about five hours to reach a model resolution of 0.1 mm.

Conclusions

The research used the theoretical framework developed in the first part of this text to explore the feasibility of a digitally-supported participatory approach, the WikiBIM, aiming at integrating both tangible and intangible dimensions of cultural built heritage in conservation practices. The developed reflections have been tested on a pilot case, the preservation of the Loka-hteik-pan temple in Bagan, Myanmar. The investigation has focused on the strengths and weaknesses of the proposed approach in facilitating and enhancing conservation practices based on the active engagement of local stakeholders and the employment of digital tools allowing integration of data about material and immaterial factors. The specific case of Bagan provided the opportunity to test the proposed approach in a context vulnerable to natural disasters, thus considering its potential in the recovery and conservation of earthquake-affected buildings.

It is possible to draw some general conclusions based on the evidence gathered on the ground. They concern the following issues: the challenges of integrating different dimensions in conservation efforts; the role of technological innovation in heritage conservation; the constraints faced by the application of BIM to complex historic buildings; the opportunities of the semantic characterization in a BIM environment; the benefits of a WikiBIM approach; its potential role in the aftermath of natural emergencies; its challenges and limits; and future perspectives for this type of modelling in the broad field of cultural built heritage. The choice of the case study was based on a set of research criteria described in Part III, and namely:

- Richness of intangible aspects associated with the tangible dimensions of built heritage;
- Limited availability of recorded archives;
- Incidence of important macro-level threats that jeopardize the preservation of built heritage, like the impact of globalization;
- Vulnerability to natural disasters that provide additional challenges to effective conservation strategies;
- The 'living' features of built heritage that constitute an important condition for the mobilization of local traditional expertise for conservation activities.

The site of Bagan was selected because it meets all the above criteria and represents a territorial context in which the socio-economic and cultural milieu significantly influenced the conservation aims and processes.

Although validated through the results of the case study analysis, the following conclusions are relevant to the general field of the conservation of built heritage and provide a roadmap for further research on effective approaches to the documentation and integration of its tangible and intangible dimensions in preservation strategies.

a) Integrate intangible aspects to think globally and act locally in heritage conservation actions

The research approach highlighted the problematic issues that need to be faced in planning any conservation project, by stressing the key role of a comprehensive knowledge of informed actions.

In line with Mason's positions (De La Torre, 2002), the research approach exemplifies, adopting Bagan as a pilot case study, the relevance of the social, cultural, economic, geographical, institutional and governmental context in shaping heritage values and consequently influencing the heritage conservation processes of any built historic structure. The Loka-hteik-pan temple provided the case study on which this assessment has been carried out. Avrami and Mason (Avrami, Mason, and De La Torre 2000) argued that any decision in conservation prioritizes specific values. In line with this idea, the research approach aimed at identifying and understanding these values, in a participatory and democratic logic. The final aim was to use this knowledge as a basis to justify and define shared conservation processes while engaging at the same time with a range of relevant stakeholders and actors who may contribute to preservation interventions.

In order to achieve this aim, the preliminary analysis of the main heritage stakeholders in built heritage conservation - developed in chapter 1 *New interpretation paradigms in the conservation field*, paragraph 1.1 *Social meanings, scientific aspects, and aesthetic values* - has been relevant to determine:

- Who has the power to shape conservation outcomes;

- The role of the main participants in the heritage field, in determining built heritage values;
- Which kind of values guide conservation practice on a global scale and how are they declined locally.

The research explored different methods and attitudes to preserve embedded and symbolized values of built heritage sites. Such methods stem from a comparison of different conservation approaches developed in the West, essentially in Europe and Canada, and the main conservation practices adopted in South-East Asia, with a focus on Myanmar. The safeguard of cultural heritage does not mean cultural colonization imposing western-driven approaches. The future of heritage conservation lies in turning diversity into a resource for conservation.

The diverse interpretations of historic structures emerging from this analysis seem to call for flexible approaches that take into account the specific features of each context of intervention. No 'one-size-fits-all' model can resolve the tensions between general principles, like the one affirmed in this research - the integration of tangible and intangible aspects of cultural built heritage - and the peculiarities of any given site. However, such tensions are not an obstacle to smarter approaches to heritage conservation; they are indeed an enabler, since they stress that the social meanings embedded in a heritage site are the result of the constant interplay between the agency of local actors and communities, the implementation of national cultural policies and the impact of global forces. The first general conclusion of the present research is the need for smart, context-sensitive solutions, consistent with a comprehensive approach to cultural built heritage conservation and at the same time grounded on the complex and diverse range of local knowledge and skills.

The intangible aspects of built heritage can be better understood by engaging local communities through participatory approaches and heritage engagement strategies. However, this approach does not simply improve the quality of conservation; it influences also its strategic choices. In fact, it stresses the importance of sustainability for heritage conservation in an innovative manner, by anchoring it in the social, cultural and economic context of the site. The intention of the research of deepening the intangible aspects associated with built historic structures is also motivated by the growing globalization of the economic value that is strongly influencing also the conservation market as shown, in the case study analyzed, by the iconic example of the tourism development pressures in the Bagan historic area – presented in chapter 6 *The living religious heritage site of Bagan, Myanmar*, paragraph 6.3 *Socio-cultural and economic context*.

The approach tries to appreciate the same factors that played an important role in shaping a site for its conservation and maintenance. The present research focused on how technological innovation in the fields of ICTs and digital documentation can best support this effort. The methodology adopted, shows that the identification and understanding of both tangible and intangible dimensions of a heritage site can support comprehensive approaches to heritage conservation, thus orienting informed actions. This would consequently operationalize the concept of social and cultural sustainability in the conservation process. The reasons of a participatory logic adopted by this research are justified by the dynamic relation between historic value and use value[1]. These concepts are subject to continuous reinterpretation depending on the cultural environment or *Istanza Culturale* (Cultural Issue) (Niglio, 2013). The aim of the research of testing collaborative approaches in heritage conservation finds also validation in the 'constructive' (Niglio, 2013) aim of heritage conservation as evidenced by the growing number of initiatives based on a bottom-up logic, illustrated in chapter 3 *The documentation of the intangible aspects of built heritage*, paragraph 3.2 *How to document the intangible aspects of built heritage?* and paragraph 3.2.2 *Social media and digital platforms.*

[1] Bagan, for instance, is an outstanding example of use value since the preservation of its monuments would shortly lose significance with the loss of their religious function as place of meditation and worship for pilgrims and local community actors. Additionally, Bagan monuments are usually maintained by local communities, hence the loss of their use value would consequently affect their maintenance on an ongoing basis, increasing lack of interest in these buildings and their possible abandonment.

b) Make use of traditional local knowledge for built heritage conservation

The thesis provides scientific evidence of the initial research assumptions stressing the relevance of conserving and deploying the intangible traditional knowledge associated with building materials fabrication and construction techniques.

Following the adoption of the Loka-hteik-pan temple as a representative case study of Bagan built heritage, two bricks selected on site were analyzed. The two bricks are representative of the temple main historical construction and reconstruction events. They are particularly relevant from the physical point of view. One brick dates back to its construction in the XII century[2], while the other one dates back to the repairs carried out after the big earthquake of 1975 (which hit Bagan with a magnitude of 6.5, according to the Richter Scale) after which the temple was heavily repaired.

On the two selected bricks were carried out destructive and non-destructive tests[3]. These evidenced the good quality of the ancient brick which presented higher density, lower porosity[4] and consequently higher mechanical properties than the modern brick. A possible explanation of the obtained results can be found in the traditional brick

[2] Confirmation of the dating derived from the several experts including: four members of the DoA staff, two senior members of the Bagan Heritage Trust (BHT) as well as from the French architect Pierre Pichard associated member of the Ecole Française d' Extrême-Orient (EFEO) and UNESCO expert, who worked extensively for the study and conservation of Bagan built heritage since the '80s. The experts dated the bricks employing five criteria: dimensions, stamp on the brick, visual comparative analysis, sound (when hit) and color.

[3] Tests were carried out at the National Research Council (NRC) laboratories in Ottawa, Canada.

[4] According to the water absorption test carried out.

fabrication methods and particularly in the longer cooking processes, according to the analysis and observations carried out with the DoA members and local masons in Bagan[5].

Table 1 Comparison of absorption percentage, density and of the maximum stress under compression of the two selected bricks.

	XII CENTURY BRICK	MODERN BRICK
Cold water absorption (%)	12.7	19.1
Density (Kg/m^3)	1777.0	1623.716
Maximum stress under compression (MPa)	37.5	13.4

The results of the tests also stimulated some reflections to be considered in the case of conservation actions or repairs.

Firstly, bricks' fabrication workflow should be revisited in order to guarantee similar or better quality in comparison to the ancient materials. In this case, possible source of inspiration could derive from the recovering of traditional intangible knowledge of the building materials fabrication processes, still owned by local actors on the site, as evidenced by the REAP analysis. The significance of this issue is particularly important in the case of Bagan. The use of materials in the restoration with poorer mechanical properties, in comparison with original materials, must be considered as a flaw to be avoided in future interventions and should promote the use of traditional knowledge, when it is more effective if compared with the current practice.

The relevance of these considerations in Bagan is also due to its historic brick masonry structures (which work mainly under compression) and to its location in a seismic area.

[5] Further information on the tests results are reported in Chapter 7, paragraph 7.4.1 *Construction Materials and Structural Systems.*

A second reflection considers also the recovery of another traditional practice. In fact, the high absorption of the contemporary brick shows the fragility and the high exposure to possible deteriorations of the brick masonry considering the heavy rains during the monsoon season. Further, the clay based mortar in between the bricks is an additional potential weakness of Bagan historic structures in case of water infiltration causing the loss of compactness between the bricks and a consequent weakening of the structure that can lead to possible collapses. Therefore, conservation and repairs actions could contemplate the renewal of the coated plaster, as used in the past, that could be intended as *"superficie di sacrificio"* (sacrifice surface) (Marconi, 1984).

This could be justified from the technical point of view for a long-term conservation[6] and from the social point of view since the white color of the coated stupas and temples was aimed at recalling the snow on the top of the Mount Meru, the sacred mountain in the Theravada Buddhist religion, considered the centre of the Buddhist cosmos (Stadtner, 2013).

[6] Since the layer of plaster coating would ensure a protection against weathering.

c) Technological Innovation: a *deus ex machina* for built heritage conservation?

The second conclusion concerns the potential of technological innovation, as a powerful enabler for the discipline, provided that its application is not conceived as an end in itself. The potential of innovation is fully exploited if guided by a theoretical framework that defines the scope of what should be achieved through its deployment. The risk of defining an analytical approach simply to tailor conservation practice to the technological needs of any particular innovation should be avoided. Conservation principles should drive technological development, otherwise technological innovation, instead of being an enabler - providing efficient tools to know, understand and plan interventions on built structures - would turn technology into the shaper of preservation, by influencing its strategies and choices.

Technological innovation is affecting our society in all its fields and heritage conservation is affected like any other domain of public policy. In the present research, the current and potential use of IT-supported and web-based techniques and tools in relation to built heritage was analyzed with reference to the so-called five Ws (and one H)[7], method, by questioning information related to applications, use, constraints and opportunities for built heritage conservation and management.

[7] When, What, Where, Why, Who and How.

Jacques Ellul, in his book *The Technological Society,* addressed the issue of the implications of living in a society run by technicians. He claims that technique must be understood as the set or regime of means (or techniques) that are employed to execute a rational action with a predetermined end (Ellul, 1967). Furthermore, the French philosopher observes that in this new organization of the world, ends are turned into means, while means become ends. This observation, fully considered by this research, is relevant to the application of technology in the cultural heritage field, where the means - pointclouds, 3D models, digital files, etc. - may be considered as *ends* while they only provide a tool - *means* - to the final goal, that is the conservation or the management of a historic building.

This consideration is at the basis of an approach that combines 'traditional' archival research and community-based strategies to identify intangible aspects and values embedded in built structures through the use of digital technology and web tools with a double purpose. The first one is to gain crowdsourced information through web tools and to digitally archive and process this data. The second one is to document and reference these aspects in a spatial information system.

This study is aware that the technology used in this study cannot be considered a thorough solution and that, while it provided some tentative answers to the research questions, it opened up new areas of inquiry and investigation. Therefore, challenges, limits, and constraints of the proposed approach have been analyzed.

In web-based solutions for crowdsourcing and engagement strategies, some problems have been outlined. These are related to:

- The persistence of the digital divide, and the availability of internet connections worldwide (broadband, the internet, and digital signal);
- The challenge of democratic uses of web tools;
- Economic constraints to purchasing access tools (computers, mobile phones, tablets, etc.) that are critical for participating in web crowdsourcing;
- Increasing difficulty of involving and nurturing continued participation through the web, associated with the increasing diffusion of social networks and shared web platforms;
- Privacy issues.

Some limits and constraints of collecting information in spatial information systems such as BIM are presented in the following paragraph.

d) Limits and constraints of BIM applied to complex historic buildings

The research has addressed some issues related to 3D modelling in a BIM environment. They pertain to the application of such technology to built heritage, a domain of current experimentation that exceeds the narrow scope of designing new buildings, which is the ecosystem that originated BIM as a technical tool.

The first issue consists in the required process to create geometries in a BIM environment. The employed case study of Loka-hteik pan temple reconstructed geometries in AutodeskRevit 2016 from the imported point cloud. This manual process proved to be very time consuming (it took about three months, considering 5 working days per week) and costly[8].

Furthermore, it implied several subjective choices in the model generation phase. These choices were based on several criteria according to the required level of detail (in this case the LoD was set at 300), constraints in the parametrization of geometries and families (i.e. terrace dentils and windows) and limitations in representing the real conditions and irregular shapes of the temple (i.e. dentils displacement, stupas rotation and inclination, terrace ditch, etc.). The final model accuracy depended on choices about the extent of simplification of the representations that have been made explicit for the sake of replicability and control.

[8] The model has been developed for research purposes. Nevertheless, it would have costed about 9000 CAD $ considering 20 CAD $ per working hour and a total of three months (working eight hours per day) to complete the model.

In addition, modelling a Buddhist temple from the XII century evidenced limits and constraints of BIM software to accurately represent the irregular shapes and complex geometries of historic buildings. For instance, modelling walls out of plain, irregular wall curves or vault paths were very challenging steps.

Another limit of the software concerned the pre-defined components suitable for existing historic buildings. In particular, in the case of Loka-hteik pan temple, components such as windows, doors, stupas, dintel, etc., were created from scratch. As already anticipated, this operation extended the time of the model creation.

All these aspects evidenced the need for more advanced workflows and tools in the modelling of irregular and complex geometries that characterize historic buildings. Last but not least, the current lack of automation in modelling historic structures is one of the challenges in the application of BIM to built structures, making it time and cost consuming. Despite some researchers have experimented automation in a BIM environment, their scope is limited and their application in the domain of cultural built heritage remains to be tested.[9]

Then, considering the 3D modelling aspects necessary to create BIM models, the research paid attention to the parameterization and customization of building elements.

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[9] There are some examples of automation from scan to BIM developed by some researchers such as Jung, Xiong, Zhaug and Zakhor. They tested features extraction from the pointcloud. Similar application attempts drove the development of software application such as VirtuSurv, Point Sense and EdgeWise.

Starting from the assumption that, in several cases, the uniqueness of architectural elements of historic structures is also associated with their quality, the research questioned the possibility to customize every element and addressed the efficiency argument, i.e. whether the huge efforts that this operation would require are worth the while. Hence, the approach proposed by Maurice Murphy[10] – aiming at creating a library of all the built heritage families through a customization of all components of each historic architecture, thus establishing an abstract and generic taxonomy – can be questioned.

[10] Dr. Maurice Murphy is a lecturer and researcher in built heritage documentation and computer graphics in the new School of Surveying in the College of Engineering and Built Environment at the Dublin Institute of Technology (DIT). At the DIT he leads a research group specialized in the application of new technologies for digital surveying and modelling of historic buildings and environments in order to support the conservation of these heritage assets. He is currently lead supervisor for Ph.D. and M.Phil. students. In the last three decades he developed a highly experienced profile in building surveying and conservation. He also led and participated in several EU programs in the area of Cultural Heritage. He completed his Ph.D. in 2012 at the Department of Civil, Structural & Environmental Engineering, School of Engineering at the Trinity College Dublin. He worked as a consultant to National Monuments (OPW) for a number of years developing new technology based education and training programs for architectural heritage conservation. Murphy has several publications in the areas of heritage documentation (Academia.edu, n.d.).

e) Opportunities of the semantic characterization in a BIM environment

Another conclusion concerns the extent to which a BIM approach could represent an opportunity for Built Heritage conservation and management.

Indeed, the semantic characterization of the temple analyzed in the case study allowed one to associate quantitative and qualitative information to geometric entities directly visible and manageable from the model. Furthermore, the semantic characterization of a BIM model enables this tool to play a key role in the management and conservation of social, technical and cultural values of historic structures.

Quantitative and qualitative information associated with a BIM model stresses the potentiality of the "I" (information) component of BIM.

While geometric data are provided by the "M" (modelling) component of a BIM, information on the geometry (material, type of architectural component, thermal and graphic properties, etc.) as well as qualitative information related to the "B" (building) element of the model are provided in its "I" component.

This concept can be clarified with an analogy.

If we think about a tree structure, it is easier to categorize the different level of information of a BIM.

With the roots, it is possible to identify the building, "B", as the basis of any process and consideration. The trunk would represent the geometric 3D model "M", to which information can be linked. The branches can instead be interpreted as the information associated with the model.

This can be split into two levels of information: metric information (associated with the visible elements of the wooden branches and the leaves) and information on the intangible aspects (associated with the invisible and yet fundamental processes regulating the life of the tree, like the regulatory cycles adjusting its behavior to the variations of temperature, alternation between day and night periods or change of season, the vital systems of communication and distribution that keep the plant alive, like the lymphatic system, and the processes that ensure the transformation of nutrients in energy, the chlorophyll photosynthesis, etc.).

Information on Intangible aspects indeed is dynamic in the time as the regulatory systems that activate the change of the leaves in the different seasons.

Furthermore, there are also the “fruits” to be intended as the fruitful and useful information that these intangible aspects can provide to conservation stakeholders. For instance, information on workshop locations and contacts of local craftsmen to be involved in conservation and restoration or data on keepers of traditional knowledge that can provide information on constructive material-making processes (i.e. stucco, plaster, etc.,), information on specific designs that proved effectiveness in resisting natural hazards and adaptive solutions of constructive techniques to specific territorial or environmental contexts.

From these considerations and from the experimentations developed on the tested case study emerged the challenging categorization of semantic information “cluster” in association with a specific LoD as per the geometric level of detail of the “M” component of a BIM model. Information associated with a model can barely be categorized in LoI (Level of Information) linked to each LoD since they vary according to each specific building and to each project purpose, or to the reasons for which a model has been generated. It would be very difficult to identify standards for assessing the value, quality and quantity of information to be correlated with the (geometric) LoD of a BIM project, particularly if experts aim at establishing and applying static rules and standardized protocols. This effort would also be questionable from a theoretical point of view, because the diversity of the context of each intervention would require flexibility.

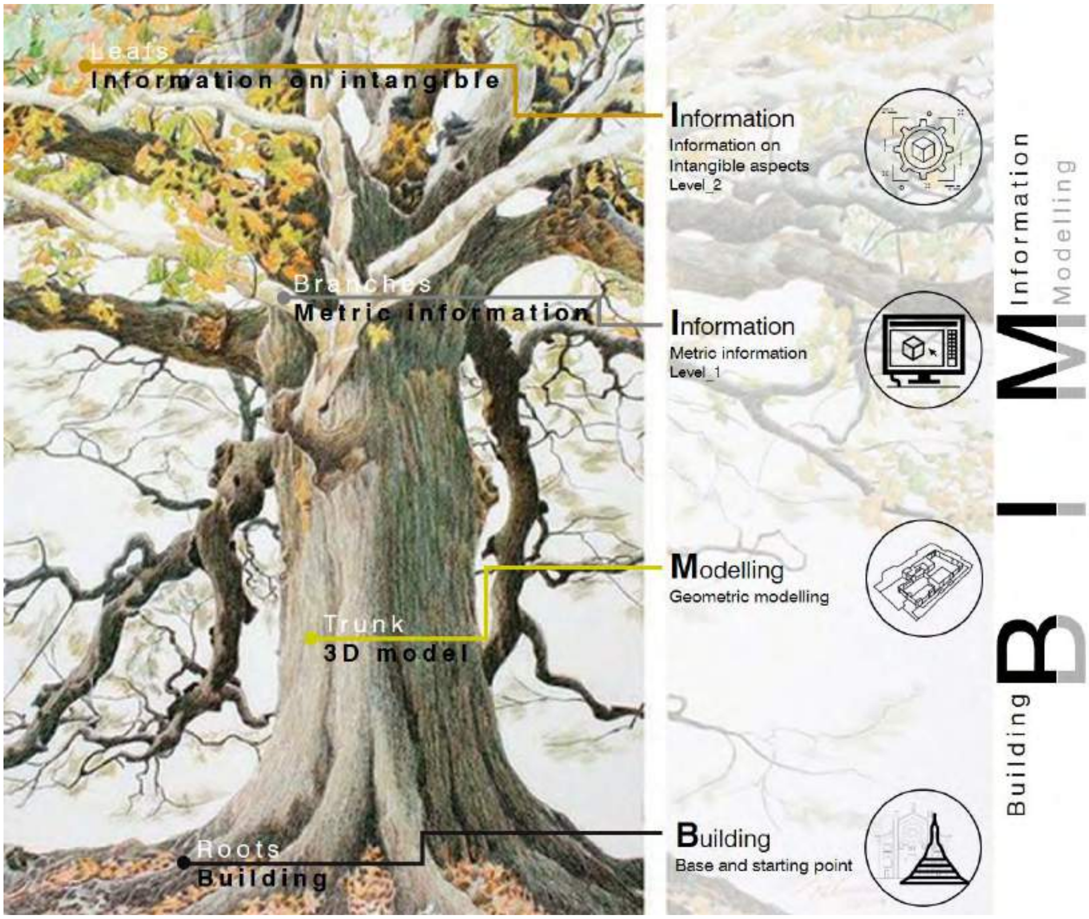


Figure 1 Image illustrating the analogy to clarify the concept of BIM as a database to collect quantitative and qualitative information at multiple levels. Image source: Author.

Additionally to these considerations, future opportunities may further arise in relation to the accessibility of information, maintenance and updating of the model and the conditions for its replication on a large scale.

The first issue is related to the relationship among different types of technical information (i.e. brick-making process and the association with the geometric element ‘wall’ of the model) and their accessibility.

The second one is related to the accessibility of the information on the long-term (data longevity) and access to such information by different project stakeholders, especially those who lack specific training and are therefore unable to know how to use BIM software applications.

The third issue is instead related to the replicability of the proposed approach (i.e. for private sector actors, or public institutions such as DoA, or other project stakeholders) in terms of economic feasibility, time, skills and availability of human resources.

f) Benefits of WikiBIM in case of available historical sources and efficient archives

While the challenges addressed in the previous paragraphs are related to the use and relevance of BIM in the area of built heritage, the research coped also with other issues specific to the effort of using such semantic-modelling technique as an organizing platform for data processing and analysis that elaborates, measures and documents both tangible and intangible dimensions of cultural built heritage. The research named such endeavor as a WikiBIM approach because its building components are modelled in a BIM environment and the information to characterize each building element in the model derives from participatory or Wiki approaches.

Drawing inspiration from past and ongoing initiatives analyzed in the previous chapters, such as the CASPAR project, the WikiBIM approach relies on the concept of conservation grounded on the combination of contributions to expert knowledge, gathered through a restricted-access modality for specialists, and local knowledge, collected through constant users' access on an open-access modality. The concept relies on the assumption that, in order to develop effective conservation actions, archives of built heritage structures should allow constant access to users who may become engaged actors, thus contributing to its maintenance through a constant use and updating of archival material.

Constant use and usability of an on-line archive would allow access and interaction of users, keeping alive their interest and maintaining at the same time the archive updated in terms of content.

The constant update of the contents is a particularly relevant factor considering the changing nature of values and meanings associated with built heritage sites. Furthermore, from a technical point of view, it would assure the longevity of the operative system thanks to information availability (i.e. in terms of formats, data exchange, and compatibility).

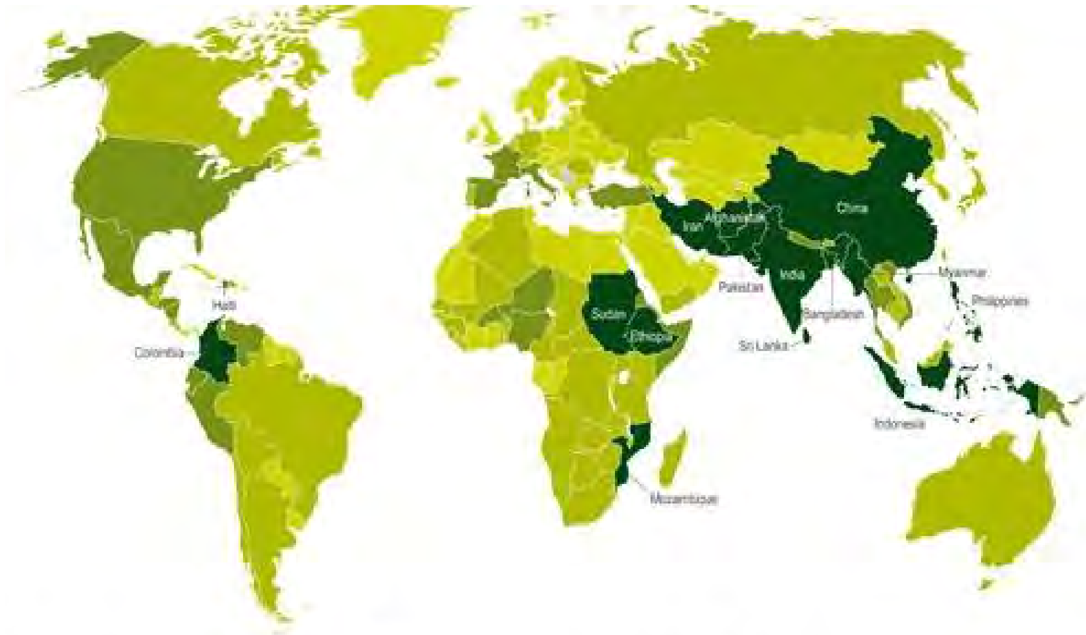
These considerations open up several perspectives for future developments of the outlined proposal.

g) The potential role of a WikiBIM approach in case of natural emergencies

The United Nations recognizes on the 2030 Agenda for Sustainable Development, with Sustainable Development Goal 11 (Target 11.4), that the world should *"strengthen efforts to protect and safeguard the world's cultural and natural heritage"* to *"make cities and human settlements inclusive, safe, resilient and sustainable"*. For this reason, the identification and documentation of cultural heritage are therefore key components of the sustainable development of mankind.

Within this framework, disasters are serious and urgent threats to achieve this goal (SDGGoal 11.4). They can strike unexpectedly and cause, alongside the loss of many human lives, irreversible damages to cultural heritage. As confirmed by the 2009 Global Assessment Report on Disaster Risk Reduction, Risk and Poverty in a Changing Climate (UNISDR, 2009), the number of disasters around the world increases every year (UNESCO, 2010a). Cultural built heritage is exposed to various hazards and one or more types of risk. In March 2015, the third United Nations World Conference on Disaster Risk Reduction recognized the increasing impact of disasters and their complexity worldwide (Sendai Declaration, Art.1).

They can include natural catastrophic events such as earthquakes and floodings, as well as man-made destructions or damages. Focusing on destructions caused by seismic events, in the past decade, the number of heritage sites strongly affected and damaged by earthquakes has substantially increased.



Legend	
Extreme risk	
High risk	
Medium risk	
Low risk	
No Data	

Rank	Country	Rating
1	Bangladesh	Extreme
2	Indonesia	Extreme
3	Iran	Extreme
4	Pakistan	Extreme
5	Ethiopia	Extreme

Rank	Country	Rating
6	Sudan	Extreme
7	Mozambique	Extreme
8	Haiti	Extreme
9	Philippines	Extreme
10	Colombia	Extreme

Figure 2 Natural disaster risk map in 2010 (Maplecroft, 2010).

Among known cases are the Iranian city of Bam (2003) as well as the urban area of L'Aquila in Italy (2009), Haiti’s earthquake (2010), the Shwebo seismic event in Myanmar (2012), the Emilia earthquake in Italy, that strongly affected many rural villages and small urban centers (2012), the earthquake in Bohol in the Philippine islands (2013), the earthquake that affected the capital, of Nepal, Kathmandu, and its surrounding territory (2015), the Kumamoto earthquake in Japan (April 2016), the Chauk earthquake in Myanmar (2016) and the continuous earthquakes that since August 2016 have been are shaking central Italy with no break.

Figure 3 Examples of highly damaged heritage structures in Bagan after August 2016 earthquake. Images source: Author.

The physical integrity of built heritage resources is significantly affected by conflicts and natural disasters at an alarming rate. This situation is worsening due to the problem of limited availability of, and accessibility to, information on a substantial number of built heritage resources that do not have archives, paper or digital documentation needed for conservation monitoring and protection.

The international community has recognized the lack of systematic documentation as a factor that contributes to increasing the impact of natural disasters on built heritage, especially in a conservation perspective. Therefore - the Hyogo Framework for Action, which is the main UN-wide policy on the subject of Disaster Reduction (UNISDR, n.d.), as well as other policy statements, like the Strategic Objectives established through the Budapest Declaration (UNESCO web page, n.d.) and Article 5 of the World Heritage

Convention, underlines the importance of a documentation methodology addressing the issues of heritage sites' risk prevention and monitoring.
This situation clearly evidences the importance of developing adequate strategies and tools such as spatial information systems to help protect built heritage in emergencies, supporting risk reduction and preparedness ex-ante and ex-post catastrophic events (i.e. reconstructions through anastylosis, with contemporary additions, in style *'com'era, dov'era'*, i.e. 'where it was, as it was', etc.).

An essential first step in managing disaster risk is the preparation of an inventory showing quantity, type and present conditions of heritage properties. In the development of effective information systems, acquisition of information, also supported by bottom-up strategies, can effectively provide tools for decision-making in risk management. In this framework, different documentation strategies, employing emerging recording technologies, should be considered. Previous chapters illustrated, combined uses of documentation strategies and emerging technologies - to document such elements as geometry, shape, color, building materials, construction systems, relative building condition, geotechnical aspects, patterns of past repair and cultural aspects. Issues such as resources, costs, time and skills required for built heritage documentation techniques and tools have been also addressed.

According to Patrick Meier, several recent events showed an increasingly popular attitude to communicate through social media and digital platforms in critical situations (Meier, 2015). This can be extremely useful to support conservation and possible reconstructions in the case of natural disasters in a participatory logic. The relevance of bottom-up logics for tangible and intangible heritage documentation is particularly relevant in the case of natural emergencies since they are the starting point of any recovery, repair and restoration after natural disasters, such as earthquakes.

This documentation can perhaps be employed in defining conservation policies and implementing conservation actions after a seismic event, for instance by choosing between a reconstruction through a virtual means, reconstruction through anastylosis, a combination of contemporary interventions with the damaged ruins or a faithful philological reconstruction *com'era e dov'era* (how it was, as it was). This would potentially strike a balance between the seismic upgrade of damaged or partially collapsed structures and the psychological instance of the local population.

h) A roadmap for future action

In conclusion, the research has verified that a digitally-supported participatory methodology for the conservation of cultural built heritage, capable of integrating its tangible and intangible dimensions, is feasible. It has also shown the potential of a WikiBIM approach in terms of supplementing, triangulating and managing data collected through diverse methodologies, including Rapid Ethnographic Assessment Procedures, and advanced information gathering techniques on the structural features of the built heritage. It has highlighted the strengths of such approach and it has outlined possible ways of addressing its weaknesses. Further, the proposed methodology aims at facilitating long-term conservation actions through an effective integration of historic built assets, memories, intangible cultural resources, socio-economic aspects and local communities.

The proposed modelling approach does not simply improve the conservation documentation process by capturing and integrating new information into a consistent framework. In fact, it may contribute to the sustainability of the conservation project, because it is strictly related to the “living” features of built heritage, thus creating the conditions for the mobilization of local traditional expertise for conservation activities.

The proposed approach constitutes, therefore, a “lens” for the definition of conservation efforts that integrate both intangible and tangible dimensions of built heritage on the basis of the following factors:

- the awareness of social, economic, cultural and environmental sustainability as a key concern for preservation;

- the engagement of local communities in such endeavor;
- the involvement of key stakeholders for the definition of effective conservation solutions;
- the need to strengthen institutional preparedness and community resilience in order to cope with the consequences of disasters (like earthquakes, floodings, etc.) on cultural built heritage in areas vulnerable to natural emergencies;
- the combination of qualitative and quantitative analysis for data gathering and processing;
- the use of advanced digital documentation tools, techniques and protocols;
- and the need to strengthen the capacities of the institutions responsible for conservation at the national and subnational levels, as well as the skills and capabilities of their local officers and practitioners.

Appendices

Appendix A Glossary of key terms

TERM	DEFINITION	SOURCE
3D imaging system	A device for 3D recording that uses a laser stripe or spot to record the surface of an object. The real world object is translated into digital metric measurements in the form of a *pointcloud* with many millions of colored coordinates in space. A laser scanner is one example of such a system.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
3D model	The replication of a real-world object as a digital 3D model. It is the result of a 3D measurement process and its processing, either by a stand-alone 3D imaging system (laser scanner) or by photogrammetry and post-processing on a computer. A typical 3D model includes geometric information (size, shape, surface characteristics) as well as color information (texture maps).	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
3D scanning	The process of gathering object or environmental data through 'touchless' collection. Although the actual mechanics may vary from system to system, the process in general consists of a series of laser pulses that are bounced from the scanning unit to the object. By calculating the time of flight of the pulse along with the	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology

	speed of light, the scanner can then deduce exactly how far away the object surface is at each bounce. This technique collects dimensional data in the form of a "point cloud."	
Abacus	A flat square slab placed on top of a column's capital.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Accuracy	The degree to which physical measurements performed on a heritage object conform to the actual (true) metric values of the object. Accuracy is related to the scale and precision of the recording technique used.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Actual Data	Data recorded with a SUT (System Under Test) which will be compared to a reference (nominal) data set. Often this comparison is also called Actual-Nominal comparison.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Adhisthana	The base of a Buddhist temple. The high basement or plinth upon which a temple is built.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Adobe	Sun-dried mud brick used for buildings in Spain, Africa, New Mexico, and Latin America.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Aerial photogrammetry	Uses large-format aerial imagery to recreate the 3-dimensional geometry of territories, landscapes, urban contexts or buildings as a model in a virtual environment. The imagery must contain two or more stereoscopic (overlapping content, from different camera positions) pairs of images. The camera must be calibrated to correct for lens and curvature distortions in images. Reliable horizontal and vertical measurements may be taken from the model if accurate ground coordinate information (x,y,z for at least three image-defined object points) is appended to the virtual geometry.	D. Myers, Y. Avramides, and A. Dalgity, "Changing The Heritage Inventory Paradigm The Arches Open Source System," *CONSERVATIO N PERSPECTIVES HERITAGE INVENTORIES*, vol. 28, pp. 4–10, 2013.
Aerial photography or imagery	Refers to the activity of taking photographs from aircraft. The term may also be used to refer to any photography from the air, including photographs obtained by cameras mounted on aircraft, rockets, or Earth-orbiting satellites and other spacecraft. The purpose of photography from airborne or space-borne vehicles is generally to provide information on ground features for military and other reconnaissance, or to record the dimensional disposition of such features for surveying or mapmaking. Aerial photography include any form of photography taken from the air, including aircraft, spacecraft, satellites, balloons,	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.

	or drones with mounted cameras. It is an efficient and effective means of quickly documenting the condition of a large site or a collection of sites via a 'bird's eye view'. Useful for surveying and mapmaking – sometimes used as a substitute entirely. Often used for aerial photogrammetry.	
Altar	A raised structure, often a table or stone stab, upon which offerings are made to a god and religious rites are performed. Used in many ancient cultures for making sacrifices.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Ambulatory	A roofed passageway. In a church, refers to the continuation of the aisled spaces on either side of the central part of the church to form a continuous semicircular processional path.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Amortizement	The sloped upper portion of a buttress or projecting pier. Slopes away from the building or structure face to encourage water shedding and drainage.	Merriam-Webster Dictionary.
Analysis	The interpretation of research and investigation results to improve understanding of cultural heritage places. Also: the examination of an object, action, material, or concept in detail by separating it into its fundamental elements or component parts.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.

Ananda	The infinite, the endless. Ultimate joy. Also the name of a first cousin and disciple of Guatama Buddha. It is thought that most of what is known about the Sutras in Tripitaka comes from Ananda's memory.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Anthropology	Within the category of the social science, concerning society and the relationships among individual within a society, anthropology deals with the analyses different ways people understand their lives and lifestyles. The term anthropology derives from the Greek ἄνθρωπος anthrōpos, "human being" and λογία-logia, "study." This discipline is frequently used in interdisciplinary approaches within the architectural field.	Ray, L. 2016. Research Methods for Architecture. London: Laurence Kind Publishing.
Aperture	An opening, such as a hole, gap, or slit. Small windows in brick structures.	Author.
Arcade	A series of arches supported by columns or piers. May be freestanding or used to decorate the wall of a building.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Arch	A construction of stones, bricks or other materials that spans an opening and does not use a lintel. There are numerous types.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
ArchiCAD	An architectural BIM CAD software for Macintosh and Windows. It was developed by the Hungarian company Graphisoft. ArchiCAD offers computer aided solutions	Graphisoft ArchiCAD http://www.graphisoft.com/archicad/

	for handling common aspects of aesthetics and engineering during the design process of the built environment, buildings, interiors, urban areas, etc.	
Architrave	A horizontal lintel that rests upon and spans the distance between two columns or piers. May also refer to a molded frame that surrounds a door, window, or other opening.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Archivolt	An architrave above a curved opening. Tends to refer to a series of concentric ornamental arch moldings.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Arcuated	Describes a building whose structure depends on a series of arches rather than on beams and lintels (trebeated form).	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Arimaddanapura	The classical Pali name for Bagan. Translates literally to 'City of Enemy Crusher' or 'The City that Tramples on Enemies'. Sometimes written as Arimaddana Pura or just Arimaddana.	Malalasekera, G.P. 2007. Dictionary of Pali Proper Names, Vol 1. Motilal Banarsidass Publishers Private Ltd.
Artifact or Artefact	A human-made physical object that gives information about the culture, history, beliefs, and lifestyle of the society that created the object.	Author
Asana	The sitting posture of a Buddha or Bodhisattva.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.

Assessment	The formulation of a new set of general results through the combination and interpretation of existing and newly collected information.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Atrium	An inner court that is sometimes entirely covered but usually left open in the middle. Provides light and ventilation to the interior.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Attic	A space or room within the roof of a building or house.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Automated monitoring systems	A grouping of different sensors and devices that collect a wide range of data measurements. They include, but are not limited to, inclinometers to measure the degree of inclination; level-meters to measure differential settlement; weather stations to measure wind speed and direction as well as ambient temperature; and strain gauges to measure crack propagation. Usually these systems are connected to computers to provide continuous data to engineers.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Avant-corps	A section of a building that projects from the main part. Translates literally to 'in front of body' or 'before body' from French.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Ayeyarwaddy River	The longest and most important river in Myanmar, flowing from north to south and into the Andaman Sea. Much of the raw materials of Bagan buildings' construction, such as bricks and mortar, are directly connected to the river. (i.e. are delivered via the waterway).	Author
Bagan Art-Wall or Mural Painting	A type of painting inside temples – often depicting 'jatakas', stories telling the multiple lives of Buddha. Meant to educate the surrounding community, monks, and future generations. The paintings were generally done as 'Fresco', using charcoal and natural animal or plant material for water-soluble pigments with a lime plaster wash.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Balcony	A platform projecting from the wall of a building. It has a railing or balustrade around its outer edge. Accessed usually via a door or window.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Bamar	The name of the major ethnic group in Myanmar. Formally: Burman. Adjective was Burmese.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Barrel Vault	A series of uniform and typically semi-circular arches lined up in series to form structural support. Also known as a 'tunnel vault'.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.

Base map	A scaled graphic (or photographic) record of the basic physical configuration of the heritage asset. Used by conservation professionals as the base layer over which to illustrate (or map) investigation and treatment related data. Also called a 'base drawing'.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Bas-relief	A low-relief (shallow) carving that protrudes slightly from the background.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Bodhi Tree	The Buddhist scared fig tree. An important religious symbol representing the tree under which Buddha sat to meditate. Bodhi refers to wisdom, awakening, or enlightenment. Bodhi Tree imagery is often used as decoration in Bagan temples. Also known as the Bo or Peepal Tree.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Bodhisattvas	Individuals who have passed through the spiritual perfection, but out of compassion to other beings choose to delay their entry to Nirvana. They work to help other sentient beings discover the right paths to Nirvana.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Boss	An ornamental projection, usually at joints for ribs of vaults or beams in a ceiling.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Bracket molding	A type of molding that projects from a wall or column, usually to carry weight or strengthen an angle. It is an	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

	intermediate piece that fixes two structural members to each other. May be ornamental.	
Broken pediment	A pediment that has its simple triangular shape broken at either the apex (top) or base.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Buddha	Literally means 'Enlightened One'. Usually refers to Guatama Siddhartha Buddha but also includes the other four past Buddhas.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Buddhism	A religion that originated from India and spread throughout Asia when Siddhartha Gotama (Buddha) attained enlightenment around 5th century BCE. It focuses on teaching Dharma (truth) and provides a way of life to lead to true happiness.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Built environment	The collection of man-made structures and surfaces that constitute a city or site. Includes buildings, streetscapes, neighbourhoods, bridges, infrastructure, and monuments. Does not include the natural environment.	F. LeBlanc, "Heritage conservation terminology." [Online]. http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Built heritage Asset	This term is used in this report to refer in general to immovable cultural heritage resources, such as archaeological sites, single monuments, groups of buildings, historic towns, or cultural landscapes.	F. Letellier, R. Schmid, W. LeBlanc, Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places. Los Angeles: The Getty Conservation Institute, 2007.

Built structure	Build structure indicates any building or structure, including roads, bridges, gun emplacements, walls, mines, etc. over 30 years old.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Buttress	A mass of stonework or brickwork built against, or projecting from a wall to give additional strength.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Calibration	A predefined process to correct the measurements taken from a measuring device. Calibration is required to guarantee consistent results in measurements. A controlled test usually involving a calibrated reference artefact. The internal parameters of the scanning system will usually be optimized as a consequence of the calibration result.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Catalogue	A complete list of the items in a collection or at a museum, usually containing the object names, descriptions, and additional provenance information. A catalogue may be illustrated if relevant imagery is available (as is common in digital catalogues).	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Character-defining element or feature	The materials, forms, locations, spatial configurations, uses, and cultural associations or meanings that contribute to the heritage value of a historic place, which have been selected as relevant to be retained to preserve its heritage	Standards and Guidelines for the Conservation of Historic Places in Canada, 2010. F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/termin

	value. Character-defining elements or features contribute to the heritage value of a historic place, and which must be retained in order to preserve its heritage value. They are prominent or distinctive aspects, qualities or characteristics of a cultural resource that contributes significantly to its physical character.	ology/doc_terminology_e.html.
Chattravali	The top portion of a sikhara or stupa above a harmika. A series of stone chattras (umbrella-like disks) stacked upon each other and decreasing in size towards the top.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Cloister Vault	A domelike vault having a square or polygonal base from which curved segments rise to a central point. Often the result of two barrel-vaults crossing at a right angle.	http://www.thefreedictionary.com/cloister+vault
Column	A freestanding vertical pillar, usually a form of support. Consists of a base, shaft, and capital; often square or round in cross-section. May be erected as a free-standing monument or as a decorative member.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Community	Any group sharing cultural or social characteristics, interests, and perceived continuity through time, and which distinguishes itself in some respect from other groups. Some of the characteristics, interests, needs and perceptions that define the distinctiveness of a community are directly linked to heritage.	F. Letellier, R. Schmid, W. LeBlanc, Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places. Los Angeles: The Getty Conservation Institute, 2007.

Computer Aided Design (CAD)	Computer-aided design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. CAD is flexible enough to allow the user to produce quick, basic sketches as well as drawings of great precision and detail. Serving as a common platform for printing and sharing data among specialists, CAD images can be imported and data added manually or input directly from survey instruments. Data can be displayed in different ways, including two-dimensional orthographic projections or three-dimensional isometric, or perspective, views. Information can be divided using multiple layers, or views, which can then be recombined in various ways.	Author (or use same ref from "CAD") F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Condition assessment	A record of the state of the critical aspects of a site or place at a given time. A condition assessment must include the character defining elements. This is useful to develop options for future preservation actions and as a timestamped record of the site's history.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Condition reporting	Formalized reporting on the condition of an object by a conservator. The report contains information about the object's material, geometry, damage, and provenance. Part of the documentation process for object treatment.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.

Conservation	The means by which the physical structure and intangible meanings of an object or site are preserved through repairing existing damage and preventing, or at least limiting, future change. Conservation can also be defined as the set of actions taken to understand a heritage property or element, know, reflect upon and communicate its history and meaning, facilitate its safeguard, and manage change in ways that will best sustain its heritage values for present and future generations. The conservator or restorer executes the diagnosis, documentation and the treatment process. Conservation can also be intended as all that actions or processes aimed at safeguarding the character-defining elements of a cultural resource so as to maintain its heritage value and extend its physical life. This may involve Preservation, Rehabilitation, and Restoration, or a combination of these actions.	Mona Valerie Micaela Hess, PhD thesis, University College London (UCL), 2015. F. Letellier, R. Schmid, W. LeBlanc, Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places. Los Angeles: The Getty Conservation Institute, 2007. ‘*Standards and Guidelines for the Conservation of Historic Places in Canada*’ by Parks Canada http://www.historicplaces.ca/media/18072/81468-parks-s+g-eng-web2.pdf
Conservation plan	Outlines and documents the sequence of steps taken during the conservation process. It states what has been established as significant for a place, and which policies, methodologies, and materials are appropriate to maintain the significant features in the site’s future use and development.	F. LeBlanc, “Heritage conservation terminology.” [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.

Conservation process	The informed decision-making process, which ensures that conservation at all levels will respect and maintain the values and significance of the cultural heritage place. See conservation.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Conserve (verb)	The act of conservation. Used as a general term in the place of rehabilitation, restoration or repair as they pertain to the actions taken to protect a heritage object, building, or site. The effort to prevent the wasteful use of a built resource or heritage landscape using a carefully planned approach.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Consolidation	Stabilization of deteriorated or weakened areas by introducing or attaching additional materials. Pertains to the structural integrity of the subject. Traditional materials and trade work are preferred. Consolidation interventions should attempt to be reversible – brick repointing, for example.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html. Heritage BC Website. http://www.heritagebc.ca/resources/guides-tips-1/terms-definitions
Consultation	Part of the practice of conservation. Discussions between those proposing a course of action (conservation intervention) and those who will be affected by the action (i.e. conservators and local stakeholders).	Author.
Corbel	A projecting bracket, usually made of stone, that supports a beam and is often decorated.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Cornice	The decorative top edge of a building or column that extends past the building face. Also refers to horizontal decorative moldings at the top of other elements, i.e. above a door or window, or along the top of an interior wall. Cornices are functional too – they allow for water drainage clear from the building face. The term is comes from the Italian word 'cornice', meaning 'ledge'.	Merriam Webster Dictionary
Crenellation	A sort of parapet or stone wall around the top of a building with repeated gaps or notches at regular intervals.	Author. Glossary of Architectural Terms. Trust for Architectural Easements. Web: https://architecturaltrust.org/outreach/education/glossary-of-architectural-terms/
Crest	An ornamental ridge along the top of a wall or building.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Cross vault	Formed by two barrel vaults of identical size intersecting at right angles. Also called a 'groin vault. Similar to a cloister vault but differs in the way that the barrel vaults intersect.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Cross-domed	Refers to churches built in the shape of a cross, with a large dome over the centre.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Cultural heritage	Expressions of the value systems and lifestyles developed by a human community of interest. According to the UNESCO definition, the term cultural heritage encompasses several main categories of heritage including: ▪ Tangible cultural heritage: movable cultural heritage (paintings, sculptures, coins, manuscripts), immovable cultural heritage (monuments, archaeological sites, urban contexts, cultural landscapes, etc.) underwater cultural heritage (shipwrecks, underwater ruins and cities); ▪ Intangible cultural heritage: oral traditions, performing arts, rituals.	http://www.unesco.org/new/en/culture/themes/illicit-trafficking-of-cultural-property/unesco-database-of-national-cultural-heritage-laws/frequently-asked-questions/definition-of-the-cultural-heritage/ Accessed: on October 31, 2015.
Cupola	A small dome, usually crowning a turret or a larger dome.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Data acquisition	The process of measuring a real world object through imaging and scanning sensors to replicate the real physical model as virtual dataset. The process include the use of tools to collect measurements, imagery, condition information and cultural information of a real world object or site to represent the subject as a reference	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.

	dataset. This information may then be entered into a database.	
Database	Try: Any collection of data or information organized for rapid search and retrieval via computer. Facilitates the easy storage, retrieval, modification, processing and deletion of data. May include a multimedia collection, containing images, sketches and measurements, condition assessments and location information. Individual data entries are separated into sets, themes and fields with unique identifiers for proper indexing. Databases can help to connect information from separate data entries together based on their common identifiers.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Debris	Scattered pieces of waste or remains. Ruins, rubble; pieces that have toppled or broken off of a main structure.	Author.
Dentil	A small block used as a repeating ornament in a cornice or pediment base	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Dhamma, Dharma	The Truth, the teaching of Buddha. The righteousness. Opposite is 'Adhamma'; the injustice, unfairness.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Dhyanamudra	The gesture and posture of meditation. Position of sitting with hands folded in lap.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon

		Technical University.
Diaphragm arch	An arch that subtends or divides a space between two walls or vaults. An intermediate support at mid-height of a structure to relieve some of the load from the upper roof arches.	Author.
Digital Heritage Recording	All forms of digital data acquisition as they pertain to heritage sites. Includes but is not limited to digital photography, rectified imagery, photogrammetry, total station measurements, 3D laser scanning, audio and video recording, and CAD and 3D models. See: heritage recording	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Digital photography	Photography captured using a digital camera rather than with a film camera. Digital cameras store photographs as a collection of colored 'pixels' in a virtual image file that may be manipulated in real-time with a computer. Digital photography imaging systems use opto-electronic sensors for image acquisition instead of photographic emulsion.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Digital preservation/ Digital (information) curation	Management of digital information over time, in order to ensure accessibility of 'digital-born' information – that is, content that has no hard-copy origin or archive (only exists on a hard-drive or on the internet).	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.

Documentation	The act of systematic collection and archiving of records in order to preserve them for future reference. New documentation is created from archaeological measurements, photography, film, socio-political research, and the interpretation of these media. It can also be defined as the already existing stock of written, visual, audio and electronic information about a place. Tends to include a site's condition across a number of different dates.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Drone	An Unmanned aircraft controlled by a remote, which is able to capture photographs and video. This tool can also be employed in reconding of heritage sites. See Aerial Photography.	Author
Elevation	The flat, vertical face or side of a building. May also refer to a technical drawing observing the projected vertical face of a building.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Entresol	A low story between the first and second floors of a building; a mezzanine floor.	Merriam-Webster Dictionary.
Epigraphy	The study and interpretation of inscriptions, especially of ancient origin.	Merriam-Webster Dictionary.
Error	The arithmetic difference between a measurement and the measured object's true metric value. Accumulated error occurs when a measurement is done by a series of parts.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University

		College London (UCL), 2015.
Evaluation	A test of the performance of a scanning system, under specified measurement conditions.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Façade	An exterior face of a building, usually referring to the front. One type of elevation.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Facing	Finish applied to the exterior of a building. Materials such as wood, glass, or stone that are put onto the outer surface of a building. Cladding.	Jones, Frederic H. 1990. The Concise Dictionary of Architecture. Crisp Publications, Inc. California.
Fired Brick	Brick that has been burned in a kiln to increase its desired physical properties, such as strength and durability.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Flat Arch	A horizontal (not curved) arch constructed of mutually supporting 'vourssoirs' (wedge-shaped elements). Used to span openings or give structural support, especially where a squared-off appearance is desired.	Merriam-Webster Dictionary.
Frieze	A continuous horizontal band that may be painted or decorated with moldings or bas-reliefs. The wide, central part of an entablature.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Gargoyle	A water spout in the shape of a grotesque figure. Extends outwards from a roof, ledge, or wall.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Geographic information system (GIS)	Computerized geographic databases, combining spatial information in graphic form with tabular location data. Useful for mapping and assessing sites at the macro scale. Typically, a GIS consists of three major components: 1) A database of geospatial information; 2) The capability to spatially model and analyze the database; 3) The ability to graphically display the manipulation of geospatial data. GIS are effective descriptive, analytical and communication tools to map and assess sites and prioritize necessary work. GIS are geographic database combining spatial information in graphic form with tabular data.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology_e.html.
Global Positioning System (GPS)	A satellite-based navigation system made up of a network of 30 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS allows the rapid acquisition of location data with good accuracy, depending on the two types of GPS radio receivers: 1) Survey-grade GPS receivers can attain an accuracy within several centimeters if they are corrected with a	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology

	second supplementary signal from ground-based radio stations or transmitters. 2) Non-survey grade or handheld GPS devices are usually not corrected by a ground-based station and range between 5 and 15 meters accuracy.	
Gotama	An alternate spelling for Gautama. Refers to Siddhartha Guatama Buddha.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Groin vault	See: cross vault	
Gu	Literally means 'cave'. Refers now to all temples or pagodas with accessible interior space	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Harmika	The element on top of a stupa, placed between egg-shaped andha (or the dome of a stupa) and chattravali.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Heritage Asset	Used in this report to refer in general to immovable cultural heritage, such as archaeological sites, single monuments, groups of buildings, historic towns, or cultural landscapes.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.

Heritage Assets controlled vocabulary	An organized arrangement of words and phrases used to index and/or retrieve content through browsing or searching. Typically includes preferred and variant terms and has a defined scope or describes a specific domain", "the purpose of controlled vocabularies is to organize information and to provide terminology to catalogue and retrieve information" (GRI, 2010). The application of this controlled vocabulary ensures consistency and accuracy in the terminology used to characterize heritage assets.	F. Letellier, R. Schmid, W. LeBlanc, Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places. Los Angeles: The Getty Conservation Institute, 2007.
Heritage information	The integrated activities of recording, documentation, and information management for heritage sites.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Heritage protection	Rewritten: The means of taking care of a heritage asset by preventing interventions or changes that are unconcerned with or uninformed about the heritage values and character defining elements of the asset. Heritage protection takes place within legislation, policies, and management frameworks.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Heritage record	A technical dossier or ready-to-publish information package about a cultural heritage place prepared by	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/d

	heritage recorders. The dossier includes measured drawings, photographs and technical analysis of the condition of the site and its components. Heritage records are the necessary first step for any heritage conservation project and are instrumental in evaluating the evolution of a heritage place over time. Heritage records are often released as public archives.	ocuments/terminology/doc_terminology
Heritage recorder	An expert in measured survey and photographic techniques applied to heritage places to produce heritage records and documentation. Often will work in a team.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Heritage recording	The metric, graphic or photographic capturing of information describing the physical configuration, evolution, and condition of a heritage site at known points in time. Includes both digital and analogue methods for data acquisition.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Heritage resource	It refers to an artifact, building, site, or other feature that has heritage value or character. See: heritage asset	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Heritage Value	The aesthetic, historic, scientific, cultural, social or spiritual importance or significance of a heritage place or object for past, present and future generations. The	Standards and Guidelines for the Conservation of Historic Places in Canada, 2010.

	heritage value of an historic place is embodied in its materials, forms, location, spatial configurations, uses and cultural associations or meanings. See: character defining elements.	
Historic Place	A structure, building, group of buildings, district, landscape, archaeological site or other place that has been formally recognized as having heritage value.	Standards and Guidelines for the Conservation of Historic Places in Canada, 2010.
Historic Preservation	A synonym (US) for 'Heritage Conservation' (CAN) or 'Heritage Preservation' (UK). An endeavour that seeks to preserve, conserve, or protect buildings, objects, landscapes or other artifacts of historical significance. Tends to refer to preservation of the built environment. See: conservation.	Author
Hti	The top portion of a pagoda. Literally means 'umbrella'.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
ICOMOS	The International Council on Monuments and Sites. A global non-government organization dedicated to the conservation and protection of cultural heritage places.	http://www.icomos.org/en/
Information management	The process of finding, cataloguing, storing, and sharing information by making it accessible to potential users now and in the future.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage*

		Places. Los Angeles: The Getty Conservation Institute, 2007.
Information sources	All physical, written, oral, and figurative sources that contribute to the understanding and appreciation of the nature, specificities, meaning, and transmission of a piece of cultural heritage and the collective memory it embodies.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Inscription	Records of the thoughts and beliefs of ancient people in writing. Chiselled, carved, or cast into hard surfaces like stone or stucco. May also be written on delicate surfaces like papyrus or paper scrolls.	Author.
Intervention	Any action, other than demolition or destruction, that results in a physical change to an element of a historic place. See: consolidation	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Jatakas	Birth stories and fables of Guatama Buddha's previous lives, taking both human and animal form. There are approximately 550 in number, with the last 10 the most important as he his born into his final life as Prince Guatama Siddhartha.	Myanmar book
Karma	The quality of one's current and future life as determined by that person's actions in their current and previous lives. Actions determining the future state.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.

Keystone	The central stone at the apex (top) of a semicircular arch.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Lintel	Horizontal structural members made of wood or stone. Tend to span openings such as windows or doors, or between two columns.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Loka, Lawka	The universe.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Loka-Nanda	The endlessness of the universe.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Maintenance	Repeated, non-destructive actions of care and upkeep aimed to slow or combat deterioration agents of historic places.	Author
Management	Management of a place involves making conscious choices about what happens to the place and taking action to make those things happen. Management includes the widest possible range of actions and decisions, such as: ▪ establishing the appropriate decision-making group and processes; ▪ assessing significance;	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology

	▪ deciding to open or not open a site to visitor engagement; ▪ approving site work and conservation interventions; ▪ setting up decision-making structures to implement strategies; ▪ arranging access rights or means to attain access (such as transport); ▪ deciding to take no action.	
Mandala	In Indian architecture, a geometric diagram used as a plan for a Hindu or Jain temple. An ancient Hindu and Buddhist spiritual graphic symbol representing the universe. Represents the cosmos, metaphysically or symbolically.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Masharabiya	A wooden screen or grille (ie latticework) for windows. Common in houses in Islamic countries. Allow for continuous airflow while providing shading.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Metadata / Digital Provenance	Embedded textual information about the content of a piece of data. Tends to include the date, method or tool, location, operator, and various other parameters that were in place when the recording was developed. For example, provenance data for a set of total station measurements should include the operator's name, the date and time that the measurements were captured, the total station model	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.

	name, the filters or targets that were used, the visibility conditions, and the level of accuracy that was being used in the total station settings.	
Mon	The name of the state in the southeast of Myanmar. Also the name of the corresponding ethnic group.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Monastery	Buddhist religious architecture; served as dwelling and meditation places secluded from the outside world for Buddhist monks.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Monitoring	Repeated measurements based on defined standards, which allow for the evaluation of changes occurring to a heritage asset. In conservation used especially for the observation of damage propagation and material changes.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Mudéjar	A Spanish style of architecture that includes Islamic elements in the design of Christian buildings.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Mudra	Gesture or position, when referring to Buddha.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.

Multi-image Photogrammetry	This term that sometimes is used interchangeably with ‘Structure from Motion Photogrammetry”, describes a recently developed approach to photogrammetry, where larger datasets of overlapping digital images of a feature taken from different positions can be loaded in a single batch into software capable of automatic camera calibration, feature matching and reconstruction of complex dense 3-Dimensional models, with minimal manual input.. With the right combination of hardware and software, multi-image photogrammetry can produce highly detailed and accurate models of both topography and discrete objects or monuments. It is also capable of modelling more complex objects and it is not necessary to maintain a known distance from the subject. The range of multi-image photogrammetry software packages is broad: from free open-source programs to professional-grade packages. Regardless of which software package has been chosen, the transformation of 2D digital images into 3D digital models is generally carried out in a similar way. The first step is to acquire a set of images of the subject of interest. These images must have a large amount of overlap with each part of the surface to be modelled visible in at least three images. Almost any	J.McCarthy,“Multi-image photogrammetry as a practical tool for cultural heritage survey and community engagement,” *J. Archaeol. Sci.*, vol. 43, pp. 175–185, 2014.

	camera can be used although better results are more likely with a high end camera such as a Single Lens Reflex (SLR). The second step is to load the images into the software for analysis and automatic detection of matching correlated features at various scales between images. Most of the multi-image photogrammetry packages currently available use an algorithm known as Scale-Invariant Feature Transform (SIFT) that match features despite changes in the scale or orientation of the images.	
Naga	Mythological creature, sea serpent. Normally understood as living under the sea, however sometimes meant to mean large snake.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Nara Grid	A method for determining the historical value of a place, developed by Koen Van Balen (R.Lemaire International Centre for Conservation, University of Leuven) based on ICOMOS' Nara Authenticity Document (1994).	http://orcp.hustoj.com/wp-content/uploads/2016/01/2008-The-Nara-Grid-An-Evaluation-Scheme-Based-on-the-Nara-Document-on-Authenticity.pdf
Nat	Spirit in the Theravada Bhuddism religion.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Natural Hazards	Severe geo-physical or climatic events, including earthquakes, volcanic eruptions, landslides, droughts,	S. Lewis, "Remote sensing for natural disasters: Facts and figures." [Online]. Available:

	floods, cyclones and fire that threaten people and/or properties.	http://www.sciedv.net/global/earth-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html. [Accessed: 11-Nov-2009].
Niche	A concave recess in a wall, usually arched and housing statuary, an urn, or other forms of decoration.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Nirvana	Spiritual liberation. The attainment of freedom from worldly things; the end of the birth-rebirth cycle in the Theravada sense.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Noise (data)	'Noisy' data can occur due to the specified parameters of a scanner or camera, a result of a measurement 'error' of the system. A photograph with noticeable and exaggerated grain is a form of noisy data.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Open Archival Information System (OAIS)	Brian Lavoie, associate research scientist at the Online Computer Library Center OCLC Office of Research, defines the Open Archival Information System (OAIS) reference model as "a conceptual framework for an archival system dedicated to preserve and maintain access to digital information over the long term". The purpose of this reference model consists in increasing awareness and understanding of key concepts in archiving digital objects. The OAIS model defines terminology and	http://www.oclc.org/research/publications/library/2000/lavoie-oais.html

	concepts to describe and compare data models and archival structures. It provides principles to preserve and access digital information and develop a framework to guide the identification and development of standards.	
Open-source software	A computer program whose source code may be used, modified, or altered. Developers of proprietary software usually do not allow modification by others. Open-source software is developed as a public collaboration and made freely available.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Pagan	Another way of spelling Bagan.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Pagoda	A Hindu or Buddhist temple, tower, or place of worship, typically characterized by many levels. Each storey must be slightly smaller than the one below and have its own roof and balcony. Originated from stupas. Pagodas are one type of religious architecture found throughout Myanmar.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Pahto	Myanmar word for pagodas with inner space, i.e. temples	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.

Parami	Gained and accumulated actions, thoughts, skills, and experiences from previous existences.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Parapet	A low protective wall or barrier along the edge of a roof, bridge, walkway, or balcony.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Paya or Hpaya	Persons of a higher rank. A term used to address higher rank persons like kings or rulers. Also: the Myanmar word for stupa or pagoda.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Pediment	An ornamental piece, usually triangular in shape, resting above a doorway, portico, or entrance.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Pendant	An elongated boss that hangs down from a vaulted roof or ceiling.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Photogrammetric survey	Producing heritage records by means of photogramm1etry.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Photogrammetry	In simple terms, photogrammetry is the process of making measurements of features through analysis of overlapping photographs, and is fundamentally based on trigonometry. Photogrammetry can be defined as "the art,	Benjamin Wolf, Paul Dewitt, Bon Wilkinson, Elements of Photogrammetry with Application in GIS. New York, McGraw-Hill Education, 2014. J.McCarthy,"Multi-image

	science, and technology of obtaining reliable information about physical objects and the environment through the processes of recording, measuring, and interpreting photographic images." (Wolf, Dewitt, & Wilkinson, 2014). This technique can obtain measurements of objects, buildings, sites or earth surfaces. The process includes the recording of convergent images with a calibrated camera, targets around and on the object and subsequent computational intersection and mathematical intersection of the images to create a *pointcloud* or polygon mesh.	photogrammetry as a practical tool for cultural heritage survey and community engagement," *J. Archaeol. Sci.*, vol. 43, pp. 175–185, 2014.
Picturesque	Visually attractive, especially as it relates to landscapes and buildings. A scene that would strike the imagination of an observer as if it were a painting. An aesthetic ideal.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Pier	A solid vertical support, often rectangular in shape. Sometimes has a capital and base, similar to a column.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Pilaster	A column attached to a wall that is used for decoration or support. Usually rectangular. Sometimes called an attached or engaged column.	Merriam Webster Dictionary
Pillar	See: pier, or column.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Pinnacle	A small, usually ornamental construction at the top of a spire, buttress, or some other part of a building. Turrets, for example.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Pixel	A word invented from "picture element"; the basic unit of programmable color on a computer display or in a computer image. It is a logical - rather than a physical - unit. In digital imaging a pixel (or picture element) is a single point in a raster image. Digital Photography creates images with a collection of millions of pixels.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Plinth	A block, usually square, that is the bottommost section of a column or wall base.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Pointcloud	A three-dimensional model with which it is possible to interact and get metric information. These numerical models are a mathematical description of the reality they represent. This entails a simplification of the recorded object (through photogrammetry and 3D scanning) transforming them into a finite set of points.	C. Bianchini, *Documentation of Mediterranean ancient theatres. Athen's activities in Merida*. Roma: Gangemi Editore, 2013., 2013. V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Porch	A low structure, usually with a roof, at the entrance to a building.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Portal	An impressive entrance, gateway, or doorway. Often heavily decorated.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Portico	An open space with a roof supported by columns. At the entrance to a building such as a house, temple, or church.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Precinct	An area or built complex with a fixed boundary, often in the form of a wall.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Preservation	The action or process of protecting, maintaining, and/or stabilizing the existing materials, form and integrity of a historic place or of an individual component, while protecting its heritage value. This is often used as a synonym of conservation; many people use the word in an all-encompassing sense, including also issues related to the broader administrative, economic, legal, political and social context in which conservation takes place (e.g. legal protection, policies, public awareness).	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Preventive conservation	Includes all measures and actions aimed at avoiding and minimizing future deterioration or loss by the features in the immediate vicinity of a heritage asset. They are carried out within the context of or on the surroundings of an item. These measures and actions are indirect – they	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology

	do not interfere with the materials and structures of the items. They do not modify their appearance.	
Processing	The processes carried out on data. For point clouds, this includes alignment, meshing, hole filling, and decimation. For digital photography, this includes color correction and cropping.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Protection	The act or process of applying measures designed to affect the physical condition of a property by defending or guarding it from deterioration, loss or attack, or to cover or shield the property from danger or injury. For built structures, treatments tend to be temporary, anticipating further preservation treatments in the future.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Quatrefoil Motif	A stylistic ornamentation with four petals around a centre, which is found in both Eastern and Western architecture.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Raking light	Light that strikes a surface from a small incident angle, i.e. nearly parallel to the surface. Used to exaggerate contrast in the features and geometry of a surface – useful and necessary for shallow inscriptions or carvings. Similar effects can be obtained in 3D modelling software by using a virtual light at a small incident angle.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Reconstruction	The re-creation of a once-existing building on its original site. An informed approach that uses literary, graphic and	F. LeBlanc, "Heritage conservation terminology." [Online]. Available:

	archaeological historical evidence and documentation. The reconstruction may be a contemporary expression of the building using modern materials and practices or a replica using traditional materials and trades.	http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology
Recording	Used in this thesis in a broad sense, referring to the acquisition of any new information derived from all activities to do with a heritage asset. It includes heritage recording, research and investigation, conservation, use and management, as well as maintenance and monitoring.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Reference data	A surface or dataset against which the measured 3D dataset, the actual data, can be compared. The surface is often a technical drawing (CAD) model, part of a CAD model or a geometric feature such as a plane.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Relieving arch	An arch built over a lintel or span to relieve or distribute the weight of the structure above. Also called a 'discharging arch'.	Merriam-Webster Dictionary.
Religious Architecture	Sacred architecture that is designed and specially created for the praise, learning, and worship of a religion.	Author
Remote sensing	The science of acquiring information about the Earth using high-flying remote instruments, such as satellites, or drones.	S. Lewis, "Remote sensing for natural disasters: Facts and figures." [Online]. Available: http://www.scidev.net/global/earth

		-science/feature/remote-sensing-for-natural-disasters-facts-and-figures.html. [Accessed: 11-Nov-2009].
Repeatability	The ability of an entire experiment, measurement, or series of measurements to be repeated, yielding equivalent values within a specified tolerance. That is to say, using the same instrument to measure the same item, under the same conditions after some time interval to obtain the same values as the initial test or measurement. Repeatability gives a measure of the stability and certainty of a measurement method over time. Also called 'test-retest reliability'.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015. Bryan, P., Blake, B., Bedford, J., Mills, J., 2009. Metric Survey Specifications for Cultural Heritage (English Heritage), 2nd ed. English Heritage, Swindon, UK.
Research and investigation	Used to describe in general the variety of activities aimed at the acquisition of information pertinent to increasing knowledge of a cultural heritage place. While research refers more to off-site surveys (e.g., archival research), investigation corresponds to the direct acquisition of information using the heritage place as a primary source. Carefully indexed recording is an essential component of research and investigation at every step of the conservation process.	F. Letellier, R. Schmid, W. LeBlanc, *Guiding Principles Recording, Documentation, and Information Management for the Conservation of Heritage Places*. Los Angeles: The Getty Conservation Institute, 2007.
Resolution	It is the separation of something into its constituent parts. In this research it mainly refers to the smallest	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage

	measureable and meaningfully distinguishable distance between single coordinates describing a pointcloud generated from laser scanning and photogrammetry techniques. It is an effectively parameter to measure the precision of a pointcloud.	artefacts," University College London (UCL), 2015. Author.
Sangha	Buddhist Monk (in Theravada Buddhism).	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Section	The surface or view obtained by a cut made through a part of, or an entire structure. Tends to reveal the composition of walls or structural assemblies. Reveals interior detail. In scale technical drawings, a section represents an imaginary vertical cut made through a structure. Horizontal cuts are used to make plan drawings.	Jones, Frederic H. 1990. The Concise Dictionary of Architecture. Crisp Publications, Inc. California.
Secular Architecture	Non-religious architecture.	Author
Shaft	The main vertical part of a column, between the base (bottom) and capital (topping)	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Shrine	A container or building in which sacred relics have been placed. Also: a site associated with a sacred person; may include the person's tomb. A place of worship. It is	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.

	common for Buddhists to burn incense, offer food, and offer flowers at a shrine, in addition praying.	
Shwe-Zigon	A pagoda (Buddhist temple) located near Bagan, Myanmar.	Author.
Siddhartha	The name of the prince who later became Buddha. Siddhartha Guatama Buddha.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Sikhara	Spire or tower on top of temples. Tends to be beehive-shaped in Myanmar.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Spire	A tall, slender structure that tapers to a point, built upon a roof or tower.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Splay-foot spire	A spire that is square at its base but octagonal in cross-section for most of its height.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Squinch	A small, repeated arch or lintel positioned around a square or polygonal structure (usually an opening) to create the appearance of roundness.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Squint	An obliquely cut small opening in an interior or exterior wall of a church that allows the altar to be viewed from places where it may not otherwise be seen.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Stakeholders	A person, group or organization who has a particular interest in a heritage building, site, or artifact on the basis of special associations, meanings and/or legal and economic interests and who can affect or be affected by decisions regarding the heritage.	Authors and "Stakeholder definition." [Online]. Available:http://www.oxforddictionaries.com/it/definizione/inglese_americano/stakeholder. [Accessed: 11-Oct-2015].
Standards	Accepted practices for the respectful conservation of historic places.	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomos.org/~fleblanc/documents/terminology/doc_terminology '*Standards and Guidelines for the Conservation of Historic Places in Canada'* by Parks Canada
Stucco	A type of fine plaster used for decoration, ornamentation, or as a cover over an exterior/interior wall. It is plaster made of gypsum, lime, and sand, for external cover. Also, a finer plaster used for interior decoration and ornamentation.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Stupa	Buddhist religious architecture; a structure with hemispheric form to enshrine relics or mark an important Buddhist site. Stupas are a monumental structure used to commemorate the Buddha or his memorable deeds. The bell shape is common for larger stupas. Originally created	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO. Good source on Stupas (has its own glossary too): Khanjanusthiti, Pinraj. 1996. Buddhist Architecture: Meaning and Conservation in the Context of Thailand. University of

	by piling up ashes from cremations and covering them with earth or stones, creating a hemispheric mound. Buddhist religious architecture. A structure with hemispheric form to enshrine the relics of a holy person or mark an important Buddhist site. Meant to commemorate the Buddha or his memorable deeds. Originally created by piling up ashes from cremations and covering them with earth or stones, creating a hemispheric mound; over time, this has developed into the tall, bell-shaped and spired monuments seen throughout Myanmar. Stupa is called Zedi in Myanmar language.	York. King's Manor (UK) http://etheses.whiterose.ac.uk/9785/1/297134.pdf
Stupika	A small stupa. Sometimes tops a gateway to a Buddhist or Hindu temple complex. May refer to the topmost part of a temple.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Tangible Cultural Heritage	Heritage that exists in a concrete, physical sense. This includes buildings, monuments, artifacts, objects, and natural or built landscapes.	http://en.unesco.org/
Temple	In Buddhist religious architecture temples are used as places of worship, devotion, and meditation which are accessible to the public.	Author

Terrace, Terraced	A level walkway or platform attached or next to a building; a series of attached levels rising one above another.	Jones, Frederic H. 1990. The Concise Dictionary of Architecture. Crisp Publications, Inc. California.
The Venice Charter	One of the most influential documents for internationally accepted standards of conservation of architecture and sites, with special attention payed to 'authenticity' and harmonious interventions. Specifies that the conservation of a building must serve some socially useful purpose, but doing so should not cause changes to the layout or decoration of the building. New construction, demolition, or modifications shall also not be allowed to alter the existing relation of mass and color. Adopted by ICOMOS in 1965.	http://www.icomos.org/charters/venice_e.pdf
Therevada	The form of Buddhism practiced in Sri Lanka, Myanmar, Thailand, Laos and Cambodia. Normally understood as Southern Buddhism. Therevada is derived from 'Thera-Vada', 'The Path of the Elders'.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Tie beam	The main horizontal transverse beam in a roof.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Tope	See: stupa.	Author.
Total station	A survey device that consists of a powerful telescope and EDM (electronic distance measurement) sensor mounted	F. LeBlanc, "Heritage conservation terminology." [Online]. Available: http://ip51.icomo

	on a base that rotates both horizontally and vertically. An operator can measure distances as well as horizontal and vertical angles by locating points through the scope and 'shooting' them with the EDM sensor. Trigonometric calculations are performed by the onboard computer, combining horizontal and vertical angles to yield a coordinate point in 3-dimensional space (XYZ). A series of coordinates may be combined to form lines and planes, representing the object being recorded. Often post-processed with a CAD software.	s.org/~fleblanc/documents/terminology/doc_terminology
Tripitaka or Tri Pitaka	Literally means 'three baskets' or 'three volumes'. Refers to the sacred 3-section canon of Theravada Buddhism, written in the Pali and Sanskrit languages. Literally means 'three baskets' or 'three volumes'. Refers to the sacred 3-sections canon of Theravada Buddhism, written in the Pali and Sanskrit languages. It consists of: 1) Vinaya: The Discipline – the monastic and ethical code for Sanghas; 2) Sutra: The Discourse – narratives about the origins and circumstances from which the rules for Sanghas were adopted;	Oxford living dictionary, https://en.oxforddictionaries.com/definition/tripitaka

	3) Abhidhamma: The Higher Doctrine – beyond Dhamma. The analytical texts of the teaching of the Buddha.	
Turret	A small tower, often projecting from the corner of a building or wall.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Tympanum	The recessed face of a pediment within the frame made by the base and angled cornices of the pediment. Usually triangular and decorated.	Merriam-Webster Dictionary.
UNESCO	United Nations Educational, Scientific, and Cultural Organization (UNESCO): an organization aiming to create holistic policies that are capable of addressing social, environmental, and economic dimensions of sustainable development; it is known as the "intellectual" agency of the United Nations.	http://en.unesco.org/
UNISDR	The United Nations (UN) General Assembly adopted the International Strategy for Disaster Reduction in December 1999 and established UNISDR, the secretariat to ensure its implementation. Its mandate was expanded in 2001 to serve as the focal point in the United Nations system to ensure coordination between the United Nations disaster risk reduction system and regional	http://www.unisdr.org/who-we-are/mandate (last accessed: Oct 19, 2015)

	organizations and activities in socio-economic and humanitarian fields.	
United Nations (UN)	The United Nations is an international organization comprising 193 (in 2011) sovereign states. It was founded after the Second World War to maintain international peace and security, develop friendly relations among nations and promote social progress, better living standards and human rights.	"United Nations-Member States." [Online]. Available:http://www.un.org/en/members/growth.shtml. [Accessed: 11-Nov-2015].
Urn	An ornamental vase or vessel, usually with a closed top. Used for various purposes, such as preserving the ashes of the deceased, after cremation.	Merriam-Webster Dictionary.
User Interface	Graphic surface on the computer or mobile devices where 'user meets the program'.Enables the user to give commands and get information from a computer program or a database in a visual way.	V. M. Mona, "A metric test object informed by user requirements for better 3D recording of cultural heritage artefacts," University College London (UCL), 2015.
Vault	An arched roof or ceiling of stone or brick.	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.
Vestibule	An entrance room/area between the exterior and interior of a building.	Pichard, Pierre. 1992. Inventory of Monuments at Pagan. Paris: UNESCO.
Vitarkamudra	The mudra of Buddha using both hands in the gesture of teaching.0	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.

World Heritage Site (UNESCO)	A natural or man-made site, area, or structure recognized as being of outstanding international importance and therefore as deserving special protection. Sites are nominated to and designated by the World Heritage Convention (an organization of UNESCO).	http://en.unesco.org/
Yakha	Human beings with rough character, normally translated into 'ogre'. Unlike the European idea of ogres, southeast Asian ogres are not giants. Called 'Bilu' in Myanmar.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Zedi	Myanmar word for stupa.	Lat, Kyaw. 2010. Art and Architecture of Bagan and Historical Background, First Edition. Yangon Technical University.
Ziggurat	A form of religious architecture built in Sumer, Babylon, and other Middle Eastern civilizations between 3000-600 BCE. Rectangular in base and constructed as a solid 'truncated, stepped pyramid with rectangular or square tiers'. A series of ramps led to the shrine at the top. (Ancient Mesopotamia)	Cole, Emily. 2002. The Grammar of Architecture. First United States Edition. The Ivy Press Limited.

Appendix B Biography of the main cited authors

Aziliz Vandesande

Aziliz Vandesande was a Doctoral Researcher at the Raymond Lemaire International Centre for Conservation (RLICC), at the KU Leuven. Her expertise in on the preventive conservation strategy for the built heritage stock (Raymond Lemaire International Centre for Conservation, n.d.).

Bernard Feilden

Sir Bernard Feilden was a conservation architect and UNESCO consultant. Director of the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) in 1977, since 1968 fellow of the Royal Institute of British Architects and from 1972 until 1977 he sat on the institute's council. He received several awards including the Aga Khan Award for Architecture, he was appointed OBE in 1969, CBE in 1976 and knighted as a Knight Bachelor in 1985 (The Telegraph, 2008).

Caroline Bruzelius

Caroline Bruzelius is a Professor at the Duke University, Durham, United States. Her expertise is medieval architecture and urbanism. She is a member of the American Academy of Arts and Sciences, and a Fellow of the Society of Antiquaries, London, and the Medieval Academy of America. She was awarded with a Ph.D. at Yale University. In 2016 she received the leadership of the the Wired! Lab at Duke. In the Lab she is focusing on how to integrate digital technologies with Humanities teaching strategies and research approaches. From

1994-1998, she served as the Director of the American Academy in Rome (Tamborrino, 2014).

Clay Shriky

Clay Shriky is an internationally recognized expert of the social and economic effects of Internet technologies. On this subject he published several books including: Here Comes Everybody: The Power of Organizing Without Organizations (2008), Cognitive Surplus: Creativity and Generosity in a Connected Age (2010) and Little Rice: Smartphones, Xiaomi, and the Chinese Dream (2015) (Shirky, n.d.). Clay Shriky stresses the rising usefulness of networks and new technologies and how they "are enabling new kinds of cooperative structures to flourish as a way of getting things done in business, science, the arts and elsewhere, as an alternative to centralized and institutional structures, which he sees as self-limiting" (TED conferences, n.d.).

Donatella Calabi

Donatella Calabi is a Professor of Urban History at the IUAV University of Venice, Italy. She is also visiting Professor in several academic institutions and former president of the European Association of Urban Historians (EAUH) and of the Italian Association of Urban History (AISU) (Tamborrino, 2014).

Frank Matero

Frank Matero is a Professor at University of Pennsylvania, School of Design. His expertise is in historic building technology with a particular focus on the conservation of building materials and issues related to “preservation and appropriate technology for traditional societies and places” (University of Pennsylvania School of Design, n.d.).

Ernst Bloch

Ernst Bloch (Ludwigshafen 1885 - Tubinga 1977) was a German Marxist philosopher who asserted the importance of link the utopia to the potentialities of the nature and the material/substance. (Enciclopedia Treccani, n.d.-a).

Giovanni Scepi

Giovanni Scepi is Assistant Programme Specialist within the Programme Implementation Unit of the Secretariat of the 2003 Convention for the Safeguarding of the Intangible Cultural Heritage. He is in charge of periodic reports submitted by States Parties on the implementation of the Convention and of nominations to the Convention’s Lists. Within the Section he is Regional Officer responsible for Europe and North America (since May 2011), as well as Asia-Pacific States (since January 2013).

Horst Bredekamp

Horst Bredekamp is a Professor of Art History at the Humboldt University in Berlin. A part for Iconoclasm, sculpture Romanesque, Renaissance art and mannerism and Political Iconography, his expertise focus on art and tech Iconography, his expertise focus on art and technology as well as new media (Institut für Kunst- und Bildgeschichte, n.d.).nology as well as new media (Institut für Kunst- und Bildgeschichte, n.d.).

João Campos

João Campos, is an Architect and Urbanist, member of the bureau of CIVVIH/ICOMOS. He was also Professor of “History of Architecture and Urbanism” and of “Project” at Escola Superior Artística do Porto, from 1986 to 1998. He worked as consultant and author of several projects of the rehabilitation of patrimony of Portuguese origin outside Portugal (Campos, n.d.).

Joanna Sanetra-Szeliga

Joanna Sanetra-Szeliga is a chief specialist at the Research Institute for European Heritage of the ICC and coordinator of the Anna Lindh Euro-Mediterranean Foundation for the Dialogue between Cultures in Poland. Authors of several publications on EU cultural policies and financing, investigating the role of culture in regional development and intercultural dialogue. Sanetra-Szeliga is also a Ph.D. candidate at the Krakow University of Economics and university lecturer(Van Balen, 2016), Sanetra-Szeliga is also a Ph.D. candidate at the Krakow University of Economics and university lecturer(Van Balen, 2016), p. 321.p. 321

Joel Taylor

Joel Taylor is a Researcher and lecturer in heritage. He worked as researched at the Norwegian Institute for Cultural Heritage Research (NIKU). He is currently project specialist at the Getty Conservation Institute (GCI).

Koen Van Balen

Koen Van Balen is a full professor of the Faculty of Engineering Science at the KU Leuven, in Leuven, Belgium. He is also the head of the Heritage @ KU Leuven and Director of the Raymond Lemaire International Centre for Conservation. Van Balen's research expertise are related to conservation techniques for ancient constructions, structural analysis and repair of ancient structures, heritage research for conservation and sustainable construction technology, building lime and its influence on masonry behaviour, carbonation and durability of lime and of hydrated or hydraulic lime based mortar (KU Leuven, n.d Koen Van Balen is a full professor of the Faculty of Engineering Science at the KU Leuven, in Leuven, Belgium. He is also the head of the Heritage @ KU Leuven and Director of the Raymond Lemaire International Centre for Conservation. Van Balen's research expertise are related to conservation techniques for ancient constructions, structural analysis and repair of ancient structures, heritage research for conservation and sustainable construction

technology, building lime and its influence on masonry behaviour, carbonation and durability of lime and of hydrated or hydraulic lime based mortar (KU Leuven, n.d.)..).

Luciana Mariotti

Luciana Mariotti an Italian ethno anthropologist. From 2006 to 2012, she was the responsible for the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage within the Italian Ministry of Cultural Heritage and Tourism.

Martin Heidegger

Martin Heidegger (Messkirch, Baden, 1889 - ivi 1976) was a German philosopher who asserted the importance of the art as tool to reach the truth (Enciclopedia Treccani, n.d.-b).

Maurice Murphy

Dr. Maurice Murphy, is a lecturer and researcher in built heritage documentation and computer graphics in the new School of Surveying in the College of Engineering and Built Environment at the Dublin Institute of Technology (DIT). At the he DIT, he leads a research group specialized in the application of new technology for digital surveying and modelling of historic buildings and environments in order to support the conservation of these heritage assets. He is currently lead supervisor for Ph.D. and M.Phil. students. In the last three decades he developed a high experienced profile in building surveying and conservation. He also led and participated in several EU programs in the area of Cultural Heritage. He completed his Ph.D. in 2012 at the Department of Civil, Structural & Environmental Engineering, School of Engineering at the Trinity College Dublin. He worked as a consultant to National

Monuments (OPW) for a number of years developing new technology based education and training programs for architectural heritage conservation. Murphy has several publications in the areas of heritage documentation (Academia.edu, n.d.).

Maurizio Ferraris

Maurizio Ferraris is a Professor of Theoretical Philosophy at the University of Turin where he runs the Ontology Lab (LabOnt) and the Inter-University Centre for Theoretical and Applied Ontology (CTAO).

Olimpia Niglio

Architect, professor at the Universidad de Ibagué, Carrera, Colombia and visitor professor in many universities including ’Universidad Tecnologica de Bolivar di Cartagena de Indias in Colombia, the Western Galilee College of Akko in Israel, the Kanto Gakuin University di Yokohama, Yokohama, the Kyoto University, Kyoto, the Universidad Jorge Tadeo Lozano, Bogotá, the Universidad de Concepción, Concepción. She is also member of ICOMOS Italia, of the Forum UNESCO University Heritage and of the ICOMOS International Scientific Committee for Theory and Philosophy of Conservation and Restoration. She is author of more than 200 publications in the architectural conservation field (Aracne editrice, 2012).

Peter Stabel

Peter Stabel is a Professor of Medieval History at the History department of the University of Antwerp in Belgium. His research expertise is in urban history and economic culture in the Middle Ages and the Early Modern Period (Tamborrino, 2014).

Randall F. Mason

Randall F. Mason is an Associate Professor of City & Regional Planning at the University of Pennsylvania School of Design, Philadelphia, United States of America. He is also Chair at the Graduate Program in Historic Preservation at the same university. His research expertise focuses on historic preservation planning, urban conservation, history, and cultural landscape studies. Mason's research interests include theory and methods of preservation planning, cultural policy, the economics of preservation, historic site management, the history and design of memorials, and the history of historic preservation. He is also the director of the Center for Research on Preservation and Society. The Center undertakes applied research projects on site management and on social, economic and political aspects of historic preservation (University of Pennsylvania School of Design, n.d.).

Richard Sennet

Richard Sennet is a professor at the New York University and London School of Economics . His expertise is in sociology with a focus on urban environments. He wrote several books analyzing the connection among cities, labor and culture (Sennett, 2017).

Sidney Colvin

Sir Sidney Colvin (1845-1927), was the first director of the Fitzwilliam Museum in Cambridge University; British Museum Keeper of Prints and Drawings. As a boy he knew John Ruskin, whose work he emulated. He entered Trinity College, Cambridge where he was follwoign appointed as fellow. He entered the circle of Dante Gabrielle Rosetti from 1868 to

1872. In 1873 he was elected Slade professor of fine art at Cambridge. Archaeology and especially sculpture captured Colvin's interest (Dictionary of Art Historians, n.d.).

Tim Ingold

Tim Ingold is a Professor of Social Anthropology at the University of Aberdeen, United Kingdom. His researches include, among the others, the relations between perception, creativity and skills as well as the relation between the “practice of academic inquiry in the human sciences” and the knowledge deriving from it (The University of Aberdeen, n.d.).

Yusuf Arayici

Dr Yusuf Arayici is a Reader in the School of the Built Environment (SOBE) at the University of Salford, Manchester, UK. He lectures in Computer Aided Design, Building Information Modelling and urban regeneration. He is currently leading interoperability specification development in the Design4Energy Project (2013-2017), aiming to develop a BIM based integrated platform for energy efficient design and retrofit, particularly researching into the development of an IDM based interoperability specification development for collaborative BIM based design practice at level 2 and level 3 BIM use for the energy efficient building design and optimisation. He also plays a leading role for scenario development in the Multidisciplinary approach to plan smart specialisation strategies for local economic development (MAPS-LED) project (2015-2019). He is author or more than 60 publications and two books on BIM titled: "Building Information Modelling" published in 2015 and “Requirements Engineering for Computer Integrated Environments In Construction”, providing technical guidance for BIM development and implementation, published in 2010 (Salford, n.d.).

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