

A STUDY FOR DEVELOPMENT OF DIGITAL CONSERVATION FRAMEWORK FOR THE HISTORIC CORE OF LAHORE, PAKISTAN



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2016-PhD-Arch-01

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2025

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A DISSERTATION

Presented to the University of Engineering and Technology, Lahore in partial fulfillment of
the requirements for the degree of

Doctor of Philosophy in

Architecture

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UNIVERSITY OF ENGINEERING & TECHNOLOGY, LAHORE

2025

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DEDICATION

To my beloved mother, whose unwavering love, sacrifices, and prayers have been the foundation of my journey. Your strength, resilience, and endless encouragement inspired every step of this path. This work is a tribute to your boundless faith in me.

STATEMENT OF ORIGINALITY

It is stated that the research work presented in this dissertation consists of my own ideas and research work. The contributions and ideas from others have been duly acknowledged and cited in the dissertation. I wrote this complete dissertation. If, at any time in the future, it is discovered that the thesis work is not my original work, the University reserves the right to revoke my degree.

Asia Jabeen

ABSTRACT

The historic core of Lahore embodies a rich tapestry of architectural, cultural, and intangible heritage, serving as a testament to continuous urban development over a millennium. However, this unique heritage is under grave threat due to rapid urbanization, environmental degradation, insufficient conservation resources, and fragmented policy implementations. Existing conservation efforts are valuable but constrained by limited documentation, inadequate stakeholder engagement, and the absence of integrated digital tools that can enhance data-driven decision-making.

This doctoral research presents a comprehensive study aimed at developing a Digital Conservation Framework (DCF) for the historic core of Lahore (HCL). It advocates for the urgent need to incorporate advanced digital technologies such as 3D documentation and Historic Building Information Modelling (HBIM) into the heritage conservation process in Pakistan. The study positions itself at the intersection of architectural conservation theory, digital heritage innovation, and urban policy, offering a multi-scalar and multidisciplinary approach.

The research employs a mixed-methods approach, integrating archival research, field surveys, stakeholder interviews, and digital data acquisition techniques, including 3D laser scanning and Historic Building Information Modelling. A detailed review of international and national conservation practices, coupled with comparative case studies from Jordan, UAE, Europe, India, and other Pakistani cities, informs the contextual development of a tailored digital framework. A detailed review of digital conservation has been conducted, utilizing case studies within the Walled City of Lahore. Existing digital conservation initiatives have been reviewed through case studies, such as the Barood Khana Lahore Fort, Sheesh Mahal Lahore Fort, Chauk Wazir Khan, and Jogi Mohallah, as well as Bazaar-e-Hakeema, which were examined to investigate conservation practices. The Mai Eidaan Courtyard within the context of the Walled City of Lahore is selected as a Pilot site for testing and validating the proposed framework.

The resulting framework encompasses a suite of integrated components, including digital documentation workflows, BIM-based heritage modelling, spatially enabled inventories, and web-based platforms for public engagement. Through implementation at the

pilot site, the framework demonstrates its ability to enhance documentation accuracy, streamline conservation planning, and foster participatory heritage stewardship. Stakeholder feedback, spanning heritage professionals, government bodies, and local communities, validates the framework's effectiveness, while also informing its refinement for broader applicability.

Key findings highlight the transformative potential of digital tools in enabling evidence-based, transparent, and inclusive conservation strategies. The study reveals that integrating digital heritage practices can significantly enhance decision-making processes, resource management, and public awareness, while aligning conservation priorities with urban development agendas. Additionally, the research identifies critical success factors, including capacity building, data governance, and policy integration, as essential for implementing a sustainable framework.

By bridging technological innovation with conservation ethics and local realities, this thesis makes original contributions to both the theoretical discourse and practical methodology of digital heritage conservation in South Asia. It provides scalable guidelines and policy recommendations, envisioning future directions such as AI-assisted predictive maintenance, city-wide digital twins, and immersive public engagement platforms. Ultimately, the study sets a precedent for how heritage-rich urban centers such as Lahore can responsibly embrace digital transformation in safeguarding their architectural legacy.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance, care, and comprehensive support I received from many exceptional individuals and organizations throughout my research journey. I want to express my sincere gratitude to all of them. However, I would like to thank several people explicitly. I want to thank Prof. Dr. Ghulam Abbas (Late), who supported me in initiating my research.

I want to extend my special thanks and appreciation to my supervisor, Dr. Shama Anbrine, for her patience, constant support, encouragement, and feedback, which have been instrumental in the development of this study. I would also like to thank and express gratitude to the members of my supervisory committee, Prof. Dr. Yusuf Awan and Prof. Dr. Neelum Naz, for their invaluable advice and guidance. Without their guidance, this study would not have been completed.

I am also grateful to Prof. Dr. Rizwan Hameed and Dr. Munazza Akhter, as well as all the faculty members, for their positive support and advice on behalf of the Department of Architecture. Many thanks to the staff, particularly Muhammad Ibrahim, of the Department of Architecture, for their kind help. I want to express my appreciation and thanks to Mr. Binyameen and Miss Khalida for their ongoing support in the completion of this research.

I would particularly like to thank you for the following:

- I am thankful to Ar. Shafiq Malik (Late), who supported me in providing data regarding the work done for the preservation of the Historic Core of Lahore under the Lahore Development Authority umbrella.
- I would like to thank Ar. Najam us Saqib and Ar. Azeem Dad Khan provided me with the opportunity to complete my on-site surveys using a Terrestrial Laser Scanner at Mai Eidaan Courtyard and supplied me with archival records required for the completion of this research, as part of the management of the Walled City Lahore Authority (WCLA).
- I am especially thankful and obliged to Ar. Muhammad Waqar and Mr. Raqeeb for their guidance and expertise in conducting the on-site survey and for supporting me in processing the scan data into Autodesk Suite, as part of the technical team at WCLA.

- I would like to thank Ar. Wajahat Ali for providing me with the opportunity to join the technical team for an on-site survey of Sheesh Mahal using a Total Station, and afterwards, for providing materials for this research, as Manager of Conservation at Aga Khan Cultural Services Pakistan.
- I am also thankful to Mr. Shukrullah Baig and Ar. Umair Ajmal for providing me with data regarding the Revitalization of Wazir Khan Chowk, Walled City Lahore, as a team member of AKCSP. I want to thank Ar. Naheed for guiding me about the conservation methodologies implemented in the conservation of the Walled City of Lahore.
- I would like to thank Ar. Mazhar Munir for supporting me throughout my research on data collection and on-site surveys. Without his support, it would have been challenging to materialize this research.
- I am thankful to my colleagues and friends, particularly Ar. Maliha Khalid, Ar. Beenish Hassan and Ar. Nida Qanber for encouraging me during the crucial time of this research.
- I am thankful to Engineer Danish bin Arif for supporting me during my on-site surveys in the capturing of photographs and casting of videos.
- My family, particularly my mother, Shahnaz Shaheen, who has always been a pillar of support for me in the absence of my father, who left for the eternal abode at a tender age, to complete my research. My siblings, Mussarat Jabeen, Amiruddin, and Waheed Uddin, were a source of inspiration and encouragement.
- My children, Arooj Zainab, Zubaida Qurban Ali, and Ehsan Ali, have been my go-to people and delightful support to cheer me in times of distress.

Once again, thank you all. I appreciate and am highly obliged to your contribution in facilitating an understanding of my imagination.

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ACRONYMS

2D	Two-dimensional
3D	Three-dimensional
AKCSP	Aga Khan Cultural Services of Pakistan
AKTC	Aga Khan Trust for Culture
AR	Augmented Reality
BIM	Building Information Modelling
CAD	Computer Aided Design
CBD	Central Business District
CH	Cultural Heritage
DCF	Digital Conservation Framework
HBIM	Historic Building Information Modelling
HCL	Historic Core of Lahore
ICOMOS	International Council on Monuments and Sites
LDA	Lahore Development Authority
LIT	Lahore Improvement Trust
PEPAC	Pakistan Environmental Planning & Architectural Consultants
TLS	Terrestrial Laser Scanner
VR	Virtual Reality
WCL	Walled City of Lahore
WCLA	Walled City Lahore Authority
LOA	Level of Accuracy
SDWCLP	Sustainable Development Walled City Lahore Project

Chapter 1: Introduction

1.1 Background

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1. INTRODUCTION

The historic core of Lahore (HCL) is a living paradigm of cultural evolution, architectural grandeur, and urban transformation over the centuries. As one of the historic cities in South Asia, Lahore has experienced multi-layered development from its Mughal, Sikh, and British Colonial past to its post-independence urban challenge (Sohail et al., 2020, p. 12). The Walled City of Lahore (WCL), with its winding streets, historical monuments, heritage sites, and vibrant communities, faces challenges due to rapid urbanization, modernization, climate change, environmental degradation, and inadequate conservation Practices.

Despite innumerable preservation initiatives, a significant gap exists in integrating digital technologies for sustainable heritage management (Teneketzis et al., 2024). Conventional conservation methods, though effective in physical restoration, often lack the precision, accessibility, and scalability of digital solutions. (Gomes, 2023a, p. 6473) . Emerging technologies, such as Total Station, 3D laser scanning, and Historic Building Information Modelling (HBIM), can revolutionize heritage conservation by enabling detailed documentation, analysis, and extrapolative modelling (Masciotta et al., 2021a, p. 6).

The historic core of Lahore represents cultural heritage that combines living heritage with its identity and cultural memory. Digital conservation Framework (DCF) for the historic core of Lahore is not only a tool for heritage protection, but it is a strategic necessity for integrating heritage into the contemporary urban landscape, with community participation, and ensuring that the cultural heritage of Lahore can be acknowledged by future generations (Khalid, 2021a, p. 33).

The historic core of Lahore is being encroached by a fast-growing metropolis, resulting in illegal encroachments, unplanned infrastructure developments, and modernization projects. Urbanization and modernization often compromise and marginalize heritage sites (Sasaki & Baba, 2024) . The historic core of Lahore (HCL) is facing multiple challenges and threats to its sustainability within the context of modern Lahore.

Rapid urbanization and modernization pose significant threats to the safeguarding of the valuable urban heritage. The historic core of Lahore is compromised by the surrounding fast-growing metropolis, encroachment, infrastructural development, and modernization projects (Seraj, 2019, p. 40). Another significant threat is the loss of tangible and intangible heritage due to negligence, poor maintenance, and inappropriate preservation. Moreover,

intangible heritage such as oral histories, artisanship, rituals, and cultural ceremonies is the most neglected part of conservation practice (Warracih et al., 2014, p. 9).

Data management and accessibility are also among the significant threats. Currently, heritage documentation is fragmented among various institutions, including the Punjab Archaeology Department, Lahore Development Authority (LDA), Agha Khan Cultural Services of Pakistan (AKCSP), and Walled City Lahore Authority (WCLA). The historic core of Lahore is subject to climatic changes, environmental degradation, and urban activities, and there is no appropriate system for disaster vigilance and risk management (M. R. Mughal, 2011a, p. 128).

Lack of community participation and accessibility of heritage sites for educational and cultural tourism are among the list of threats, as is the lack of a comprehensive digital record. Lack of continuity in conservation efforts due to changing political and institutional priorities is also a threat (Khalid, 2021a, p. 32).

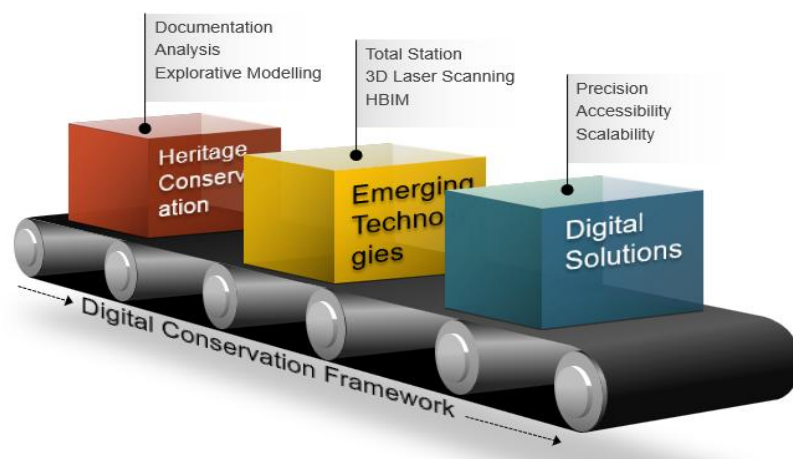


Diagram 1-1-1: Flow Chart for Digital Conservation Framework (DCF) for the Historic Core of Lahore

Source: Author

The research aims to develop a Digital Conservation Framework (DCF) for the historic core of Lahore, integrating digital technologies and tools with traditional conservation practices to ensure a data-driven, participatory, and practical approach for the sustainable development of the historic core of Lahore. The research identifies the gap between digital technologies and heritage preservation, examining case studies, technological advancements, and stakeholders' engagement, contributing to the safeguarding of the architectural, historical, and environmental legacy of historic Lahore.

1.1. BACKGROUND

Historic urban cores are facing mounting challenges due to rapid urbanization and industrialization. As traditional activities evolve into commercial and trade-based enterprises, many historic centers, particularly in developing countries, have transformed into Central Business Districts (CBDs) (Gul et al., 2023, p. 23). This transformation has led to various issues, including out-migration, illegal encroachments, the deterioration of historic monuments, the loss of historic character, the encroachment of pedestrian spaces by vehicles, and the replacement of historic monuments with new structures (Warraich et al., 2014, p. 5) .

Historic urban cores possess distinct characteristics that differentiate them from modern urban areas. Their unique architectural styles, significant buildings, public spaces, and townscapes contribute to the metropolitan areas' cultural landscape and identity. (Hankey, 1999, p. 34) However, cumulative urban pressures have changed city functions, often resulting in high-rise developments that overshadow the historic environment. (Ali, 1990a, p. 84). Socio-political and economic changes further complicated the management of these heritage sites as historic cores evolved over centuries, reflecting cultural and architectural narratives of their respective eras. These environments, composed of individual and clustered buildings, create a harmonious and aesthetically pleasing urban setting. Preserving these historic spaces is crucial to connecting past and present urban life (UNESCO, 2010c, p. 20).

Historic cores thrive when integrated with human activities, as vibrant public engagement ensures relevance and sustainability. Conversely, areas devoid of human activity, despite their architectural grandeur, often lose their appeal. Addressing the decline in public engagement within historic cores is crucial for the long-term survival of these areas (Bruno & Roccella, 2019). The negative impacts of urbanization, industrialization, and modernization threaten key heritage features, as development policies frequently prioritize high-rise construction over the preservation of historic assets, leading to urban chaos and the loss of historic integrity (Stefano & Marco, 2008).

Given the increasing threats to historic urban cores, there is an urgent need to adopt digital conservation frameworks that ensure accuracy and authenticity. In Pakistan, historic cores such as Lahore, Multan, Peshawar, and Hyderabad face similar challenges, including traffic congestion, out-migration, deteriorating infrastructure, illegal encroachments, and urban decay. Lahore's historic core stands out for its exceptional architectural and historical significance (Mughal, 2010). Despite previous efforts for the conservation, restoration, and

redevelopment of the historic core of Lahore, there is a need to integrate digital technologies into conservation practices.

Conservation methodologies play a crucial role in accurately and precisely documenting both tangible and intangible heritage, as well as recording past interventions. Conventional methods must be integrated with digital methods that provide multilayered information, minimize errors, and improve efficacy. A Digital Conservation Framework (DCF) is essential for effectively preserving and restoring urban heritage in a period of rapid technological advancement and urbanization. This digital conservation framework bridges the gap between conservation practices and the sustainable development of the historic cities within Pakistan. The integration of digital tools in mapping and data analysis ensures a comprehensive and precise approach to conserving the historic urban landscape (HUL) (Bandarin & Oers, 2012) through DCF. Detailed physical characteristics of historic structures can be captured using high-resolution imaging, laser scanning, and photogrammetry, creating accurate digital replicas that are invaluable references for restoration and maintenance efforts. The digital archives ensure the availability of precise records of heritage assets, in case of disasters or civic pressures. Conservation experts can identify susceptibilities, predict potential risks, and prioritize interventions by analyzing the overlap of environmental conditions, urban developmental trends, and historical data. (Elashry, 2019a, p. 26).

Digital platforms enable urban planners, conservationists, researchers, and local communities to access and contribute to a shared repository of information. This inclusivity fosters a collective sense of ownership and responsibility toward cultural heritage, aligning diverse perspectives for more holistic conservation outcomes. (Mansuri et al., 2021, p. 122). The Digital Conservation Framework ensures that urban heritage preservation is sustainable and adaptable to future challenges. By harnessing the power of digital tools and data-driven insights, the DCF safeguards cultural legacy for future generations while embracing innovation and efficiency in conservation practices.

1.1.1. Historical Significance of Lahore's Historic Core

The Historic Core of Lahore is a walled section located on the Northwestern side, known as the Walled City of Lahore. This human settlement is believed to be as old as 2000 BCE. Lahore is the traditional capital of Punjab, a rich, essentially flat agricultural zone made more fertile by a network of significant irrigation canals. It is situated on the south bank of the Ravi River, the smallest of the five rivers that give Punjab its name, with the Walled City on

an ancient mound in its northwest quadrant (Haroon et al., 2019, p. 291). The waters of the Ravi washed the city walls until the river's course was pushed away from the city in the second half of the 17th century to alleviate the constant threat of flooding. Including the famous Mughal fort, located in the northwest, the Walled City covers an area of just over 2.5 square kilometers. It houses approximately 200,000 people (Ali, 1990a, p. 81).

The historic core of Lahore remained as the focal point of the trade route between Kabul, Delhi, and Kashmir. The area was repeatedly attacked by various invaders who were influenced by their traditions and rituals, generating a transformed social life. Socio-cultural values were grimly affected by these political invasions (Rizvi, 2011a, p. 77) . The Mughals played the dominant role in upgrading the city's status as a center of Government. The Sikhs developed a blend of Mughal and indigenous architecture and introduced a new skyline (Din, 2018, p. 62) . British annexation introduced various typologies of buildings, including educational and public office buildings. They established the new colonial city in the southwestern part and laid the foundation of a new style of architecture, later termed as Colonial Architecture. The British introduced a variety of residences and provided a chance to migrate to new colonial cities with modern facilities (WCLA, 2009).

The evolution of the old city of Lahore is linked with the invaders who attacked the region on political grounds. The Muslim conquests began with Mahmood Ghaznavi in 998 A.D, who appointed Malik Ayaz as Governor, the founder of the old city of Lahore. Ghazni served as the royal capital of Afghanistan, while Lahore was affectionately referred to as "Little Ghazna." Over time, Lahore experienced diverse influences, from the era of Mahmood Ghaznavi to the arrival of the Mughals, who originated from Persia and enriched the subcontinent with a flourishing culture of art and architecture (Goulding, 1924). The Mughal era in the subcontinent spanned from 1526 to 1752 A.D., and this period was marked by city development. It gained its highest value when Emperor Akbar declared Lahore the headquarters of his state. and the city maintained its status from 1584 to 1598 A.D. Sikh rulers occupied the city and ruled from 1799 to 1849 A.D. The British intruded in 1857, and their period continued until independence in 1947. The Mughal and British sandwiched Sikh rule, and the contributions of the Sikh period are remarkable (Kaur, 2019, p. 958). To study the current social, economic, traditional, and historical character of the historic core of Lahore, we must deeply analyze three dominant periods: Mughal, Sikh, and British. The physical interventions that follow independence must also be considered when visualizing the city's future. (Din, 2018, p. 1)

The physical fabric of the Historic core of Lahore also includes historical monuments and cultural hubs. During the reign of Emperor Akbar, Lahore extended beyond its city walls. However, it extended its boundaries to the surrounding areas, including Chah Miran, Kot Khawaja Saeed, Singhpura, Mughalpura, etc., and Mughal Emperor Akbar developed thirty-six (36) districts for the administration of Lahore, and nine (09) out of thirty-six were inside the city walls. These districts inside the city walls were divided by the main spines (guards), and the junctions of these guards are termed Chowks. These chowks were hubs of commercial and cultural activities. (Sheikh, 2016b).

The urban fabric of the historic city of Lahore includes thirteen city gates. The main spines were known as Bazaars, secondary spines as Gali, and tertiary as s, and junctions of the main spines/Guzars as chowks / squares (Sheikh, 2016a). The Historic Core of Lahore has been a vital center of art and architecture, attracting visitors from Pakistan and around the world.

1.1.2. Current State of Conservation Efforts

Conventional methods are effective for preserving tangible heritage in a historic environment. They often fall short of safeguarding the intangible aspects of cultural heritage, such as traditions, social practices, and economic structures (Webb, 2012a). Conservation techniques continue to evolve, incorporating advanced methodologies for identification, assessment, surveying, documentation, archiving, planning, and monitoring (Stefano & Marco, 2008). Adopting strategies that balance precision, accuracy, and budget constraints is imperative to ensure authenticity and integrity in conservation efforts. Historic Building Information Modeling (HBIM) provides a digital approach to conceptualizing heritage assets, enabling stakeholders to better understand and protect the unique character of historic urban cores (Bruno & Roncella, 2019a) .

During this period, the legitimacy and reliability of heritage sites have been prioritized while preserving their historical significance. Historical Building Information Modelling has emerged as a scientific methodology to facilitate the historic structures through digital documentation, 3D data analysis for materials, archaeological assessments, conservation planning, and long-term maintenance (Baik & Boehm, 2015). Digital technologies, including 3D visualization, photogrammetry, photo-rectification, total station mapping, and 3D laser scanning, play a key role in heritage preservation through their documentation and analytical capabilities.

Heritage preservation is essential for preserving the cultural and historical legacy of the historic cities in Pakistan. Over the years, conventional and technological methods have contributed to conservation practices.

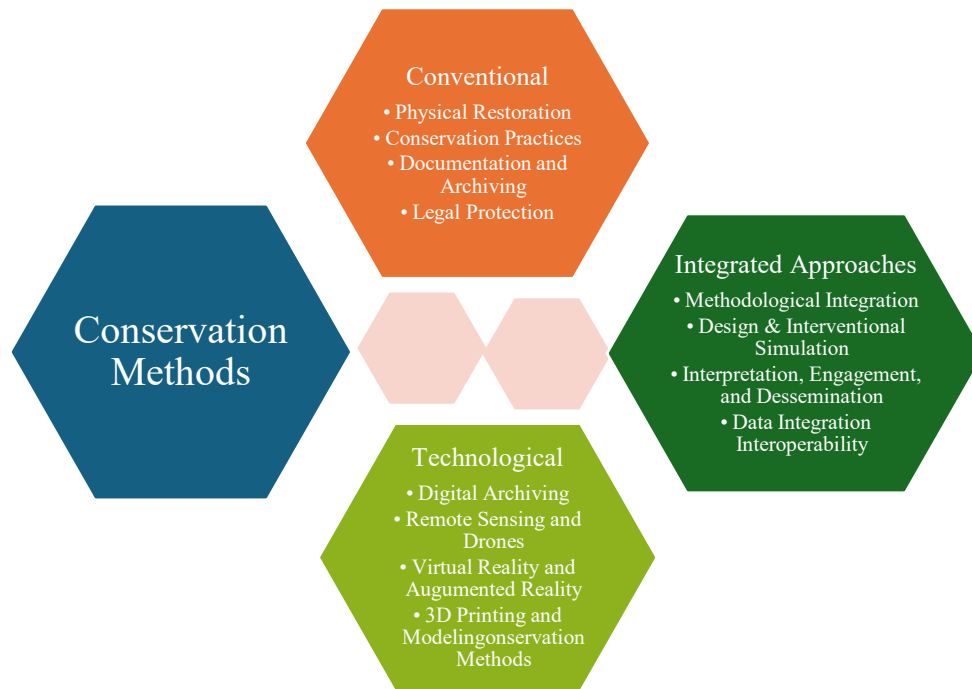


Diagram 1-2 : Conservation Methods used in the Historic Core of Lahore
Source: Author

Conventional Approaches

Traditional practices of restoration, conservation, and documentation are known as Conventional methods, with a focus on authenticity and originality of heritage sites, utilizing well-established techniques (Cody & Fong, 2017a). The key components are:

- **Physical Restoration:** This involves repair and reconstruction of damaged parts of historical buildings, while maintaining the original design and the original materials of construction utilizing skilled artisans and traditional craftsmanship.
- **Conservation Practices:** Conservation efforts aim to protect heritage sites from environmental damage, vandalism, and neglect. This includes regular maintenance, protective measures, and controlled access to sensitive areas.
- **Documentation and Archiving:** Conventional documentation methods, such as hand-drawn architectural plans, photographs, and written records, help to preserve the knowledge and history associated with heritage sites.

- **Legal Protection:** Enforcing heritage laws and regulations ensures that historic sites are safeguarded against unauthorized modifications and destruction. The Antiquities Act of Pakistan, 1975, and the Punjab Special Premises Ordinance, 1985, provide a legal framework for the protection of antiquities (Hanson et al., 2000).

Technological Approaches

In recent years, technological advancements have provided innovative solutions for heritage preservation in Pakistan, making documentation, conservation, and restoration more efficient and accurate (Masciotta et al., 2021b).

- **Digital Archiving:** High-resolution photography, 3D scanning, and digital mapping create precise digital records of heritage sites. These archives can be used for virtual tours, research, and future restoration projects.
- **Remote Sensing and Drones:** Drones equipped with high-definition cameras and remote sensing technology enable the inspection and surveying of hard-to-reach heritage sites, reducing the need for invasive methods.
- **Virtual reality (VR) and augmented reality (AR):** their experiences bring heritage sites to life, enabling people to explore historical landmarks digitally and promoting cultural education.
- **3D Printing and Modeling:** This technology enables the creation of accurate replicas of artifacts and architectural elements, aiding in education and restoration efforts.

Integrated Approaches

An integrated approach combining conventional and technological methods ensures more effective heritage preservation in Pakistan. Traditional expertise maintains cultural authenticity, while technology enhances precision, accessibility, and documentation. Collaborative efforts between government bodies, academic institutions, and private organizations are crucial for the sustainable preservation of Pakistan's heritage.

- **Methodological Integration:** Traditional techniques, such as measured drawings, photographic surveys, and archival research, are increasingly augmented by digital tools, including Total Stations, 3D Terrestrial Laser Scanners and 360 Digital

cameras make it possible to track material degradation over time with high temporal precision.

- **Both Digital and Conventional Practices:** They are encompassed by intervention and design simulation. Traditional methods emphasize aesthetic coherence and empirical repair, whereas digital tools are tailored for the integration of historical documentation, material diagnosis, and intervention planning.
- **Interpretation, Engagement, and Dissemination:** They encompass both cultural narratives and augmented and virtual reality. Cultural narratives are conveyed through guidebooks and plaques, whereas augmented and virtual reality provide an immersive experience of damaged heritage components, maintaining their physical integrity. Moreover, cultural mapping combined with spatial data enables the visualization of intangible heritage.
- **Data Integration and Interoperability:** It involves the employment of open data standards and the development of heritage-specific ontologies to link digital assets with historical taxonomies. The solution is web-based heritage portals for collaborative access.

1.1.3. Challenges in Preserving Architectural Heritage

Integrating conservation practices also causes new complexities. Technological determinism exposes the risk of overshadowing local knowledge and manual crafts. Data fragility necessitates ongoing maintenance, posing a threat of obsolescence, and epistemic conflicts between the objectivity of digital tools and the subjectivity of cultural meanings (Institute, 2010).

A balanced hybrid is needed for ethical conservation. For this purpose, digital tools are to be used as an extension, and not a replacement for conventional skilfulness. Pakistan will be better positioned to protect its cultural heritage by embracing both technological and conventional approaches. In this way, future generations will be able to learn and appreciate their diverse heritage.

Historical buildings and monuments come under the category of urban built heritage. They have cultural significance and are representative of a community's history and identity. Preservation of such architectural heritage is a challenging task (Bersani et al., 2014). These challenges can be environmental, economic, social, technical, or political and can hinder the preservation of such structures. A detailed view of these challenges is as follows:



Diagram 1-3: Current Challenges and Threats to the Historic Core of Lahore

Source: Author

Although urbanization plays a key role in the economic development of a country, from a historic preservation perspective, it puts pressure on architectural sites through its alteration and demolition.

- The first and foremost challenge is a lack of resources, mainly funding. Preservation requires substantial investment. Mostly, new developmental projects are prioritized over conventional heritage sites, which leads to constraints on the budget.
- A significant threat to old structures is environmental hazards. One of the most contributing factors to the deterioration of old buildings is acid rain and pollution. Apart from this, other environmental hazards such as floods, fires and earthquakes cause irreversible damage to such sites.
- Traditional architecture is often overshadowed by modernization. There is mostly lack of appreciation, lack of awareness and educational gap between architecture and local history. This reduces community engagement.
- Preservation of historical building is often hurdled between public and private sector because of outdated preservation laws and regulations. There are ownership and unclear disputes among authorities causing bureaucratic and legal hurdles and complicating preservation efforts.

- Historical authenticity and architectural integrity of an architectural site can be compromised by inappropriate restoration practices. A shortage of well-trained staff can result in poor execution of projects.
- Tourism bring revenue to a country but excessive visits and overcrowding at architectural sites can result in physical wear and tear of the building or monument. Similarly, commercialization is often prioritized over conservation leading to make preservation a challenge.
- Heritage sites are often targeted during social unrest or wars. The decision of granting funding and attention to heritage sites is often influenced by cultural disputes and biases. In this way, both political and social issues result in negligence and destruction of cultural heritage.
- Digitization and advancement in technology have made different task easier to do. However, it has also increased the need to make more investment in this field to digitalize the conventional techniques. Sometimes, it is difficult to apply modern safety techniques like earthquake proofing while keeping the original structure of the building.
- Preserving old buildings for contemporary use is sometime tricky. This is also known as adaptive reuse. It can be a challenge during preservation as adaptive reuse can lead to compromise the authenticity of the architecture of the building.

To address these challenges, a multidisciplinary approach is required. It can involve conservationists, local communities, international organization and government bodies. Apart from these, public education, sustainable tourism practices, adequate funding and legal framework also plays a vital role in the preservation of architectural heritage.

1.2. RESEARCH PROBLEM

Lahore is famous for its rich cultural heritage and historical architecture. However, its historical core has faced multiple challenges for the preservation, rehabilitation, conservation, and regeneration due to modernization and urbanization. These challenges have worsened with the passage of time due to lack of organized framework of digital technologies and its applications. This has led to unauthentic documentation, lack of management strategies and disorganized resources (Gomes, 2023b) Based on these observations, there is a dire need of integration of digital conservation framework. This framework is focussed on the preservation and conservation of historic core of Lahore. This may include enhancing documentation by integrating trailblazing digital technologies, increased participation of stakeholders,

incorporation of safeguard of valuable cultural heritage and promotion of sustainable practices for the socioeconomic and sociocultural vitality of architectural assets (Moyano et al., 2022a).

The historic core of Lahore has a wealth of monuments, heritage sites, and urban squares, reflecting significant elements of the various architectural styles, a blend of Indigenous and intruded features introduced by the invaders. The historic city was planned as a pedestrian and linked with the Royal throne at Lahore Fort. The city was walled, which was demolished during the British annexation in 1857 (Latif, 1994a). The historic core of Lahore got its highest political, economic, and social values during the Mughal period when it was declared as a royal throne (Mumtaz, 1985). After the fall of the Mughal Empire, the city was occupied by the Sikh rulers who destroyed the historic character of the city through interventions and the use of the monuments insensitively, making the city ruined. After the Sikh empire, the city was gone under the administration of the British who developed their colonial city around the vacant sides of the historic area (Goulding, 1924a).

The heritage site was termed a Mughal city, showcasing the architectural styles and characteristics of three periods. Various types of buildings index various cultures, e.g., Hindu, Muslim, Sikh, and British. The political changes in the area changed the urban fabric and socio-cultural values of the historic core due to the migration of the residents to modern Lahore, overpopulation, the induction of vehicles, and unplanned commercial activities. The historic site has intrinsic cultural values and norms, mandatory to transfer to future generations as a symbol of dignity (Tufail, 1962a).

To understand conservation, we must situate it in the realm of material, culture, history, and architecture while acknowledging the future fabric of the cities; we must consider that area's historical evidence and architectural remains. Built Heritage carries multi-layered information beyond physical characteristics. The preservation and restoration of built heritage and the urban fabric of the city requires an integrated representation of different information before the finalization of the conservation plan (Brusaporci, 2017a).

The application of digital technologies has speedily been increasing as tools for representing and research data analysis. Initially, these techniques were used for projects at the planning stages, specifically for energy simulations and life-cycle cost analysis (Duca & Machado, 2023). Whereas their application to build heritage conservation has been limited, recent research has begun to explore the implementation of digital technologies for the conservation of historic monuments and archaeological sites to develop a bridge between

technology and the preservation of cultural heritage through a comprehensive framework (Remondino, 2011).

1.2.1. Need for Digital Conservation Framework (DCF)

The traditional conservation efforts in Lahore have often been constrained by fragmented documentation, inadequate monitoring, and a lack of comprehensive planning tools. The emergence of digital technologies offers an opportunity to enhance heritage conservation through better documentation, analysis, and management. A Digital Conservation Framework (DCF) aims to integrate 3D scanning and Building Information Modeling (BIM) driven data analysis to create a systematic approach to preserving historic sites. This digital approach will:

- Provide an accurate and updated database of historic structures.
- Support heritage conservation planning and restoration strategies.
- Enhance public engagement through interactive platforms.
- Improve decision-making for policymakers and conservationists.

1.2.2. Gaps in Existing Conservation Approaches

Cultural heritage conservation is crucial for preserving societies' historical, social, and cultural fabric. Despite numerous efforts worldwide, significant gaps in existing conservation approaches hinder effective and sustainable preservation. These gaps can be categorized into several key areas:

- **Lack of holistic approaches** to integrate both tangible and intangible heritage is essential for maintaining the cultural significance of heritage sites.
- **Insufficient community involvement** in conservation planning and decision-making processes. Since these communities are the custodians of cultural heritage, their knowledge, practices, and needs should be at the center of conservation strategies. Greater community engagement ensures conservation efforts aligned with the cultural context and promote local stewardship.
- **Inadequate Funding and Resources** result in incomplete or poorly maintained preservation efforts. Consistent and adequate funding, along with the training of skilled professionals, is necessary for the sustainability of conservation programs.
- **Weak Legal and Institutional Frameworks** result in ineffective management and an increased risk of heritage degradation. The overlapping jurisdiction, weak

enforcement mechanisms, and inappropriate policies can result in the loss of heritage assets.

- **Rapid urbanization and modernization** resulted in the loss of the physical fabric of the city, with the loss of cultural heritage. Unplanned urbanization threatens the cultural heritage due to new constructions. The need is to balance the conservation practices with urban development through the application of strategic plans.
- **Climate Change and Environmental Challenges** must be incorporated while planning conservation strategies to avoid the expected risks, as environmental threats can cause permanent loss of heritage assets.
- **Limited Technological Integration** efforts fail to leverage these innovations. Digital mapping, 3D modeling, and data analytics can enhance preservation techniques and provide more effective management solutions (Saygi et al., 2023).

Addressing these gaps requires an interdisciplinary approach, collaborative partnerships, and a long-term vision. By strengthening conservation frameworks and embracing inclusive, innovative strategies, we can ensure the sustainable preservation of cultural heritage for future generations.

1.3. Research Aim and Objectives

The research aims to generate a platform towards the placement of Historic Building Information Modeling as a methodology for documentation, evaluation of the historic significance, documentation, digital achieving, managing and remote monitoring of the heritage sites based on the information provided in the three-dimensional digital model. The study will help develop a conservation plan based on the HBIM software suited for historic buildings, urban open spaces, and archaeological sites. It also includes identification of critical information, management between real-time operation and monitoring systems, and the handling of uncertainty due to the unavailability of resources and skills.

1.3.1. Primary Objective

This study aims to develop a comprehensive digital conservation framework for Lahore's historic core, ensuring the preservation and sustainable management of its cultural heritage, and adapting it for the other historic cities in Pakistan.

1.3.2. Secondary Objectives

- i. To categorize the significant historical monuments and open urban spaces within the historic core of Lahore.
- ii. To identify the current challenges faced in the conservation, restoration, rehabilitation, management, and remote monitoring of the historic core of Lahore.
- iii. To integrate digital technologies into the conservation efforts within the historic core of Lahore.
- iv. To bridge the existing gaps in the digital technologies and heritage preservation, with a particular focus on the historic core of Lahore.
- v. To develop a digital conservation framework (DCF) to enhance the sustainability of preservation practices within the historic core of Lahore.

1.4. RESEARCH QUESTIONS

- i. What are the various categories of the significant historic monuments and open urban spaces of the Historic Core of Lahore?
- ii. What are the current challenges faced with the conservation, restoration, rehabilitation, management and remote monitoring of the historic core of Lahore?
- iii. How can digital technologies be integrated into the conservation efforts of the historic core of Lahore?
- iv. What are the existing gaps in digital technologies and heritage preservation, with a particular focus on Lahore's historic core?
- v. How can a digital conservation framework enhance the sustainability of preservation practices within the historic core of Lahore?

1.5. SIGNIFICANCE OF THE STUDY

The historic core of Lahore, Pakistan, is a treasure trove of cultural heritage, architectural marvels, and historical significance. However, this rich legacy is increasingly threatened by urbanization, environmental degradation, and inadequate conservation practices (Mughal, 1995). This study on developing a digital conservation framework for the historic core of Lahore holds immense significance in preserving and protecting this invaluable heritage for future generations.

The study aims to integrate modern technologies to systematically document, analyze, and manage the historic assets within the Walled City of Lahore through a digital conservation framework. It ensures informed decision making for conservation practices to obtain

accessible and accurate preservation. Different techniques which can be used by researchers, experts and policy makers include panoramic views, digital archives and Virtual 3D models.

The implementation of this study is not limited to documentation, public awareness and community engagement but extends beyond it bringing ownership, leveraging digital tools and participation of local communities. Moreover, this digital approach increases different opportunities like public understanding and collaboration of educational initiatives.

This framework can be applied and adapted by other historic cities of Pakistan facing similar problems. It can be applied in various contexts helping in global efforts for the need of conservation and hence broaden the discourse of integration of technologies with traditional methods.

In a nutshell, development of a framework based on digital conversational technologies is critical for the safeguard of the cultural legacy of Lahore. It aspires in creation of a collaborative and sustainable approach for the heritage conservation of Lahore's cultural essence for future generations.

1.6. SCOPE AND LIMITATIONS

Built Heritage carries multi-layered information beyond physical characteristics. Protecting the built heritage and the city's urban fabric requires an integrated representation of different information before finalizing the conservation plan. Globally, there have been attempts to apply building information modeling in heritage conservation. In Pakistan, an initiative was also taken by Dr. Murtaza Taj from LUMS University in 2012 with a project titled "Digital Preservation of Pakistan's Heritage," using a 3D laser scanner for the documentation of six selected heritage sites within Pakistan, collaborating with local authorities, various educational institutes, and international agencies (Hashmi & Taj, 2016) (Cyark, 2020). According to the Ar. Najan us Saqib (WCLA), the Government of Punjab. awarded the project of digital documentation of Chauburji, under the supervision of Walled City of Lahore Authority (WCLA), to TROJAN, a private company engaged in 3D Modelling of different projects in a variety of fields using the terminology "Reverse Engineering". They utilized a 3D laser scanner from Faro Technologies and manual drafting to develop 3D virtual models and a panoramic view of the heritage site. This Model has been used to visualize the tangible and intangible features of the site, while developing a plan for the conservation of Chauburji.

The historic city of Lahore are a significant part, reflecting various cultures through their physical fabric, traditional values, and norms. This historic city has evolved dynamically due to its urban morphology and hierarchy, characterized by street patterns, building typologies, and a historic urban landscape. Their significance is based on population growth, area of residence, and functionality (Ali, 1990a).

As a result of urbanization, historical structures will be replaced by high-rise buildings to meet contemporary requirements with improvements in hygiene. The process of modernizing historic cities has created chaos and violated heritage protection policies. On the other hand, Valletta Principles for the safeguarding and management of Historic Cities, Towns, and Urban Areas states that the Historic Towns and Urban areas require an integrated approach for their protection, conservation, and management as well as their coherent development and harmonious adaptation to contemporary life (ICOMOS, 1987a). Urban knowledge production is near the ground at the National level in Pakistan. At the International level, there is a research gap between technology and Practice. A systematic study is needed to investigate new urban interventions and create a balance between urban transformations and heritage conservation. Analyzing the current conservation techniques and applying the Digital Conservation Framework can help to achieve this balance.

BIM is not a methodology but a technology and a process of generating and keeping a parametric, object-oriented, rule-based building model (Azhar et al., 2012). There is a challenge of the time to implement BIM as a tool to collect survey data with the help of a photogrammetric survey tool, terrestrial laser scanner combined with digital cameras and total station for the presentation of Architectural, structural, and engineering drawings , and finally, creation of 3D BIM model to finalize the method of conservation, material make-up and real-time operations and maintenance of the Historic Urban Cores in Pakistan (Taj, 2015)

1.7. STRUCTURE OF THESIS

1.7.1. Introduction

This Chapter explores the historical and architectural significance of the historic core of Lahore, providing the contextual foundation for the research. It highlights the current state of conservation efforts, which are challenged by rapid urbanization, weak policy implementation, and inadequate community engagement. The research identifies the inadequacy of conventional conservation methods and emphasizes the holistic need to develop a digital conservation framework that proposes improved documentation, monitoring, and

participatory practices. The primary objective is to develop a digital conservation framework, supported by secondary goals such as policy evaluation and community-focused strategies, tailored to the historic core of Lahore. The research questions are introduced to investigate the transformative potential of digital tools in heritage conservation, suggesting a model adaptable to other historic urban centers. The scope is limited to Lahore's historic core, with acknowledged constraints including data access, technology integration, and policy challenges.

1.7.2. Literature Review

The chapter reviews key theories and practices in architectural conservation, with a focus on authenticity, sustainability, and cultural sensitivity. It underscores influential charters such as the Venice Charter, Burra Charter, and Nara Document. It also explores the role of digital technologies in heritage conservation, focusing on 3D documentation for precise and accurate recording, spatial analysis, and HBIM to create data-rich, interactive heritage models. An overview of the legal framework for conserving heritage has also been considered. Previous conservation efforts in the historic core of Lahore have been evaluated to assess the mandatory requirements suitable for the unique historic character of the Walled City of Lahore. This chapter identified the gaps in existing literature based on limited inclusion of digital technologies and lack of public participation in conservation efforts.

1.7.3. Research Methodology

The chapter discusses the Qualitative and quantitative approaches used for the conservation of HCL and identifies the mixed-methods approach to address the objectives of the study. A mixed-method approach provides a comprehensive understanding of the conservation policies and practices, with contextual interpretation. The chapter describes data collection methods, including archival research, field surveys, and on-site documentation of the selected sites within the Walled City of Lahore. Interviews were conducted with stakeholders, along with expert opinions and the community's vision, and data acquisition techniques. It further discusses the data analysis techniques to evaluate measurable understanding, spatial and walk through analysis, and digital mapping of the selected heritage sites. Concluding the chapter with ethical considerations, ensuring informed consent and cultural sensitivity, and identifies measure for reliability and validity.

1.7.4. The Historic Core of Lahore: Context and Significance

The architecture of historic Lahore is inspired by several historical periods. This chapter gives an overview of this evolution. Every period has influenced the architecture of buildings

in different ways. These periods include the pre-Mughal era, the Mughal period, and colonial period. The pre-Mughal era led to the early urban foundation. During, the Mughal period comprehensive urban planning and architectural grandeurs were introduced. Colonial period was the time in which civic lifestyle was introduced. Post-independence developed in the region that fabricated the urban texture of the city. Metropolitan activities increased during this time.

Building topology, unique character of streetscapes and notable monuments are also explained in this chapter identifying the socio-cultural significance along with intangible heritage. Finally, the chapter discusses the economic value of the heritage, focusing on its tourism potential and the role of traditional artisans in sustaining cultural and economic vitality.

1.7.5. Current State of Conservation and Comparative Case Studies

This chapter describes the current state of heritage conservation in the historic core of Lahore, focusing on the role of government, NGOs, and international collaborative. It also identifies the key challenges, such as rapid urbanization, environmental degradation, and limited public awareness, and resources. A SWOT analysis was done to assess the vitality of the research. This chapter includes international case studies such as As-Salt, UAE, Dubai, which are countries applying digital technologies much earlier than our region and country.

To assess the conservation methods used by neighbouring country, Shahjahanabad, a regional case study has been done. Different case studies have also been carried out in core of Lahore to evaluate the involvement or usage of digital technologies for conservational practices. These case studies include Sheesh Mahal, Lahore Fort, Barood Khana, Lahore Fort, Bazaar e Hakeema, Chauk Wazir Khan and Jogi Mohallah. These sites were visited and analysed for the integration of digital application for conservation practices.

Lastly, this chapter deals with the key implementation of digital practices for conservation, policy making, capacity building and strategies for comprehensive stakeholder engagement.

1.7.6. Conservation Techniques in the Historic Core of Lahore

This chapter deals with the development of the Digital Conservation Framework (DCF) for the conservation and preservation of historic Lahore. It provides a conceptual framework. This framework is based on technological integration, sustainability, accessibility, and focus on the characterization of digital tools for enhancing the conservation efficiency. Different data acquisition methods and digital documentations are discussed here. These methods include 3D

laser scanning, which enables high accuracy and precision in architectural details. It presents BIM modelling and digital archives for data management of heritage structures. This helps in accurate visualization, analysis and interoperability of such structure. Various digital tools are introduced for preservation and conversational planning including risk analysis, intervention simulation and condition assessment. This chapter also promotes the engagement of local communities or public using VR, citizen science initiative and web-based interpretation. This helps in fostering awareness. Overall, these elements form a calculable, robust model for the digital conservation of heritage in complex urban contexts.

1.7.7. Implementation and Validation of the Framework

The implementation and validation of the digital framework of conservation is presented in this chapter. This is done through a pilot project conducted at Mai Eidan Courtyard. This site was selected due to its architectural, cultural, and religious significance as well as its impact on ongoing preservation challenges. The framework used includes total station, digital photography, HBIM modelling, and 3D laser scanners. All these digital technologies are integrated to identify the conservation priorities.

The outcome of the proposed framework is evaluated through expert views, assessment from government institutions, and community feedback to refine this framework of digital technologies. After evaluation, this chapter provides a comparative analysis of additional methods, paying attention to cost efficiency, accuracy, and decision making. The project's scalability is considered, showing potential for application across heritage sites. Comprehensive digital conservation of the site is documented, including virtual tours and a 3D model. The framework is aligned with the urban goals of Lahore, developing large-scale adoption.

1.7.8. Conclusion and Future Directions

This chapter concludes the key findings of the research, focusing on the importance of integrating digital technologies into heritage conservation to address the current challenges in urban conservation. This chapter concludes the research findings and highlights significant theoretical contributions, including the development of digital conservation frameworks through digital innovation, and implications for policymakers. The chapter acknowledges limitations related to data accessibility, technological infrastructure, and stakeholder engagement. It offers recommendations for future research, encouraging exploration of emerging technologies. This chapter concludes with a call for continued interdisciplinary

collaboration, capacity building, and policy support to ensure that heritage conservation remains dynamic, inclusive, and adaptive in the face of evolving urban and technological contexts.

Chapter 2: Literature Review

- 2.1. ARCHITECTURAL CONSERVATION: THEORIES AND PRACTICES
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 - 2.4.1. Lahore Improvement Trust (LIT) – (1938-1975)
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 - 2.4.4. Sustainable Development of Walled City of Lahore (SDWCL) & Aga Khan Cultural Service Pakistan (AKCSP) - (2009-2014)
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- 2.5. GAPS IN LITERATURE AND RESEARCH OPPORTUNITIES
 - 2.5.1. Gaps in Literature:
 - 2.5.2. Research Opportunities:
- 2.6. CONCLUSION

2. LITERATURE REVIEW

The historic core of Lahore has a wealth of historic monuments, urban spaces that serve as cultural nodes, and archaeological sites. The heritage within old Lahore reflects the glory, architectural splendor, and urban evolution (Haroon et al., 2019, p. 3). As one of the oldest and most significant cities in South Asia, Lahore's Walled City is home to a wealth of historic monuments, residential quarters, and traditional bazaars, making it a focal point for conservation efforts. (Goulding, 1924b, p. 13). However, the rapid pace of urbanization, environmental degradation, and inadequate preservation initiatives have posed serious threats to this cultural landscape. (Waqar, et al., 2016, p. 3). In response to these challenges, integrating digital technologies has emerged as a transformative approach to heritage conservation, offering innovative tools for the documentation, analysis, and management of historic sites. (Brusaporci, 2017b). This literature review investigates the existing knowledge on digital conservation methodologies, with a focus on their application in preserving the urban environment of historic cities. This review aims to develop a theoretical framework for conserving-built heritage within the historic core of Lahore by exploring the best global practices.

2.1. ARCHITECTURAL CONSERVATION: THEORIES AND PRACTICES

Architectural Conservation is the preservation, restoration, and maintenance of historical monuments, archaeological sites, and urban areas to preserve their cultural and historical identity (Webb, 2012b). This field plays a key role in balancing the past with the needs of contemporary society. The architectural and urban landmarks of societies reflect their history and culture as a catalogue of their historical evolution (Sohail et al., 2020). Theories and practices of architectural and urban conservation have evolved over centuries, influenced by ever-changing philosophies, technological developments, and socio-cultural contexts. (Baratin et al., 2023). Conservation efforts began in the 19th century, and a balance was achieved between historical integrity and the adaptive reuse of historical structures for modern use through improvements in conservation methodologies. During the late 20th and early 21st century, the need for global interconnectivity was duly prompted to address the issues (Cody & Fong, 2017, p. 4).

Architectural conservation encompasses a range of approaches, including preservation, restoration, rehabilitation, and reconstruction (Batool, 2017). These methods reflect different

perspectives on the authenticity and integrity of heritage sites, based on specific theoretical frameworks and practical aspects (Li et al., 2023). Heritage experts and philosophers, such as John Ruskin, Eugène Viollet-le-Duc, and Cesare Brandi, have significantly contributed to the development of architectural conservation theories, presenting contrasting views on interventions, aesthetics, and authenticity (Charola et al., 2001)

Architectural conservation practices contain meticulous research, documentation, material analysis, and technical knowledge. It must be ensured that the original character of the heritage is protected while planning conservation, integrating various disciplines involved in the conservation (Mughal, 2011b)

Ethical considerations are crucial, and interventions must respect authenticity and focus on accessibility, sustainability, and community engagement. This introduction examines the development of theories and practices for heritage preservation. By analyzing case studies, theoretical discussions, and digital techniques, we extend insights into the conservation of urban-built heritage while remaining relevant in a changing world.

2.1.1. Evolution of Conservation Philosophies

Conservation philosophies provide guidelines for the evolution of conservation practices, and these philosophies contribute to the development of conservation practices (Jokilehto, 2001). The conservation experts, such as Eugène-Emmanuel Viollet-le-Duc (1814-1879), John Ruskin (1819-1900), Alois Riegl (1858–1905), William Morris (1894-1936), and Cesare Brandi (1906-1988), played a key role in outlining these philosophies (Charola, 2007).

The fundamental theories of intervention follow a dualistic approach: one involves the conservation of existing conditions, and the other is the restorative process that reconstructs elements of the past, theoretically introducing features that were never part of the original structure Digital (Elashry, 2019a, p. 42). On the one hand, preservation supports the value of the authenticity of material, form, and historical evidence. On the other hand, restoration aims to recover a past state, which may involve reconstructing or speculating about elements based on historical references, leading to an idealized rather than a factual account (Cinquepalmi & Tiburcio, 2023). This dualism raises questions about the historical integrity, authenticity, and ethical obligations of those involved in the preservation process (Moyano et al., 2022b). John Ruskin strongly favored the preservation, while Viollet-le-Duc argued for the latter. Alois Riegl argued for the value-based approach, while Cesare Brandi developed the concept of critical restoration (Elashry, 2019a).

Emmanuel Viollet-le-Duc (1814-1879)

He had played a key role in developing architectural theories from the 20th century, focusing on the structure and function of Architecture as a solitary determinant of form, entirely dismissing academic visual systems (Feilden, 2003). In conclusion, he was a follower of Louis Sullivan's theory, "Form Follows Function," for many years. He published his most influential book, "Dictionnaire raisonné de l'architecture". In 1858 (Actually 1863), he published his second book, "Entretiens sur l'architecture", and he described that "Architecture is not the sole business of architects, it is everyone's business: it is born and develops in and with the societies in which it is embodied", also, in his book "Dictionnaire du mobilier" published in 1858. He debated the value of a goldsmith's work, jewelry, musical instruments, and armor in addition to furniture (Kwanda, 2009). He wrote in his book that restoration is a "means to re-establish a finished state, which may never have existed at any given time."

During the early 1830s, France initiated an effort to restore medieval buildings and Prosper Mérimée commissioned Viollet-le-Duc to restore the Romanesque abbey of Vézelay upon his return to his home country after completing his education in Italy (Orbasli, 2017). The restoration at Notre Dame de Paris by him enhanced his personality as a Conservation Expert. His other significant works include Mont Saint-Michel, Carcassonne, Roquetaillade Castle, and Pierrefonds.

The significant features are:

- Supports restoration to a "complete" state, sometimes reinterpreting missing elements.
- Emphasizes structural integrity and aesthetic harmony.
- Criticized for being too interventionist.

John Ruskin's Romantic Approach (1819–1900)

In the Anglophone world, John Ruskin was enormously significant for his judgments on all forms of art and architecture. Proust and Gandhi were among his admirers, and his books were translated into many languages. He is famous for his efforts during his presidency of the Pre-Raphaelite Brotherhood. (Fayez, 2024) He is well known for his writings, primarily "The Seven Lamps of Architecture," published in 1849, and "Stones of Venice," published in 1851-1853. In his book "Lamp of Memory", he detailed the idea of restoration in Architecture (UNESCO, 2010c). He wrote, "Neither by the public nor by those who care for public monuments, is the true meaning of the word restoration understood. It means the most

destruction a building can suffer, out of which no remnants can be gathered, a destruction accompanied by a false description of the thing destroyed. Do not let us deceive ourselves in this important matter; it is impossible, as impossible as to raise the dead, to restore anything that has ever been great or beautiful in architecture.”

The significant features of the theory are:

- Advocates for minimal intervention.
- Believes in the authenticity of aging and decay.
- Opposes restoration, emphasizing the original materials and craftsmanship.

Alois Riegl’s Values-Based Approach (1858–1905)

Alois Riegl presented a value-based approach, which revolutionized the field of conservation by focusing on the theories and practices. He was a pioneer Austrian art historian and theorist who introduced a complex yet interesting framework for understanding how communities attribute to historical artifacts and monuments. Riegl introduced a system of values that provides a basis for shaping contemporary debates in the field of conservation of cultural heritage in his influential work, *Der moderne Denkmalkultus: Sein Wesen und seine Entstehung* (The Modern Cult of Monuments: Its Character and Origin), published in 1903. His approach diverges from the aesthetic, traditional, and historical evaluation of art and architecture. He proposed a different concept regarding values and raised issues such as how and why cultural objects are preserved (LAH, 2018). These values include historical significance, age, use, and newness, each of which contributes to the importance of heritage.

Riegl laid the foundation of a comprehensive and dynamic understanding of the conservation of cultural heritage within the domains of interpretation and meanings attached to cultural artifacts. Riegl’s value-based approach, focusing on cultural and societal contexts, offers a vital lens through which to grapple with questions of authenticity, identity, and community involvement in contemporary heritage practices (Liang et al., 2023a) . This introduction to Riegl’s approach will explore its theoretical frameworks, key concepts, and enduring concepts on modern conservation discourse. The key elements are:

- Consider a value-based approach involving historical age, use, and newness.
- Suggests that different ages comprehend historical structures differently.

William Morris (1894-1936)

He was focused on the theories of Viollet-le-Duc and transformed buildings into an idealized state from a distant place. The theories of Viollet-le-Duc involve the demolition of elements added in later times during interventions. In contrast, Morris holds the point of view that later additions must be part of the building. He laid the foundations of the Society for the Protection of the Ancient Buildings (SPAB) in 1877, based on the teachings of John Ruskin. He proposed that historic buildings should be repaired, rather than restored, to protect their historical significance as a cultural heritage (Stefano & Marco, 2008). He added to the theories of John Ruskin, who accepted all the work done since its origin as a part of the continuing story of the building, and equally valid. Society is still very active and important as a National Trust. The landowners follow their rules, and Society develops awareness among architects and craftsmen through seminars and hands-on classes, facilitated by scholarships.

Philosophical arguments about restoring a building or landscape suggest that removing historical evidence can result in a loss forever. However, adding features to a building can be more appealing, supporting the theory of Viollet-le-Duc. Alternatively, it can appear as a patchwork, differentiating old and new, supporting the Ruskin and Morris theories.

Cesare Brandi's Critical Restoration (1906-1988)

During the mid-20th century, Cesare introduced a theory based on the dual nature of the significance of the artwork, as a physical object and a work of art with historical and aesthetic significance. He revolutionized the field by introducing a new art conservation philosophy and practice. He consolidated his ideas comprehensively in his seminal work, *Teoria del Restauro* (Theory of Restoration), first published in 1963, where he upheld the principles leading the conservation of cultural heritage.

Brandi suggested that the key objective of the restoration should be to preserve the work's original intent and artistic expression while maintaining respect for its historical authenticity. He thought the original and reversible should be differentiated, ensuring that future restorers could remove or restore it without damaging the artwork. The defining feature of his approach was a balance between aesthetic integrity and historical authenticity (Jokilehto, 2001).

The key concept of his theory was the unity between visual and historical aspects without compromising their identity. This principle requires a deep understanding of context, style, and significance of cultural heritage. Brandi's concept of conservation continually

influenced conservation practices and offered a framework based on the concept for engaging with the past while preserving it for future generations. The key concepts are: -

- Believe in distinguishing new interventions from the original artwork.
- Advocate for minimal and reversible restorations.

2.1.2. International charters and guidelines

Heritage conservation makes a significant contribution to the sustainable development of urban heritage and to save the cultural legacy of the regions. The activities of the past are the index of the societies in which they took place. As communities grow, they develop their communal identities and a sense of continuity with their past. International charters and guidelines have been established to address the global nature of heritage conservation and to provide a platform that offers frameworks and principles for the best conservation practices (Iamandi, 2015).

These charters and guidelines serve as a baseline document that formulates shared values, standards, and collaborates with various nations to establish uniform principles. Global organizations, including UNESCO, ICOMOS, and ICCROM, articulate these documents and provide guidelines for methodologies, strategies, and ethical considerations for conservation efforts. These organizations emphasize the value of authenticity, integrity, and sustainability, recognizing the varied cultural contexts and unique challenges encountered globally (Kwanda, 2009). With the implementation of these Charters and guidelines within the contextual framework, heritage experts and policy makers can ensure that conservation efforts are aligned with global standards, balancing the need for conservation with the dynamic nature of contemporary communities. This research examines the key characteristics, principles, and guidelines for generating relevance in a rapidly evolving technological world.

Athens Charter (1931)

This charter focuses on historic urban areas, including cities, towns, historic centers or quarters, along with their natural and man-made environments, and emphasizes structural integrity and documentation. It recognizes these areas as expressions of the diversity of societies throughout history and emphasizes their values as historical documents embodying traditional urban cultures (ICOMOS, 1987a).

The Athens Charter, adopted in 1933 by the International Congress of Modern Architecture (CIAM), is a foundational document that shaped modern urban planning and

architecture. It established principles focused on functionality, zoning, and the well-being of urban populations, advocating for the separation of residential, industrial, and recreational areas, efficient transportation, and access to green spaces (Yuan, 2008). Influenced by Le Corbusier's vision of the modern city, the charter played a key role in shaping post-war urban development and remains a cornerstone in discussions of modernist planning and design.

Venice Charter (1964)

Internationally titled “International Charter for the Conservation and Restoration of Monuments and Sites,” the Venice Charter was implemented in 1964 during the 2nd International Congress of Architects and Technicians of Historic Monuments in Venice and advocates for authenticity and minimal intervention (Trillo, et al., 2020a). The charter focused on understanding the importance of heritage preservation for future generations, and it articulates the basic principles for the preservation of ancient Buildings, focusing on the need for

- Precise Documentation
- Minimal Intervention
- Respect for original material
- Integration of Modern Techniques

Burra Charter (Australia, 1979)

The Burra Charter, articulated by the Australian National Committee of the International Council on Monuments and Sites (ICOMOS) in 1979, is the fundamental document providing guidelines for the conservation and management of cultural heritage in Australia. It was first adopted in the historic town of Burra, located in South Australia, and hence it was named after the town itself (Woodward & Heesom, 2019). The Burra Charter emphasizes a value-based approach for conservation, focusing on the cultural significance of heritage sites and the need for their preservation, management, and adaptation. It introduces key guidelines such as

- Significance of understanding the heritage value of a place
- Participation of the stakeholders in the decision-making process
- Minimal and reversible interventions

Over the years, Burra Charter has been amended to reflect innovative ideas and approaches in heritage conservation, maintaining its fundamental guidelines. Its

implementation serves as a reference for conservation practices globally and extends beyond Australia. The Charter provides a systematic approach to assessing cultural identity, developing conservation policies, and managing heritage sites while maintaining their historical, aesthetic, social, and spiritual values. By providing an adaptable framework, the Burra Charter serves as a guide map for preserving cultural heritage for future generations.

The Washington Charter (1987)

The Washington Charter is considered as a landmark document in the mainstream of cultural heritage preservation, and it was adopted in 1987. The charter was developed under the auspices of the International Council of Monuments and Sites (ICOMOS) and provides a comprehensive framework for conserving Historic Towns and urban areas. The charter establishes principles that ensure preservation while accommodating the present-day needs of urban life, identifying the profound cultural, social, and architectural significance of historic sites. Urbanization and modernization influenced the historic cities and pressured the historic environment (Elashry, 2019a). The Charter emphasizes the importance of authenticity, integrity, and the historical characteristics of heritage sites. It promotes a balanced approach to the conservation of the historic urban landscape (HUL) and adaptive reuse of the historic monuments. It also focuses on the active participation of local communities in conservation practices, recognizing their role as beneficiaries and curators of cultural heritage (Trillo, et al., 2020a).

The guidelines outlined in the Washington Charter had a significant impact on urban conservation practices globally, influencing conservation policies and projects designed to safeguard historic towns from neglect, inappropriate development, and the loss of cultural identity. The Charter promotes a sustainable vision for historic urban conservation and remains a cornerstone in global efforts to protect the shared heritage of humanity.

The Nara Document on Authenticity (1994)

The document focuses on understanding the concepts of safeguarding, preserving, restoring, and enhancing cultural heritage. It underscores the importance of authenticity in conservation, emphasizing that authenticity is a dynamic concept that can change over time. The Nara Document describes the importance of

- Cultural diversity
- Participation of local communities
- Promoting international cooperation

- Enhancing education and awareness in cultural heritage preservation

It also emphasizes the need to reflect the values of different communities and the importance of local communities and stakeholders for conserving and managing cultural heritage. (Liang et al., 2023b). This document underscores a framework for understanding the authenticity of cultural heritage sites. Digital technologies should be used to capture and document the diverse aspects of authenticity, including materials, construction methods, social and historical values, and uses. However, it is essential to ensure that the digital representation remains accurate and precise to the original context and avoids misinterpretations.

2.1.3. The Process of Conservation in the Context of Pakistan

Urban conservation is a multidisciplinary concept for safeguarding the built heritage of a region. Contextualizing the concept of urban conservation in Pakistan, which is home to various civilizations, including the Indus Valley, Gandhara, Mughal, Sikh, and British colonial, conservation is a technical exercise and a cultural responsibility (Sohail, 2020). The core objective is to preserve cultural heritage while facing challenges such as rapid and unplanned urbanization, environmental impacts, lack of resources, and limited public awareness.

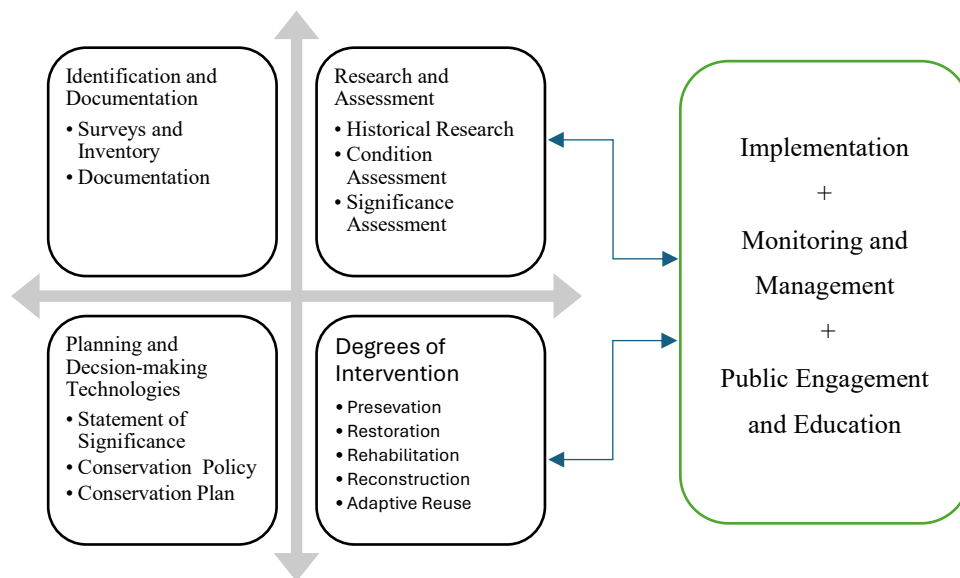


Diagram 2-1: Conservation Practices in Pakistan

Source: Drawn by the Author

a. Identification and Documentation

In Pakistan, the conservation process starts with the Systematic identification of heritage monuments, urban areas, and archaeological sites related to all past historic eras, from ancient ruins to colonial and vernacular architecture.

Survey and Inventory

Institutions such as the Department of Archaeology and Museums (DOAM), provincial heritage bodies, and non-governmental organizations (NGOs) conduct surveys to prepare inventories of heritage sites. (DOAM, 2022). However, significant gaps exist, particularly in documenting rural and indigenous contexts.

Documentation

After preparing a catalogue of heritage sites, a comprehensive record is developed, including architectural drawings, pictorial surveys, condition assessments, historical narratives, and GIS mapping where possible. Accurate and precise documentation is critical, particularly for sites at risk in areas facing challenges of rapid urbanization.

b. Research and Assessment

A robust understanding of the cultural heritage is required for conservation decisions, historical research, condition assessment, and significance assessment.

Historical Research

Archival studies, oral histories, and literature reviews are conducted to establish the historical evolution and provenance of the heritage site. In Pakistan, the research involves navigation between colonial archives, indigenous records, and vernacular oral traditions.

Condition Assessment

The physical integrity of materials, structural stability, and environmental impacts are assessed by multidisciplinary teams. Pakistan comprises diverse climatic zones ranging from arid deserts to humid plains and faces unique challenges to material preservation.

Significance Assessment

Significance assessment includes evaluating historical, cultural, architectural, social, and spiritual values associated with the site (Bartolini et al., 2024).

c. Planning and Decision-Making Technologies

This conservation phase translates the process into implementable strategies, focusing on the ethical considerations and principles within contextual needs.

Statement of Significance

The statement of significance explains heritage value and subsequent interventions. In Pakistan, it requires careful and inclusive framing due to the religious and colonial heritage.

Conservation Policy

During this phase of the conservation process, guidelines are established regarding the extent of permissible interventions, sustainability, and stakeholder involvement. The policies are aligned with national legislation and international charters.

Conservation Plan

Conservation plan includes scope of work, materials specification, traditional construction techniques like lime plaster, stone masonry, scheduling, risk management, and estimated cost. Public-private partnerships and donor funding play key role due to lack of government budgets.

d. Degrees of Intervention

The degrees of intervention vary depending on the needs of the heritage site to be conserved and are classified as follows: -

Preservation

Preservation can be defined as maintaining a structure in its current condition without significant changes. It is not meant to safeguard old structures, but rather to develop a linkage between the past, the present, and the future, fostering a sense of continuity and collective memory (Hassani et al., 2015). In an era of rapid urbanization and modernization, the challenge of balancing modern interventions with conservation becomes increasingly vital. By restoring and protecting architectural landmarks, we preserve the character of the historic environment while ensuring that future generations can appreciate and learn from their historical importance. This research explores the importance of architectural heritage preservation, its challenges, and strategies necessary to safeguard these cultural treasures for ages to come.

Restoration

Restoration of architectural heritage can be defined as returning a structure to its original state by removing later additions and applying historically accurate materials (Moyano et al., 2022c). Through restoration, Societies can maintain their architectural identity. Historic monuments, heritage sites, and culturally significant artifacts provide a tangible connection to the past, reflecting the traditions, values, and creativity of past generations. Over time, these assets often face challenges that result in natural decay due to environmental changes, urbanization, and human neglect. Restoration is not limited to the repair of physical damage but also to reviving the authenticity of the sites, ensuring they remain approachable and profound for future generations. These restoration practices can help to maintain the richness of our collective history and foster a deep appreciation of cultural diversity and legacy.

Rehabilitation

Rehabilitation is adapting a structure for modern use while preserving its historical character, and it plays a crucial role in balancing modern needs with urban conservation. It is essential to preserve the historical buildings embodying architectural styles, craftsmanship, and cultural values of their times to maintain a tangible link to the past (Aboushal & Gharib, 2020). These historical structures can continue to serve their functional purposes while preserving their historic character and significance through the appropriate restoration and accurate modernization.

Rehabilitation not only focuses on preserving the original features and integrity of historical structures but also adapts to modern standards of safety, accessibility, and efficiency. Therefore, it is different from preservation and restoration, and it involves collaboration among all the stakeholders, such as architects, conservation experts, urban planners, and local communities, to ensure that the historical authenticity is respected while making it viable for current and future purposes.

Rehabilitating of historic buildings becomes important as urbanization and modernization have marginalized older structures due to neglect and demolition. It fosters sustainable development by repurposing existing materials and minimizing the need for new construction. Moreover, it creates a sense of pride among the residents by enhancing the aesthetic and cultural richness of cities and towns and increasing tourism.

Rehabilitation safeguards stories, traditions, and the spirit of historic areas, creating meaningful and functional spaces.

Reconstruction

Reconstruction of a historical structure using the original design, often required in post-disaster or post-war situations. It helps to preserve cultural heritage and maintain the architectural legacy of past generations. These reconstructed structures are a tangible connection to history, showcasing artistic, social, and technological records of the eras in which they were built (Bajpai & Perelman, 2012). Natural agents such as aging, environmental factors, and human activities are one of the major causes of the deterioration of historic buildings, and reconstruction aims to restore the original character of the historic environment while ensuring their continued presence and relevance in modern societies.

The key challenge of the reconstruction of heritage structures is to create a balance between authenticity and modern needs while retaining the original character and historical significance of a structure, as well as practical issues such as safety, accessibility, and functionality. It involves using original materials and construction techniques, besides modern innovations, to achieve long-term sustainability.

Reconstruction of historic buildings contributes to cultural identity, education, and tourism while safeguarding architectural heritage. These projects need appropriate planning and collaboration between stakeholders to retain the integrity and authenticity of the unique historical narratives alongside adapting to contemporary needs. In this context, reconstruction emerges as a dynamic endeavor, blending the past and present to structure the cultural landscape of future cities.

Adaptive Reuse

Adaptive Reuse of historic buildings can be defined as repurposing a building for a new function while preserving its historical character. It is an innovative approach to meet the evolving needs of modern societies. Historic structures deteriorate due to human neglect, abandonment, and demolition (Conejos et al., 2018). It offers a sustainable solution to retain architectural and historical significance for new functions. This practice conserves resources and reduces environmental impacts while strengthening the cultural identity of the communities. Adaptive reuse creates a bridge between the past and the future, balancing conservation and modernization. Through adaptive reuse, historic buildings can be transformed into functional spaces useful for contemporary societies.

Implementation

Executing conservation plans requires close coordination among the stakeholders, focusing on the authenticity, craftsmanship, and minimal interventions. Local artisans and craftsmen apply traditional methods, ensuring continuity of intangible heritage (Carbonari et al., 2015). However, their skills are rapidly declining, and there is a need to revive them through training programs. Conservation experts, architects, engineers, and site managers ensure the compliance of established conservation principles and safety protocols. However, regulatory oversight remains inconsistent, emphasizing the need for strengthened institutional capacity within heritage management authorities.

e. Monitoring and Maintenance

Conservation is not a one-time activity but requires ongoing maintenance and monitoring. Regular monitoring involves scheduled inspections and technical assessments to identify new risks like water seepage, pest infestations, and vandalism. Preventive maintenance includes routine care such as removing vegetation, repairing drainage systems, etc. Conservation must integrate resilience strategies for climate adaptation, including flood-proofing and thermal insulation for traditional buildings (McArthur, 2015).

f. Public Engagement and Education

Conservation is incomplete without the inclusion of education and public participation. Public participation in decision-making can enhance the sense of ownership and custodianship. This is particularly crucial in Pakistan, where diverse cultural heritage (Mosques, Shrines, temples, churches, etc.) falls outside the formal protection framework.

Initiatives like heritage walks and public exhibitions are vital in generating public awareness. Museums, visitor centers, guided tours, and digital platforms can also serve as a platform to communicate the significance of heritage sites. Integrating heritage education into schools like universities helps build future generations of conservators and advocates.

2.2. DIGITAL TECHNOLOGIES IN HERITAGE CONSERVATION

Digital Technologies brought a revolution in the field of architectural and urban conservation, focusing on documentation, analysis, restoration, management, and community participation. These technologies increase accuracy, efficiency, and accessibility while minimizing physical changes in the historic structures (Dice, 2018a).

The dynamics between digital technologies and heritage conservation transformed the conservation procedures and practices, including documentation and preservation. The cultural heritage is under grave threat due to environmental changes, urbanization, and human neglect, and it has become evident that finding innovative and effective conservation methods is a priority (Trillo, et al., 2020b). Digital technologies provide effective tools to address these challenges by using new opportunities to preserve both tangible and intangible heritage for future generations.

From total stations to photogrammetry, 3D scanning technology, and virtual reality, digital technologies provide methods for accurate documentation and analysis of historical buildings and heritage sites (Džikić & Radin, 2019a). These digital technologies enable global audiences to interact with cultural heritage in unparalleled ways and enhance accuracy and precision in conservation practices. Moreover, digital databases and cloud-based archives increase the endurance of invaluable records, minimizing the chances of loss due to natural disasters or human activities (Ruffino et al., 2019a).

The inclusion of digital technologies also enhances the interdisciplinary collaborations between archaeology, architecture, computer science, and history. This interaction nurtures innovative and practical approaches to conservation, merging traditional methods with cutting-edge digital solutions (Wu, 2010).

Conservation of cultural heritage has undergone a revolution due to the integration of digital tools, and this study explores the impacts of digital technologies on the conservation procedures and practices, investigating key techniques, case studies, and prospects to ensure the accessibility and continuity of cultural legacy for future generations.

2.2.1. Digital Documentation and Surveying

Digital Documentation and surveying of cultural heritage have become evident practices in preserving and considering the legacy of human history. Cultural heritage, including monuments, archaeological sites, historic buildings, intangible traditions and socio-cultural patterns, showcases the identities of societies (Karasaka & Ulutas, 2023). The need for accurate, precise, and sustainable conservation methods has never been more urgent, due to the rise in risk factors such as natural disasters, climatic changes and human activities, including armed conflicts.

Advancements in the application of digital technologies have transformed documentation, surveying, and conservation methods. Digital tools such as total stations,

photogrammetry, 3D laser scanning, and Historic Building Information Modelling (HBIM) provide a highly accurate, precise, and detailed representation of cultural assets (Rizzi et al., 2007). These digital tools enable the creation of digital twins- exact virtual replicas of tangible heritage that can be analyzed, preserved, and shared with the global community for future generations. Additionally, digital documentation enables interdisciplinary collaboration among the stakeholders to work together flawlessly.

Surveying, as a critical part of digital documentation, provides strong footing for accurate recording and analysis. Traditional methods such as manual measurements and field sketches have been replaced by digital surveying techniques to achieve greater efficiency and accuracy (Guidi et al., 2015). Digital surveying techniques such as high-resolution imaging, LiDAR (Light Detection and Ranging), and drone-based surveys enable us to capture data from challenging and inaccessible locations, ensuring the documentation of the most intricate details.

The inclusion of digital technologies for documentation and surveying supports conservation efforts and provides new opportunities for education, virtual tourism, and public engagement. Virtual reality experiences and interactive 3D models offer broader access to cultural heritage, enhancing global awareness and indebtedness. Cultural heritage remains accessible and protected by maintaining digital records, even in the case of lost physical structures (Quintero et al., 2007)

The use of digital technologies is growing increasingly as digital documentation and surveying techniques continue to evolve. This research investigates the methodologies, tools, and applications of digital conservation practices, focusing on the impact on conservation efforts and the propagation of cultural knowledge. Through this investigation, we aim to highlight the importance of digital innovations in safeguarding the built environment within the context of the historic core of Lahore.

3D Digital Documentation Techniques

Heritage cities, globally, face numerous challenges, including environmental impacts, climatic changes, rapid and unplanned urbanization, and abandonment. (Khalid, 2021b). On the contrary, new methodologies and tools are available that hold the potential to enhance conservation efforts, focusing on historic cities. (Moyano et al., 2022a). Urban heritage includes cultural and natural assets with historic character that go beyond the concept of “Historic Center,” and it is mandatory to grasp much greater urban heritage by using digital technology (Asghar et al., 2021).

In the World Heritage Convention in 1972, UNESCO defined cultural heritage as the body of tangible, movable objects, immovable sites and places, and intangible oral traditions, performing arts, and rituals that have persisted in the present from the past (UNESCO, 2010). In recent years, there has been much discussion on the connection between technology and cultural heritage (Megahed, 2015). These have included studying loss and damage, doing vulnerability assessments and adaptations, reducing human errors, and communicating about the environment (Caroti et al., 2021).

The policies and guidelines for the implementation of digital technologies in heritage conservation have been developed by Governmental organizations and professional entities outside of academia, often focused on adaptation measures for cultural heritage (Sampaio et al., 2021). These policies and guidelines encompass state adaptation plans and damage assessments for built and archaeological heritage, as well as guidance for risk mitigation in heritage properties. There has also been much discussion of the enormous capacity of cultural heritage to foster community resilience and increase awareness of the very real effects of our changing environment (Oreilly & Murphy, 2024).

The opportunity to apply digital technology in novel ways has been made possible by a variety of conservation projects involving historic structures and places, including restoration and refurbishment, adaptive salvaging, defensive maintenance, heritage management, interpretation, documentation, and research (Džikić & Radin, 2019b). Digital technologies are being used more and more by people, organizations, and communities to communicate and record what they value and what they wish to leave for future generations. An all-encompassing word, "digital technology" includes any kind of electronic communication, including radio, television, cellular phones, computers, and network hardware and software. Global academic and professional practice is progressively acknowledging the use of digital technology in the cultural sector (Henchoz & Crank, 2018).

Various digital tools are being employed in the preservation of cultural heritage. The digital technologies include 3D modeling & data capturing, HBIM, laser scanner, digital photogrammetry, digital stereoscopy, digital image editing, and augmented reality, among other technologies that are now used more and more for the preservation, representation, enjoyment, and promotion of our cultural heritage.

Culture and legacy are no longer the sole purview of archaeological specialists. In this situation, the function of digital technology in cultural preservation has changed. Currently, it

serves as a tool for regional and local communities' social and economic growth as well as a means of communication across cultural boundaries. By combining digital technology with heritage preservation, it is possible to improve tourist destinations for cultural tourism as well as public engagement in study and maintenance of historical relics (Ursini et al., 2022a).

Historic Building Information Modeling (BIM), a specific use of technology, has grown in popularity. However, this has been more apparent in new construction projects than in older structures. The word "BIM" refers to a collaborative method for the creation and administration of structured electronic information rather than a particular instrument (Trillo, et al., 2020b).

The proper planning, execution, and monitoring of conservation programs all depend on heritage information. For this reason, managing and acquiring knowledge is crucial to comprehending cultural heritage. Digital technologies have completely changed how quickly, and thoroughly cultural sites are recorded; these methods provide a plethora of new options for gathering, evaluating, and sharing information about heritage sites (Bruno & Roncella, 2019b). Conflicts and a concerted attempt to include digital media in the training of conservation experts also accompany these new prospects.

To process, store and transmit information through digital circuits, equipment and networks, analog information in any form (text, photographs, voice, etc.) must be converted into digital form using electronic devices (scanners, cameras), etc.). "Cultural, educational and scientific resources, as well as technical, legal and other types of information created digitally, or converted from existing analogue resources into digital form" are all included in the definition of digital heritage (International Charter for Digital Heritage, 2009). The definition also includes "the use of digital media in the service of cultural or natural heritage conservation".

Impacts of Digitization of Urban Heritage

According to a UN study, 55% of the world's population currently lives in cities, and that number is projected to rise to 68% by 2050 (United Nations, 2018). Existing cities will be under enormous pressure to accommodate this growth in people and services, affecting the built urban fabric. Many historic buildings in Alexandria were demolished and rebuilt with large concrete blocks, threatening the city's character. Cities need historic buildings so desperately that vibrant streets and districts may be impossible to develop without them. These heritage-listed structures are an essential element of the community and urban fabric (Younus et al., 2023a).

In the twenty-first century, digital documentation has significantly changed as a technique for preserving cultural assets. Virtual databases, accessed and browsed through portable devices, maintain extensive information about preserved objects. To address the primary techniques of digital documentation and their implications for the urban conservation process, the research develops a theoretical and methodological framework for the digital documentation of urban heritage (Stengel & Schultmann, 2023).

The key challenges, such as climate change, environmental degradation, and socio-economic inequalities, are affecting the dynamics of urban development, and it has become imperative to rethink the urban development paradigms. These elements influence social interactions and health, resulting in a decline in tourism and culture industries. Therefore, cultural heritage must be protected to promote tourism resilience. It is also important to understand the potential of cultural heritage as a socio-economic driver. Digital technologies in the conservation practices are evident in this historic setting (Jordan-Palomar et al., 2018).

Cultural heritage documentation is a significant part of conservation practices, and artificial intelligence, virtual reality, multimedia, broadband networks, and databases are valuable tools to provide an innovative approach using computers and mobile devices. Over time, the integration of digital technologies in traditional methods has transformed conservation methodologies.

The goal of the research is to examine several technologies that manage urban history in a virtual environment (Osello et al., 2018a). The study examines the need to digitize conservation procedures and practices, including surveys, documentation, monitoring, and management. The research provides a historical context that examines the origin of these digital technologies and their evolution to the implementation of digital methods. The research also discusses the impact of digital recording technologies in various areas, including accelerating architectural education to create a more sustainable future (Murphy et al., 2017).

There is a consensus that local identity, diversity, and community resilience are essential to the sustainability of conservation. Therefore, cultural policies are crucial to achieving sustainable objectives, and digital technologies are having a significant impact on local industries to face the challenges of cost, technical, and legal requirements (Banfi et al., 2019).

The goal of analyzing this data is to clarify the dynamics between the three fields and their practical contradictions, shedding light on the interaction between digital technology,

planning theory, and tangible heritage conservation in the city. In doing so, the aims are to provide suggestions that professionals working for heritage conservation agencies, local governments, professional practices, charities, and digital technology businesses can use to inform smart heritage conservation planning practices worldwide. (Trillo, et al., 2020b).

2.2.2. Spatial Analysis in Conservation

Spatial analysis plays a crucial role in the conservation of cultural heritage by providing tools and techniques to study, manage, and preserve historical sites, monuments, and landscapes. Spatial analysis supports this field in:

Mapping and Documentation:

Digital tools such as total stations and 3D laser scanners help to create detailed maps of cultural heritage sites, documenting their exact location, boundaries, and condition.(Chulia & Puchalt, 2023) High-resolution satellite imagery, aerial photography, and drones capture spatial data for hard-to-reach or expansive heritage areas.

Site Analysis and Management:

Spatial analysis enables the assessment of the environmental context of a heritage site, including topography, climate, and proximity to natural hazards. Buffer analysis identifies risk zones around heritage sites, like flood-prone or earthquake-affected areas, aiding in risk management and preventive conservation.

Condition Monitoring:

Remote sensing techniques, such as LiDAR or multispectral imaging, help monitor structural integrity and detect changes in heritage sites over time. Spatial data can track erosion, vegetation growth, or urban encroachment around archaeological sites.

Cultural Landscape Preservation:

Spatial analysis helps identify historical land-use patterns and preserve cultural landscapes, ensuring their environmental and cultural context remains intact. By analyzing spatial relationships, conservationists can protect tangible (buildings, monuments) and intangible heritage (sacred spaces, traditional agricultural practices).

3D Modeling and Virtual Reconstruction:

Spatial data is used to create 3D digital models of heritage structures, aiding in virtual restoration and educational outreach. Digital twins of cultural heritage sites allow researchers to experiment with different conservation techniques without risking physical damage.

Tourism Management:

By analyzing visitor flow and foot traffic, spatial analysis helps prevent over-tourism and wear on heritage sites. Smart mapping systems direct tourists along sustainable routes, balancing accessibility with preservation.

Community Engagement and Cultural Mapping:

Participatory GIS involves local communities in mapping culturally significant sites, capturing indigenous knowledge, and oral histories. Cultural heritage inventories created through spatial analysis ensure that both famous landmarks and lesser-known cultural assets are documented and protected.

2.2.3. Heritage Building Information Modeling (HBIM)

The HBIM library utilizes data from historical and architectural documents as well as cutting-edge digital scanning techniques to produce three-dimensional digital models for any architectural style or process. A variety of instruments for conducting the building analysis are now available due to recent advancements in sophisticated surveying techniques. The use of 3D interactive models in the preservation sector is reserved for select, exceptional circumstances, and the data included in high-resolution virtual representations is still in its infancy (Brusaporci et al., 2023a).

In previous centuries, the emphasis on representation was on the theoretical functions of descriptive geometry devoted to the representation of the complexity of architectural features in space to control the process of a construction site. The previous ability to manage 3D objects in space has gradually disappeared. Because HBIM is based on 3D solids representation, the 3D model concept is once again prominent.

To construct three-dimensional digital models for any architectural style or procedure, the HBIM library uses data from historical and architectural documents alongside cutting-edge digital scanning techniques. As a result, the parts of this new library enable a more accurate interpretation of the heritage structures that have been evaluated. They may also be used to

create aesthetic preservation documentation (floor plans, scenes, facades, sections, cuts, details, perspectives, etc.) and virtual 3D models (Younus et al., 2023a).

The intricacy of architectural history and its components shows a lack of standards, protocols, and best practices in HBIM modeling. The initial stage of HBIM production has become the defining feature of the DIY modeling process in recent years. Within HBIM, the modeling step is entrusted to one person's responsibility without any guidelines about the degree of accuracy or geometry.

Beginning with a series of experiences, the Level of Geometry and the Level of Accuracy (LOA) of each BIM item were determined by applying sophisticated survey techniques to the assessment needed by the HBIM approach to architectural preservation. The goals of surveying and HBIM might alter depending on a variety of factors, but in the context of preservation, it is essential to consider the uniqueness and complexity of each individual object. This is like surveying, where the choice of a scale implies a range of accuracy and tolerance in data acquisition and processing.

The requirements traditionally used for surveying have been suggested and extended to the HBIM domain, specifically in the modeling of objects, to categorize different accuracy levels based on various experiences that have occurred in recent years. To maintain the benefits of a multi-resolution model, diversify in function of the aims, and consequently of Level of accuracy (and Level of Information) and Level of Geometry, the architectural scale is taken into consideration together with the urban scale (Heritage Urban Level).

HBIM and Sustainable Future

The idea of Historic Building Information Modeling (HBIM) utilizes the BIM approach for architectural heritage and focuses on integrating transparent documentation relating to the object's history, technical details, and construction in addition to its architecture. A workable technique for the sustainable management of constructed cultural assets is referred to as "HBIM." Resistance architecture is defined as "architecture that resists war through the background of a ruling policy and social and cultural interaction, serves all the affected people, and takes into consideration the culture and identity of society by paying attention to studying the distinctive characteristics of local communities, recording and documenting it to realize its value, and rebuilding on its basis." It is reflected in the war-related architectural movements, such as resistance and reconstruction. Resistance that adopts a developmental paradigm and transforms the catastrophe into developmental labor is described. (Ali & Sherzad, 2022).

The benefits of sustainable HBIM development are, in contrast to other 3D models created using other parametric modeling techniques, where the primary output is merely for viewing, HBIM offers automatic documentation. (Fai et al., 2011).

- By aiding budgeting for conservation and enabling community knowledge, HBIM aids building upkeep. Models may be seen with free viewer programs (Baik et al., 2013).
- Before deciding on the ultimate course of action, HBIM offers a thorough study of the planned repairs and improvements (Baik et al., 2014).
- HBIM extends the documentation environment by including information about materials, structural processes, and building pathologies (Fai et al. 2011).
- HBIM depends on the assistance of architectural reference books to create architectural rules and detail (Baik & Boehm, 2015).

The first form of digital documentation is the creation of a digital display platform. There are four subsequent approaches. In this method, all information from both image and non-image techniques is gathered to create a computerized database of urban history components. To make this knowledge accessible, it also creates geometric representations of these components and 3D retrieval techniques. By offering a 3D study of the construction phase with architectural characteristics, building processes, materials used and its leading architectural styles, the virtual database improves the depiction of documented objects. The purpose of using 3D printing technology is to create replicas of virtual 3D models, to explore architectural ideas. Similarly, this technology can be used in the rehabilitation of built heritage by printing architectural elements (Ruffino et al., 2019b).

A third technique uses HBIM technology, which provides multidimensional analysis to virtual databases. To manage urban cultural resources and incorporate them into planning schemes for the sustainable development of urban areas, HBIM provides advanced analyses. By incorporating digital identities into protected zones, the physical world – which features the architectural features of structures and urban spaces – acquires a virtual layer. Tools for on-site identification improve on-site exploration of architectural ideas. In addition, they depict how the area originally appeared during its formation and growth. By incorporating digital interpretation techniques into urban planning strategies, historic landmarks and structures become more vibrant and attractive, facilitating the development of cost-effective projects and increasing revenue (Elashry, 2019b).

To examine the status of a property's structure and fabric and to create reports, schedules of condition, schedules of dilapidations, or specifications for maintenance and repair plans, building surveys are used. Archaeological explorations of the physical remnants of former cultures, such as buried artifacts, standing structures, and ruins (Gomes, 2023). The topic of this contribution is the creation of a measured survey that will act as the basis for other evaluations, such as building and archaeological surveys that will reveal the current state of conservation through a formal inspection of the significance, character-defining elements, integrity of materials, defects, damages, and/or decay (Rocha et al., 2020).

Its goal is to organize and visually represent all data related to cultural origin into a digital information model that all management agents may use. An analytical survey in three dimensions, historical development in four, diagnostics in five, cultural context in six, and conservation and intervention in seven make up the model. HBIM is a useful tool for sustainable management and goes beyond just the technical characterization of the cultural asset.

2.3. CONSERVATION EFFORTS IN PAKISTAN

Pakistan has a wealth of rich cultural, architectural and urban heritage, spanning from ancients' civilizations, Indus Valley to Mughal, Sikh, colonial and modern period. Due to rapid and unplanned urbanization, environmental degradation, climatic changes, and human neglect, most of the heritage sites have been deteriorating and diminishing. However, various government bodies, NGOs, and international organizations are actively playing their role in preserving these historical assets. Cultural heritage in Pakistan encompasses archaeological sites, historical monuments, urban areas, traditional crafts, language, music, traditional values, and norms (Ali, 1990a). During the last few decades, the conservation of cultural heritage in Pakistan has been accomplished on priority basis, focusing on both tangible and intangible features of this inheritance. The protection of historical monuments, urban areas, and archaeological sites has always been one of the key areas of conservation. Pakistan is home to six UNESCO World Heritage Sites (UNESCO, 2010b).

In 1980, the first three listed sites were the Archaeological Ruins at Mohenjo-Daro, the Buddhist Ruins of Takht-i-Bahi and the neighboring city Remains at Saher-i-Bahlol and Taxila. In 1981, two other listed sites were Historical Monuments at Makli, Thatta, and Fort and Shalimar Gardens in Lahore. In 1997, the most recent site, Rohtas Fort was added to the list. All six sites are cultural and have been deteriorated due to the environmental effects,

rapid and unplanned urbanization and lack of appropriate maintenance (Mughal, 1995). Furthermore, 26 Heritage sites have been proposed to be added to the list of UNESCO World Heritage Sites (UNESCO, 2010b). The Government of Pakistan is collaborating with International Agencies like UNESCO, USAID, Aga Khan Cultural Services of Pakistan (AKCSP) to preserve these historic landmarks.

Museums and Cultural institutions are collaborating with Authorities in conservation efforts. The National Museum of Pakistan, Lahore Museum, and Lok Virsa Museum among those protecting artefacts, manuscripts, and art pieces that showcase the country's heritage. These institutions often conduct seminars, workshops and educational programs to raise public awareness about cultural preservation (Abbas & Wakil, 2023).

Intangible heritage such as traditional music, languages and crafts is equally important and Organizations like the National Institute of Folk and Traditional Heritage (Lok Virsa), and Dachi work to document and protect the diverse cultural expressions. Festival and cultural events also serve as podiums to present and sustain traditional practices. Despite these conservation efforts, cultural heritage in Pakistan is at grave threat and faces challenges. The limitations to protect this wealth of cultural heritage are limited funding, lack of technical expertise, and insufficient public awareness and to address these issues, there is a need for stronger policy implementation, public participation, and increased investment in cultural heritage projects (Sohail et al., 2020).

In conclusion, there is a need for collaboration between government bodies, Local communities and international organizations to continue these conservation efforts to safeguard this valuable legacy for future generations.

2.3.1. Legal Framework and Policies

The existing legal frameworks and policies support heritage preservation, and there is a need to amend these frameworks and policies after the transformations in conservation methodologies and practices. The research investigates the legal frameworks and policies for the inclusion of digital technologies to protect urban built heritage.

Antiquities Act (1975)

During the British rule, the legislation for the protection of cultural heritage was initiated, and the Ancient Preservation Act 1904 was enacted to protect heritage sites. The jurisdiction of this act applied to the whole country. After many efforts, the Antiquities Act was enacted in 1975, an extension of the Ancient Monuments Preservation Act 1904, the

Antiquities Act 1975 was amended multiple times, and the latest amendment was in 2012. For the inclusion of a Framework based on the application of digital technologies, an amendment is needed, and the Act can help to outline the Digital Conservation Framework, rather than to constitute a new Act for that purpose. The Act can help in the areas as follows: -

- The Antiquity Act 1975 ensures the government of Pakistan can acquire and protect antiquities. Digital tools such as total station, 3D scanning, high-resolution photography, and LiDAR technology can develop comprehensive digital inventories of historic monuments of Lahore.
- The digital documentation includes precise record-keeping, long-term preservation, and research opportunities according to the objectives of the ACT.
- The Act prohibits illegal activities such as the destruction and damage of antiquities and historic properties. Digital investigation systems and remote management and monitoring tools can be implemented to detect potential threats.
- The ACT promotes tourism to make dynamics through virtual tours, an online database, and interactive exhibitions to promote the visualization of heritage sites. It will help to enhance the socio-economic status of the area.

The ACT helps in knowledge sharing regarding antiquities. Digital platforms can interact with researchers, conservation experts, and the public, enabling information exchange.

Environmental Protection Act (1997). - Parliament of Pakistan

The Environment Protection Act 1997 does not directly deal with the documentation, either conventional or virtual, but environmental protection and sustainable development are dealt with by the department concerned. By focusing on digital tools in the realm of environmental protection and sustainable development, the department can create a comprehensive and holistic approach for the protection of the historic core of Lahore.

- The Act advocates for reducing environmental threats such as air and noise pollution, which are identified as historic structures and artifacts. Digital tools such as 3D laser scanning can document the damage and status of the heritage sites to prepare conservation plans and future records. These tools can perform as a virtual archive, in case physical deterioration occurs.
- The Act promotes sustainable development, which can enhance the tourist value, but it is mandatory to check the air quality to facilitate foreign tourists. Digital tools like

virtual tours and panoramic views can reduce foot traffic and associated environmental impacts and minimize the carbon footprint from travel.

- This encourages energy conservation, connecting to digital preservation's potential to reduce physical handling and storage requirements for artefacts. Digitization of records can reduce paperwork, ultimately saving energy resources.
- The Act develops community participation in protecting the environment. Digital platforms can engage communities through cultural heritage initiatives. Interactive exhibits and online forums can educate the public about environmental issues related to cultural heritage.

Punjab Special Premises Ordinance 1985

The conservation of antiquities and heritage sites is the responsibility of the Government of Punjab, under the Punjab Special Premises (Preservation) Ordinance 1985. This advocates the protection of historical monuments and archaeological sites within the province of Punjab. While this ordinance is primarily concerned with physical conservation, the inclusion of digital technologies can help the implementation of physical conservation. However, there is a need to develop a framework for the implementation of digital conservation.

The ordinance involves physical preservation through measures like restricting alterations and demolitions. Currently, it does not address digital preservation. However, the digital world is offering valuable tools for the development of High-resolution 3D models generated through various types of tools and software.

In general, the Punjab Special Premises (Preservation) Ordinance 1985 is working in the protection of antiquities and heritage sites, within a framework defined for the completion of the task (Institute, 2010). However, the inclusion of digital technologies within the framework can enhance the efficacy of the department, and digital technologies can also receive legal protection.

Walled City Lahore Act 2012.

The Walled City Lahore Act 2012 is evidence of Pakistan's dedication to safeguarding its rich cultural heritage. The authority was established to handle all the mandatory issues for restoring this urban fabric. This authority deals with the physical conservation, including documentation, record-keeping, and maintenance of the heritage site. Including digital technologies (which have already started) can foster conservation efforts and monitoring

procedures(Husnain, 2024). The WCLA Act 2012 has already framed guidelines about conservation procedures and practices. However, it does not include any framework about applying digital technologies to a specific type of artefact. Research is needed to determine the constraints of conventional methods and the benefits of virtual methods in developing a hybrid approach to the kind of urban fabric.

2.3.2. International, National & Provincial Organizations and Authorities

The Conservation of the historic core of Lahore is the responsibility of the Walled City Lahore Authority, which collaborates with international funding agencies, and AKTC is playing the leading role.

Aga Khan Cultural Services of Pakistan (AKCSP)

The Aga Khan Cultural Service Pakistan (AKCSP) is the local entity of the Aga Khan Trust for Culture (AKTC), an international non-profit organization. AKCSP focuses on the restoration and rehabilitation of historic structures and public spaces in Pakistan.

Table 2-1: List of National and International Organizations with Their Key Responsibilities

Source: Mughal, 1995

Level	Organization	Key Responsibilities
National	Department of Archaeology and Museums (DOAM)	Conservation, excavation, management of federal heritage sites, and museums.
	Pakistan National Council of the Arts (PNCA)	Promotion and preservation of intangible cultural heritage and arts.
	National Heritage and Culture Division	Policymaking involves coordination between federal and provincial bodies.
Punjab	Punjab Archaeology Department	Preservation and restoration of historical sites like Shalimar Gardens and local museums.
	Walled City Lahore Authority	Restoration and preservation of historic monuments such as mosques, temples, havelis, forts, gurdwaras, etc. Urban regeneration and provision of infrastructure within the Walled City of Lahore. Promotion of cultural tourism and community engagement. Removal of encroachments, Regulation of signage, and urban aesthetics in the zones of historic value.
Sindh	Sindh Culture, Tourism, Antiquities & Archives Department	Protection of heritage sites like Makli, Mohatta Palace, and community engagement.
Khyber Pakhtunkhwa	Directorate of Archaeology and Museums, KP	Conservation of Gandharan sites like Takht-i-Bahi and museum management.
Baluchistan	Directorate of Archaeology and Museums, Baluchistan	Preservation of sites like Mehrgarh: limited resources and accessibility issues.
AJK	AJK Department of Archaeology	Conservation of forts, shrines, and promotion of regional tourism and heritage.

2.3.3. Case Studies of Conservation Projects in Pakistan

Over the past four decades, the conservation of architectural heritage has gained increasing academic and professional attention, driven by a growing awareness among the stakeholders. The projects executed under various institutes serve as examples that illustrate the complexities, successes, and limitations within the Pakistani context (Zahid & Misirlisoy, 2021). The selected case studies underscore the methodologies employed, the socio-cultural and economic challenges faced, and the broader implications for heritage management in post-colonial contexts.

Makli Necropolis, Thatta (2006–Present)

Makli is one of the largest necropolises in the world and has been listed in UNESCO World Heritage Sites; it reflects a different scenario, shaped by monumental scale, exposure to environmental degradation, and lack of integrated management frameworks (Eppich et al., 2019). The conservation works were done under the umbrella of Endowment Fund Trust for the Preservation of the Heritage of Sindh (EFT), focusing on emergency stabilization and long-term sustainability. It involves intricate work on stone masonry, tile work, and domed structures, as well as ongoing risk assessment due to climatic and seismic threats. The projects highlight the challenges of heritage conservation in the regional context, where limited institutional capacity, inadequate documentation, and complex ownership patterns hinder comprehensive interventions. It also indicates identity politics and regional marginalization in heritage policy discourse (Qasim, 2014).

Baltit Fort, Hunza (1990–1996)

Aga Khan Cultural Services of Pakistan (AKCSP) facilitated the conservation of Baltit Fort in Gilgit-Baltistan, and it is an excellent example of the adaptive reuse in a remote mountainous context. Originally a 700-year-old structure, the fort was restored using traditional materials and techniques, focusing on the seismic retrofitting measures (Akbar et al., 2022). Local artisans were trained during the conservation works, promoting capacity-building and the revival of indigenous construction skills (Azeem et al., 2024). The fort was restored as a museum and cultural center, creating economic opportunities and fostering community ownership. It ensures the importance of contextual sensitivity, sustainability, and community participation in heritage projects (Mahmood et al., 2022).

Frere Hall, Karachi (Ongoing)

Frere Hall Karachi is an iconic colonial-era building and could not be restored due to bureaucratic inertia and conflicting jurisdictional claims. Through recent efforts by Karachi Metropolitan Corporation (KMC) and civil society groups, the aim is to restore the deteriorating masonry, stained glass windows, and structural elements. Issues such as politicization of heritage sites, lack of continuity in conservation policies, and insufficient technical expertise continue to impact its progress (Gul et al., 2023). It serves as a case to analyze the tension between colonial legacies, urban development pressures, and heritage valorization in post-colonial metropolitan centers.

Gandhara Sites in Taxila and Swat (Various Projects, 1980s–Present)

The architectural conservation of Buddhist sites from the Gandhara period, including Butkara and Saidu Sharif, illustrates the role of international collaboration in heritage conservation. These projects focused on excavation, structural consolidation, and museum development, facilitated by Japanese, and Italian missions. It also shows a concern to prioritize old heritage and reveals implicit biases in heritage funding and narratives. The sites thus present the ideological underpinnings of heritage selection and negotiation of religious and cultural pluralism in conservation practices.

Conclusion of the Case Studies

These case studies demonstrate that conservation in Pakistan operates at the intersection of technical rigor, institutional complexity, and cultural politics. The projects such as Shahi Hammam and Baltit Fort are excellent examples of community-centered and interdisciplinary approaches, while Frere Hall and Makli necropolises underscore persistent systematic challenges.

A comparative analysis of these case studies reveals the need for a comprehensive and cohesive national heritage policy, capacity building programs, and inclusion of local communities as active stakeholders. Consequently, it also identifies that conservation in Pakistan is a contested cultural process, embedded within broader narratives of identity, memory, and post-colonial urbanism, rather than a technical enterprise (Bahadur, 2022).

2.4. LAHORE'S HISTORIC CORE: PREVIOUS STUDIES AND CONSERVATION ATTEMPTS

The historic core of Lahore, encompassing the Walled City and its context, is a dense urban fabric that carries centuries of cultural heritage (CH) and political history. This area is a continuously inhabited settlement for eleven centuries. It has witnessed a range of historic periods from the Ghaznavids, Mughals, and Sikhs, the colonial to the post-colonial. It is urban morphology, characterized by narrow winding streets and courtyard houses (Havelis). Religious structures and monumental gates blend South Asian Islamic, Persianate, and colonial architectural idioms (Latif, 1994b).

Lahore has gotten the attention of the conservation community since the late 20th century, focusing on architectural typology, urban transformations, and socio-spatial dynamics. Despite its cultural significance, conservation efforts remained sporadic and fragmented. During the colonial era, early preservation attempts by the Department of Archaeology were primarily object-oriented and monument-centric (Sohail et al., 2020). However, those recent initiatives, particularly led by WCLA in collaboration with AKTC, have adopted integrated conservation approaches for urban conservation.

This section critically reviews the conservation projects, planning initiatives, and academic studies within HCL. It aims to contextualize these efforts within the limits of heritage governance, colonial legacies, and challenges of conserving living cities in the Global South. Through this lens, it seeks to assess the evolution of conservation paradigms in Lahore and their implications for future heritage management.

2.4.1. Lahore Improvement Trust (LIT) - (1938-1975)

The Lahore Improvement Trust (LIT) played a vital role for the conservation and restoration of the historic city of Lahore which is one of the most significant ancient cities in Pakistan (Husnain, 2024). Lahore Improvement Trust has conducted few very significant project for the preservation of the historic core of Lahore (Lahore Improvement Trust, 1980)

Table 2-2: Projects Completed by Lahore Improvement Trust (LIT)

Source: (Abbas & Wakil, 2023; Hankey, 1999)

Project	Goals /Achievements
Restoration Projects	LIT has organized a lot of projects, focusing on the preservation of the urban built heritage within Walled City of Lahore. The scope of the projects is renovation of the historic structures, monuments and infrastructure, ensuring structural stability and authenticity.
Infrastructure Development:	LIT has focused on the upgrading of the infrastructure of the Walled City to enhance the quality of life of the residents and visitors. The provision of infrastructure includes fixation of streetlights, upgrading sanitation facilities and improvement in transportation facilities. The most significant project of LIT is” the Lahore Urban Development and Traffic Study (LUDTS) (Lahore Development Authority, 1980).
Heritage Walks and Tourism Promotion:	LIT has headed projects such as heritage walks and cultural events to attract tourists and visitors to enhance the tourist values of the monuments. The core objective of the activity is to generate awareness among the residents and other stakeholders to promote tourism for economic sustainability in the area.
Collaboration with Stakeholders	The LIT collaborated with various stakeholders such as Government Agencies, Conservation Experts, Conservation Community, Local Communities, and international funding Agencies for the coordination to implement conservation projects. This approach can help to share technical expertise and other resources.
Public Participation and Community Engagement	It was strongly recognized that community participation can play a significant role in the process and practices of conservation. The LIT engaged residents and stakeholders in the Walled City of Lahore. The task was completed through public meetings, awareness campaigns, and capacity building programs to strengthen local communities to have ownership of their heritage through active participation programs.

Generally, the Lahore Improvement Trust put all efforts to preserve the historical assets within Walled City of Lahore. The institute fulfilled the assigned task by promoting sustainable development practices to balance preservation with urban regeneration. By making efforts for the conservation of the urban fabric of the city, LIT contributed to the socio-economic growth of the city.

2.4.2. Lahore Development Authority (LDA) - (1975 - 2012)

The Lahore Development Authority (LDA) was established in 1975 and it is an extension of Lahore Improvement Trust (LIT). LDA has played key role in the conservation of the old city of Lahore, collaborating with the Pakistan Environmental, Planning and Architects Consultants (Put) Ltd., Aga Khan Cultural Services of Pakistan (AKCSP), World Bank,

Norwegian Embassy, and USAID. There are few key challenges which was dealt by LDA (World Bank, 2005).

Table 2-3: Projects Completed by Lahore Development Authority

Source: World Bank, 2005

Projects	Achievements
Heritage Preservation and Restoration	The LDA has taken initiatives, many times for the protection of historic city and tried to rehabilitate its open spaces with cultural activities. Priority was given to the protection and restoration of the historic monuments with minimum interventions as a landmark of the glory of the past. They also joined hands with conservation experts and organizations to ensure the projects integrity to international standards and guidelines.
Regulatory Frameworks and Guidelines	The LDA develops regulatory frameworks and guidelines for sustainable development within the Walled City Lahore, giving heritage preservation on a priority basis. This includes the development of building codes, zoning regulations and design guidelines for the construction of new structures.
Urban Planning and Development	As part of its mandatory duties, LDA is responsible for the urban planning and urban developments to create a balance between development and conservation, ensuring that new constructions are aligned with the traditional architecture.
Infrastructure Improvement	The LDA plans infrastructure improvement projects within Walled City of Lahore to enhance the residents and to develop the city's life pattern according to the modern needs. It includes provision of electricity, development of sanitation system, and development of transport network within the area.
Public Awareness and Education	The LDA conducts public awareness programs to enhance the public participation. Rangila Richshaw, A night in Walled City is a program which develop visual communication of the heritage with the visitors.
Collaboration and Partnerships	The LDA develops collaborations with stake holders including Government Agencies, International partners and residents. The LDA collaborates with all the stakeholders, including Government Agencies, heritage community, international partners, and conservation experts and plan the best conservation policies, ensuring the coordinated conservation efforts.

Generally, Lahore Development Authority plans for the new developing areas and societies and existing communities upgrading. The conservation efforts of LDA reflect the commitment of the department progress of the city.

2.4.3. Lahore Development Authority (LDA) & Pakistan Environmental Planning & Architectural Consultants (PEPAC) - (1988-1993)

Pakistan Environmental Planning and Architectural Consultants (PVT) Ltd. (PEPAC) was actively involved in the preservation of the historic city of Lahore. PEPAC developed an

inventory of the buildings and documented that almost 3500 buildings can be protected out of 18000 structures within Walled City of Lahore. PEPAC prepared a conservation framework for the conservation of urban fabric of the Walled City of Lahore. Fifty buildings were selected for the conservation in first phase and 30 of them were documented in Monograph (PEPAC, 1993).

Table 2-4: Projects Completed by LDA & PEPAC

Source: PEPAC - LDA, 1986

Projects	Achievements
Conservation Projects	PEPAC has started the conservation works within the Walled City of Lahore, with the collaboration of LDA. The goal of these projects was restoration and conservation of the urban fabric of the Walled City Lahore.
Documentation and Research	PEPAC conducted extensive surveys and documented research activities to study architectural, historical and cultural significance of the Walled City Lahore. This research is supported to formulate conservation strategies based on the issues and strategies, guideline for developed for the tailored approaches.
Capacity Building	PEPAC organized workshops, seminars and training programs to build the capacity of local craftsmen, artisans, and conservation professionals involved in the project. These efforts make it possible to transfer expertise and knowledge among the stakeholders.
Public Awareness and Education	PEPAC arranged campaigns for public awareness and educational benefits for the preservation of the old city of Lahore. Such type of initiatives supported the local communities, students, tourists and policy makers to foster preservation efforts.
Community Engagement	During the efforts for the conservation of the historicity of Lahore, community was engaged through consultation meetings, heritage walks, and cultural events that encourage the residents to feel pride and actively participate in the conservation.
Partnerships and Collaboration	PEPAC collaborated with the World Bank under the umbrella of Lahore Development Authority and contacted international funding agencies and National organizations and individuals working in the field of Conservation to enhance the conservation of the historic fabric of the old city of Lahore.

Overall, the organizations prove itself as a gateway towards the protection of the historic city, focusing at the preparation of buildings inventories according to their categories, documentation of the monuments, Categorization of the monuments and identification of the zones of special values. The project was going smoothly, but the funding collapsed due to the decision-making authorities. The work done by the PEPAC is acting as Light house for the coming institutes and served as a foundation for the development of conservation strategies...

2.4.4. Sustainable Development of Walled City of Lahore (SDWCL) & Aga Khan Cultural Service Pakistan (AKCSP) - (2009-2014)

The Sustainable Development of Walled City Lahore is a comprehensive initiative aimed at preserving and revitalizing the historic Walled City of Lahore while promoting sustainable development practices. Here are some key aspects of the project.

Table 2-5: Conservation Work Completed Under the SDWCL

Source: AKCSP, 2010

Projects	Achievements
Conservation and Restoration	The project focused on the restoration and preservation of historic monuments and rehabilitation of open spaces within the historic core of Lahore. It included architectural preservation of heritage treasures to maintain the identity of the city and preserved a few significant monuments.
Infrastructure Improvement	Infrastructure of the Walled City was upgraded according to the plan developed by LIT to upgrade the living status of the community. It also worked for the solutions towards development of transportation network and vehicular movement within the city.
Heritage Tourism Development	The project focuses on enhancing the tourist value of the site to display heritage sites on the platform of the world. The activities strengthen the socio-cultural network and help to introduce the city in international heritage communities.
Sustainability Initiatives	The project is entitled as “Sustainable Development Walled City Lahore”, therefore, the main objective of the project was sustainable developments within the historic core, with the conservation of historic monuments. The project was completed by LDA, AKCSP and NRA with other stakeholders.
Public-Private Partnerships	The project was completed with the public –private partnerships including Government Agencies, non-profit organizations, conservation experts, and local communities.

In general, LDA has completed several significant projects under the “SDWCL” for the conservation of Walled City Lahore. Through this project, local communities were empowered and Walled City Lahore opened its gates for tourists and visitors.

Shahi Guzargah (Royal Trail)

Starting from Delhi gate to Royal Throne (Lahore Fort), the project is termed as “Sustainable Development of Walled City Lahore”. The Royal Trail route was selected for its first phase. The royal trail was named Shahi Guzargah. The visitors of the emperor coming from Delhi were used to travelling through this royal trail. It remained as the main spine and the most significant area of the Walled City of Lahore.

The Shahi Guzargah links many of the landmark monuments of the Walled City, including the Delhi Gate, Shahi Hammam, the Chowk Wazir Khan, Wazir Khan Mosque, Sonehri Masjid, Chooni Mandi Girls College, the Begum Shahi Mosque, and the Lahore Fort. The exact route is enriched with havelis and heritage homes. The Shahi Guzargah project was launched in 2012. In its interventions, the project has been an extremely complex but rich and rewarding one. Beginning from Delhi Gate, WCLA has restored a 383-meter-long stretch of the heritage trail leading up to Chowk Kotwali. The trail comprises 54 streets, 655 Houses, and 157 shops (Seraj, 2019). The Project encompassed the rehabilitation of the street facades of nearly 850 buildings. It includes the provision of infrastructure such as electricity, gas for domestic use, a drainage system, and a water supply to the houses located in small, winding streets. It also includes the provision of safe and better standards of public health. The project focused on the removal of encroachments into the public right-of-way and the provision of street pavement. (World Bank, 2005).

The two key monuments, Shahi Hammam and Wazir Khan Mosque, were badly encroached upon, and the facades of these historic monuments were hidden by illegal shops. Almost 72 shops were demolished from the front of the Wazir Khan Mosque, and 57 shops were demolished permanently from the Shahi Hammam to uncover the facades of the monument. The removal of encroachments was part of the Resettlement Action Plan (RAP), and it was completed under the guidelines of the World Bank. The revitalization of the Royal Trail (Shahi Guzargah) was completed in four phases: each phase being known as a package.

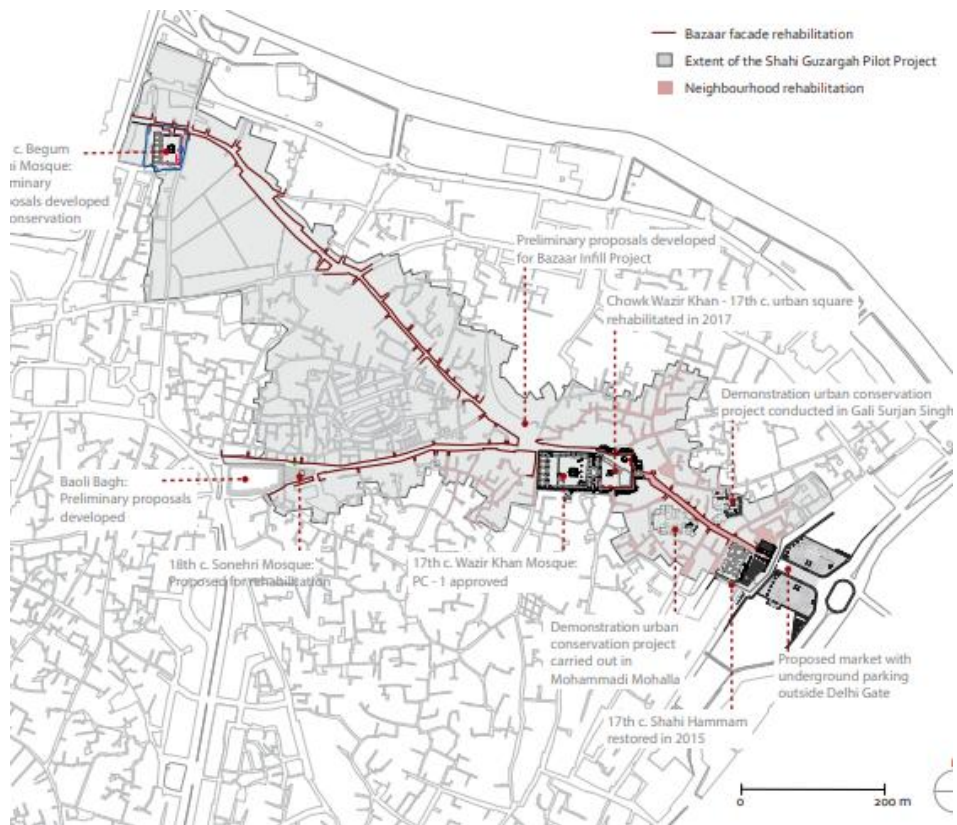


Figure 2-1: Map showing SDWCL Project (Package 1-4)

Source: AKCSP, 2005 (https://www.archnet.org/sites/21652?media_content_id=690729)

Delhi Gate

The gate of the Walled City linking the old Lahore with Mughal City Delhi and the road linking the Delhi Gate with the royal throne (Lahore Fort) was initially called Delhi Gate Bazaar, and it was renamed as Shahi Guzargah while planning the Sustainable Development Walled City Lahore project (SDWCLP). The gate was built in the mid-16th century during the Mughal period, serving as the primary trade route. Several interventions and modifications have been made to the gate over the years, including improvements dating back to the 19th century. The gate remains a noteworthy landmark despite these modifications. It is a double story building with rooms that were formerly utilized for a variety of functions, including administrative offices, barracks, and tourist centers. Its architectural characteristics, which combine European and Mughal influences, include pilasters, vaulted roofs, and ornate accents (WCLA, 2009).

SHAHI HAMMAM

Wazir Khan commissioned the Shahi Hammam, a prestigious bathing facility with influences from Turkish and Persian architecture, during the Mughal era under Emperor Shah Jehan's rule. It changed over time in several ways, including when the British and the Nawaz Sharif government renovated it in 1991. Despite these changes, recent work has concentrated on exposing its original features, exposing intricate heating system and ornate features such as floral, bird, and angel motifs. Since the Hammam's historical significance has been highlighted by careful excavation and conservation work, it may be converted into a public museum that will display its rich architectural and cultural legacy.

The conservation process, initiated by AKCSP, involved extensive research, archival studies, and physical interventions aimed at restoring the Hammam's original structure and artworks. According to the report by AKCSP, although the building was declared a cultural asset in 1955, the structure underwent severe alterations to accommodate its numerous uses over the years. The report also suggests that in 2005, Hammam was used as a restaurant and a TV set. It was decided in 2012 that, instead of adaptive reuse, the building should be restored to its original form as a bathhouse. The excavation of Shahi Hammam discovered the hypocaust system and water heating and circulation technology. The project involved removing the current interventions and renovations and converting it into a museum for adaptive Reuse. The function of the Hammam is abandoned in modern times in Pakistan. However, the site has been opened for tourists and visitors to visualize the technology of the Mughal period (Seraj, 2019)

The conservation of fresco paintings is also a part of the conservation project, as all the fresco paintings were wrongly treated and plastered during the last renovation works. The decorative works were cleaned, stabilized, and reintegrated visually. By recapturing the integrity and historical significance of the monument, it opened the way to convert heritage sites for adaptive reuse to make the sites dynamic (Baig, 2011).

2.4.5. Walled City Lahore Authority (WCLA) - (2012 – to date)

The Walled City Lahore Authority (WCLA) has been established in 2012 for the conservation, restoration, Rehabilitation and regeneration of the Historic Core of Lahore, under the constitution Walled City Lahore Act 2012 (WCLA, 2017). There were a number of projects completed by the authority since its establishment. Few of them are as under:

Table 2-6 : Key Projects completed by WCLA**Source: WCLA, 2016**

Conservation project	Key Points
Shahi Hammam Restoration	The Shahi Hammam Project was completed by WCLA under the SDWCL project, and it was a remarkable project to explore the Hypocaust System of the Hammam by digital documentation of the monument. Conservation and restoration of ornamentation is part of it. The monuments were excavated till its original level and access is provided through Akbari Mandi.
Musa Pak Shaheed Park Restoration	The Musa Pak Shaheed Park, situated in the close vicinity of Delhi gate, was conserved by WCLA. This project includes paving the pathways, landscaping of open areas, installation of lighting systems, and restoration of historical elements to transform the park into green space for recreation and leisure.
Conservation of Wazir Khan Mosque	The Wazir Khan Mosque was constructed during the Mughal period, and it was considered as a Royal Mosque before the construction of Badshahi Mosque. The project includes retrieval of original level of the facades, removing debris and side road interventions. The Bazaar between the courtyard and mosque is also conserved as this mosque is with Bazaar for the financial support to the mosque.
Conservation of Chowk Wazir Khan	The monument Wazir Khan Chowk is open space in front of the Mosque and being utilized as the forecourt of the Mosque. The courtyard was encroached by the squatted shops, illegally occupied spaces by the neighborhood residents, and transformers and beggars. The project was done, and space was retrieved for visitors and tourists.
Naulakha Pavilion Restoration	The Naulakha Pavilion within the Lahore Fort Complex was restored and it includes the restoration of the structure and fresco work and ornamentation being part of Sheesh Mahal Courtyard.
Conservation of Chowk Nawab Sahib	Chowk Nawab Sahib is located near the Lahore Fort and was conserved with the efforts of WCLA. This project involves preservation of historic elements and installation of sign boards for the guidance of the visitors and tourists.
Bazaar e Hakeema	The conservation of Bazaar Hakeema was done by WCLA with the collaboration of AKCSP in 2016 and it includes the restoration of 182 buildings and Jogi Mohallah is one of the significant part of the Project. It includes the improvement of infrastructure, renovation of the facades, and repair of structural damages and removal of encroachments.

2.5. GAPS IN LITERATURE AND RESEARCH OPPORTUNITIES

The historic core of Lahore, Pakistan, is a rich repository of cultural heritage and architectural significance. Despite numerous conservation efforts, there remains a critical need

for a digital conservation framework that can systematically document, preserve, and promote this heritage. However, there are notable gaps in literature and multiple research opportunities for the development of a digital conservation framework, focusing on the socio-cultural context of Lahore.

2.5.1. Gaps in Literature:

Limited Digital Documentation

Existing studies on Lahore's historic core primarily focus on physical conservation, with limited attention given to digital documentation methods like 3D modeling, mapping, and virtual reality, while Aga Khan Trust for Culture (AKTC) and Walled City Lahore authority (WCLA) used photogrammetry and 3D laser scanning but no city-wise digital catalogue exist. Existing studies focus on individual monuments and urban squares rather than a holistic urban scale approach for conservation in the historic core of Lahore.

Limited Use of Spatial Analysis for Conservation

There is no spatial database of degradation patterns, encroachments, and structural risks that exist, which is needed to analyze heritage loss and urban encroachment trends.

Lack of Integrated Conservation Frameworks

There is a lack of an integrated conservation framework that combines data recording of architectural details and historical significance.

Insufficient Community Involvement

Literature on participatory digital conservation is scarce, with limited exploration of how local communities can contribute to and benefit from digital heritage initiatives. The historic core of Lahore has minimal interactive digital resources for public education and tourism. On the contrary, cities like Rome and Istanbul have digital archives and VR experiences accessible to researchers and tourists.

Technological Gaps

There is minimal research on the application of advanced technologies like AI, machine learning, and big data analytics in the conservation of Lahore's historic fabric. Globally, AI-driven analysis is used to foresee material decay and impact climate change. In the historic city of Lahore, conservation plans rely on manual condition assessment, which is subjective and inconsistent. The lack of predictive conservation models is a technical gap in current research.

Policy and Implementation Shortcomings

Studies often highlight policy issues but rarely propose digital tools and strategies to bridge the gap between policy formulation and practical implementation, while institutions like WCLA manage physical conservation and digital conservation policies are still underdeveloped. There is a lack of policy framework incorporating digital strategies for long term conservation.

2.5.2. Research Opportunities:

Development of a Comprehensive Digital Conservation Framework

A study that proposes an integrated digital conservation model incorporating 3D scanning technology and archival databases could provide a holistic approach to managing heritage sites. There is a need to establish a 3D digital repository using LiDAR, Photogrammetry, and HBIM for all heritage structures within the Walled City of Lahore, and research can be conducted to analyze scalable and cost-effective documentation strategies.

Community-Centered Digital Tools

Research on digital frameworks that ensure community participation in documenting and preserving historic sites can foster engagement and ownership. Virtual reality (VR) & Augmented Reality (AR) experiences can ensure reconstruction of lost historical structures, interior of heritage buildings, Cultural heritage narratives through immersive storytelling and establishing open-access digital heritage archives for researchers, students and tourists.

Technological Innovation

Investigating the use of AI for heritage site monitoring, big data for trend analysis, and virtual reality for heritage education presents significant research potential (Zheng et al., 2024). Studies can be one to Develop machine learning models that analyze material decay, climate damage, and seismic risks for historic buildings and training AI algorithms using historical conservation data to suggest optimal restoration strategies.

Policy-Technology Interface

Studying how digital tools can support policy enforcement and streamline conservation processes offers an avenue for impactful research. A legal and institutional framework for integrating digital tools into conservation policies has been established. An effort could be made to develop official digital conservation guidelines, collaborating with WCLA, Aga Khan Trust, and UNESCO.

Digital Storytelling and Interpretation

Obtaining multimedia narratives that bring Lahore's historic core to life through digital means can foster more significant public interest and awareness. Addressing these gaps and seizing these research opportunities can significantly boost the preservation and comprehension of Lahore's historic core through digital innovation and collective efforts.

2.6. CONCLUSION

Despite the significant advancement of digital conservation practices globally, the application of such technologies in Pakistan, particularly in the historic core of Lahore, is limited and fragmented. The Walled City of Lahore is one of the most significant urban heritage sites in South Asia, and it lacks a comprehensive and structured digital conservation framework that bridges the gap between heritage conservation and modern developments by including digital methods.

The urgency to address these gaps is intensified by urban encroachments, infrastructural stresses, and environmental degradation, damaging the historic urban landscape of the historic core of Lahore and by investing in a technology-driven strategies, Pakistan and Walled City of Lahore, got the chance to set a precedent for digital heritage management across historic cities in Pakistan, along with architectural and urban preservation.

A vigorous digital conservation initiative would enhance sustainable heritage governance, support data-driven decision-making, enhance accountability and transparency in conservation practices, and enable community participation through connected digital platforms. In addition, aligning such efforts with global practices could elevate Pakistan's standing in international conservation discourse while ensuring the preservation of architectural and urban heritage for future generations in physical and digital realms.

Chapter 3: Research Methodology

3.1. RESEARCH DESIGN

3.1.1. Mixed-Methods Approach

3.1.2. Rationale for Chosen Methods

3.2. DATA COLLECTION METHODS

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3.2.2. Field Surveys and Documentation (Primary Resources)

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3.3. DATA ANALYSIS TECHNIQUES

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3.3.4. Spatial Analysis and Mapping

3.3.5. Key Methodological Phase

3.4. ETHICAL CONSIDERATIONS

3.5. RELIABILITY AND VALIDITY

3. RESEARCH METHODOLOGY

The methodology adopted for this research is multidisciplinary for developing a comprehensive digital conservation framework for the historic core of Lahore, Pakistan. The mixed-method research integrates qualitative and quantitative approaches related to heritage studies, urban planning, and digital technologies to face the complex challenges of conserving cultural heritage in a rapidly urbanizing context of historic Lahore. The research aims to identify the existing research gaps in heritage documentation and investigate digital tools and platforms within the context of the historic core of Lahore by combining spatial analysis, archival research, stakeholder engagement, and technological assessment to propose a scalable, sustainable framework.

3.1. RESEARCH DESIGN

This chapter introduces the research design and research methodology to conduct the research. It comprises a conceptual framework, research development process, and approach adopted to conduct the research. Finally, various methods and techniques used to achieve the research objectives have been elaborated.

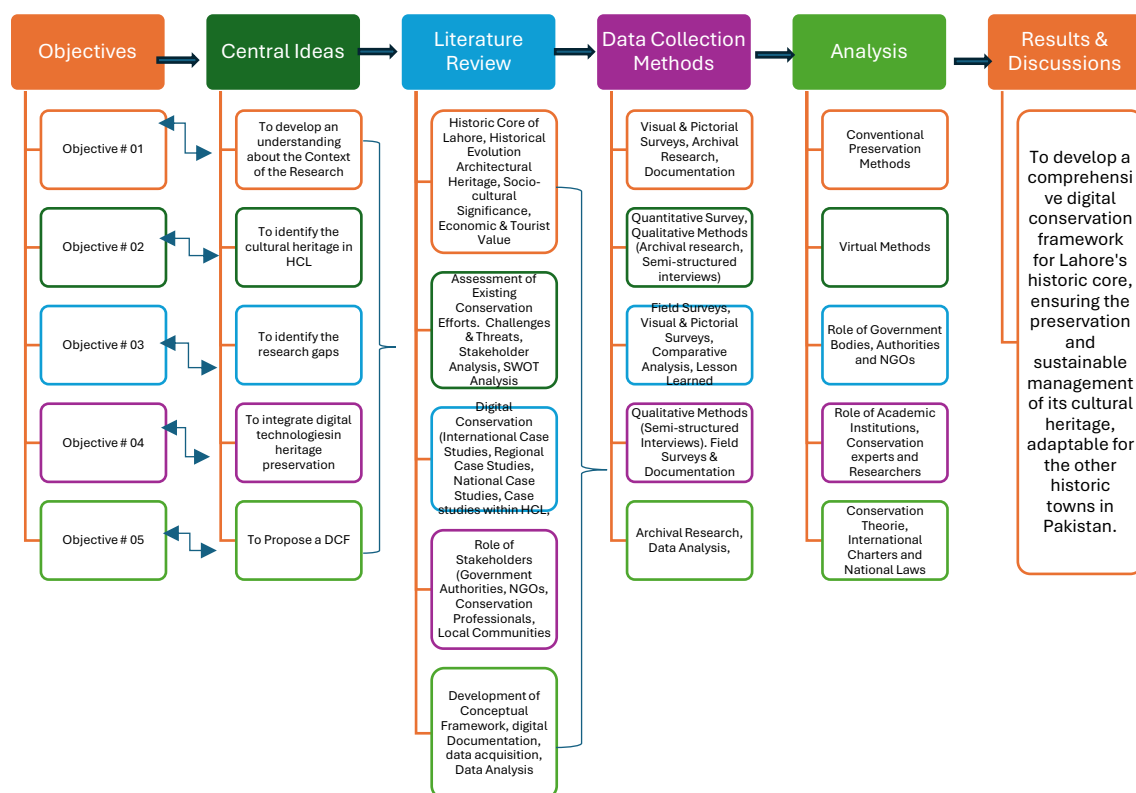


Diagram 3-1: Flow Chart of Research Design focusing on Research Objectives

Source: Developed by Author

The conceptual framework of the research gives an idea, including the selection of the topic, the development of research questions, and how the research has been shaped. It is an effort to explain an analytical framework and identify the mandatory methods to collect data relevant to the core objectives and research questions.

3.1.1. Mixed-Methods Approach

Pakistan, like other developing countries, lacks resources, education, and skills, and there is a pressing need to analyze whether traditional methods can meet targets. To find the answer to this question, an analysis of current methods and procedures is required. Globally, it has been realized that the conservation community should move towards modern techniques and processes for the best utilization of resources, maintaining identity, and securing the maximum accuracy value (Hassani et al., 2015). In the last decade of the 19th century, there were attempts to apply digital tools for the conservation of built heritage, and the process is continued by researchers (Dice, 2018b). In Pakistan, an effort was made by Dr. Murtaza Taj from LUMS University to document historic monuments, under the umbrella of Lahore Development Authority, under the USAID program in 2015. His successful efforts led the way to applying digital technologies for documentation, recording, and managing heritage (Taj & Hashmi, 2016). However, research is needed to explore the potential of applying digital techniques for conserving historic monuments and archaeological sites, investigating the constraints of traditional methods.

The historic core of Lahore is rich in cultural heritage, and its origin dates to 2000 BC. It showcases the monuments of various civilizations, the most significant of which are Mughal, Sikh, and British, and it also includes a UNESCO World Heritage Site, Lahore Fort, and Shalimar Garden. Lahore Fort remained the nucleus of the historic city for centuries, and the city adjacent to the Royal Throne was walled by the Mughal Emperor, Akbar. The urbanization and modernization of historic cities created chaos, with the new constructions replacing traditional buildings (Rizvi, 2011b). The slow deterioration of historic assets due to the legal framework, political and economic reasons, negligence of administrative bodies, and mismanagement of users, all these issues threaten the built heritage to be ruined. Thus, the need arose to protect the historic structures, with a different policy that saves our resources with the maximum output, and it was not possible with the traditional preservation methods (Street, 2005).

A plan of action has been developed to conduct archival study, data collection, case studies, and analysis of the work done. It identifies the methods of research, justifies the selection of samples for case studies, and provides criteria for the sample selection.

3.1.2. Rationale for Chosen Methods

Considering the physical fabric of the historic core of Lahore, surveys were done in three intervals: morning, afternoon, and evening. All the central spine and secondary roads have been transformed into commercial areas, and residences have been squeezed to the inner core. Access to the inner side has been a jumble, and one can't move easily due to traffic congestion. Due to the commercialization of the historic city, morning time is relatively calm and suitable for research work. The key observations of the site visits are:

- The local community is very fond of eating in the morning, only shops for eatables open, and commercial activities usually start after 11:00 am. Therefore, to attain randomization, research timings have been decided from 8:00 am to 11:00 am for surveys, and from 11:00 am to 3:00 pm for interviews.
- The historic city of Lahore is serving as Central Business District (CBD), therefore, it has specific activities on the few days of the week, as Friday is fixed for the “wholesale dealers” of the outstation as most of the cities, other than Lahore, enjoy weekend on Friday and they can get a chance to purchase their wholesale products on weekend. The local wholesale customers are not dealt with on Fridays, and it's tough to do work due to the congestion of people and hand carts. Sunday is also a weekend in Lahore, and Interviews and case studies in the residential areas were easily performed on Sunday in the morning slot. However, working on central spines and secondary areas has been conducted from Monday to Thursday during the morning and afternoon, as the site is less accessible in the evening slot due to the closing of shops and movement of hand carts.

3.2. DATA COLLECTION METHODS

The research necessitates a comprehensive data collection approach, ensuring accurate and precise documentation, preservation, and management of heritage assets. The following methods are integral to this data collection approach:

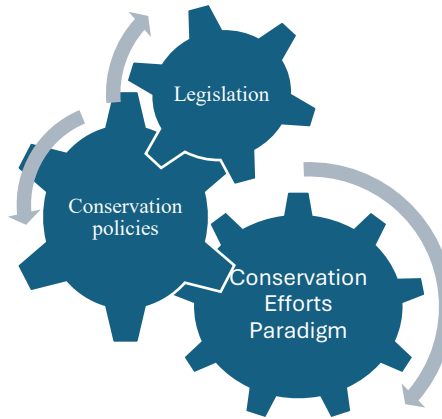
- Terrestrial Laser Scanning (TLS) captures high-resolution 3D data of selected heritage monuments and urban squares (Intignano et al., 2021). Sheesh Mahal, Lahore Fort was chosen as a monument with detailed mirror work to be documented,

using a Terrestrial laser scanner (ownership of WCLA). Mai Eidaan Courtyard was documented using a Terrestrial Laser Scanner as a pilot project. The courtyard is a significant cultural node in the historic environment.

- Total station Surveying was done on the selected sites within the context of Walled City Lahore. A detailed, scaled wire-frame 3D model of Barood Khana within Lahore Fort was prepared, showcasing the initial phase of inclusion of digital documentation.
- Photogrammetry involves capturing overlapping photographs to develop 3D models. This method is cost-effective and efficient for documenting intricate architectural details, making it suitable for large-scale projects.
- Spatial analysis was done to develop cultural maps of tangible and intangible heritage.
- Archival research was conducted to access historical documents, maps, and photographs from repositories like the Punjab archives, AKCSP, LDA, and WCLA. The archival research provided contextual information about heritage sites and historic cities. The digitization of archival records enhanced data accessibility, supporting comprehensive historical analysis (Groat & Wang, 2013).
- Stakeholder interviews and community engagement ensures inclusion of diverse perspectives. This approach helps capture intangible heritage and foster community involvement in conservation efforts. Interviews were conducted with the city's stakeholders, including conservation experts, historians, and policymakers, to gather feedback related to the constraints of the traditional methods and the benefits of digital techniques (London & Ostwald, 2004).
- Historic Building Information Modelling combines 3D and historical data to create digital representations of historic structures. This method helps in detailed analysis and management of conservation efforts (Osello et al., 2018b).

3.2.1. Archival Research

Data has been collected from archival documents and authorities related to preserving the historic core of Lahore. A detailed study was conducted regarding conservation efforts by various national and provincial authorities through international collaborations. National and provincial institutions played a pivotal role in shaping the conservation efforts within the historic core of Lahore (Qadeer, 1996).



Diagrams 3-1: Archival Research to Evaluate the Evolution of Conservation Methods

Source: Author

a. Conservation Efforts

- Lahore Improvement Trust (LIT) - (1938-1975)
- Lahore Development Authority (LDA) - (1975 - 2012)
- Lahore Urban Development and Traffic Study (LUDTS) by LDA & World Bank, Walled City Upgrading Study - (1981-1986).
 - Mohalla Kekezian is the pilot project.
- Lahore Development Authority (LDA) & Pakistan Environmental Planning & Architectural Consultants (PEPAC)- (1988-1993)
 - Monographs by PEPAC (1988)
 - Conservation Plan for the Walled City of Lahore - (1993)
- Sustainable Development of Walled City of Lahore (SDWCL) & Aga Khan Cultural Service Pakistan (AKCSP) - (2009-2014)
 - Shahi Guzargah (Delhi gate to Chowk Purani Kotwali)
 - Mohammadi Mohalla
 - Shahi Hammam
 - Gali Surjan Singh
 - Conservation Plan of Wazir Khan Mosque
- Walled City Lahore Authority (WCLA) - (2012 – to date)
 - Master Conservation Plan (Proposed Land Use Plan)
 - Zones of Special Value (Bhatti Bazaar Project)
 - Zones of Special Value (Lohari Gate Project)

b. Legislation for Conservation in Pakistan

- Ancient Monument Preservation Act (AMP Act) (1904 – 1968)
- Antiquities Act 1975 (1975)
- Punjab Special Premises Ordinance 1985 (1985)
- Amendment in the Antiquities Act 1975 (1990)
- Walled City Authority Act 2012 (2012)

c. Conservation Policies in Pakistan

- British Indian Procedures of Conservation
- Conservation Manual and Archaeological Works Code by Sir John Marshal
- Conservation Procedures of the Archaeology Department of Punjab
- Conservation Practices by WCLA

3.2.2. Field Surveys and Documentation (Primary Resources)

A field Survey has been conducted to study the Historic Urban Landscape of the City. Hierarchy of the spaces of Mughal Lahore starts from the Guzars (Districts), Mohallas (Sub-division of Districts), and s (Sub-division of Mohallas). Bazaars are the main spines (primary roads) linking districts, and the interconnection of these Guzars is termed Chowks (nodes). The city has a wealth of historic monuments, including residential, commercial, and religious. Chowks were the hub of cultural activities and served as centers for communal activities and can be termed as cultural nodes (Qadeer, 2023). Current conservation works and interventions have caused irreversible damage to many heritage sites and cultural traditions due to political and managerial priorities.

An inventory has been prepared based on urban morphology, building typology, historical, and architectural significance. Moreover, urban areas were given preferences as they constitute the physical and cultural nodes of the city and the center of communal and cultural activities. The building uses have been transformed due to the change in the activities and social patterns of the historic city. Therefore, a few examples can be observed regarding the adaptive reuse of historic monuments and urban squares (Kumar, 2011).

Terrestrial Laser Scanning Technology in Pakistan

Physical preservation involves a lot of stages to complete the process. It involves the identification and documentation of the cultural heritage to complete the conservation of the urban built heritage. Digital documentation is the phase to preserve the heritage monuments

and sites. There are four stages to complete the process of digital documentation with the help of 3D terrestrial laser scanners. This technique was introduced in Pakistan by the LUMS University under the project of “Digital Preservation of Pakistan's Heritage”. Under this project, USAID funded 3D Laser Scanner of the (Taj 2016):

- Model Leica Scan Station P20,
- Range: Up to 120 m,
- Scan rate: Up to 1’000’000 points/s and
- Field-of-view: H 360°, V 270

Field work / Scanning

The process involves Field Work scanning the object that needs to be documented. The data received by the scanner is in the form of 3D point clouds. 3D laser scanning systems which emit a huge amount of laser beams per second and generate thousands of data points. This data is termed as point cloud as it is not in the form of a picture but actual digital representation of the monument with accurate details. We need the appropriate software such as cyclones to transfer the raw data to 3D point cloud (Webb, 2015).

Point Cloud Registration

The data taken by the Laser Scanner needs registration with the help of specific software like cyclone. The data was in the form of cloud of points and the expert have to draw the images out of these clouds. This can also be done with the help of different software such as Archi CAD, Cyclones etc.

Panoramas and Texturing of point cloud model

After the registration of the point cloud data. We can have a virtual tour of the site to visualize the whole site, and we can move around the monument avoiding any mistake while preparing the Conservation Plans of any project. Autodesk Revit, 3D Studio Max, sketch up and Rhino etc. may be used to render the 3D image prepared from the point cloud data (Rahaman, 2018). These virtual tours give the chance to the experts towards the integrated approach rather than linear approach. In the traditional methods one must rely on the other and the work have tube done by individuals. On the other hand, in the integrated approach, all the team members got involved towards the project completion.

Faro Terrestrial Laser Scanning (Field Work)

Surveys of the selected site have been done using a Faro terrestrial Laser Scanner to digitally document facades of a group of buildings, around an open space, termed as the Mai Eidaan Courtyard. There are constraints regarding TLS surveys within the historic core of Lahore, in terms of the security of the scanners due to their high cost, as the historic core of Lahore is the most congested area of the city, and the application of Terrestrial Laser Scanner, as it cannot be used in high temperatures (Brusaporci et al., 2023b). The sample area has been selected in the outer periphery of the historic core of Lahore, about the UNESCO World Heritage site, the Badshahi mosque. The selected site is comprised of historic monuments, most of which are being adaptively reused as restaurants and shoe factories. Considering all the factors, scanning of the facades of the building around the Mai Eidaan Courtyard has been done from 8:00 am to 11:00 am.

Processing of Scanned Data (Studio Work)

The scanned data, received in the form of point cloud, has been registered, with the help of Faro scene (software) in the studio and it has been transformed into *.rcp files. These files have been imported in the Autodesk Recap 360 to get orthographic drawings, 3D models and panoramic views (Ursini et al., 2022b). After processing the point cloud data into cad files, we may export these files into Autodesk Revit to get sectional details with maximum accuracy with multilayer information, minimizing human errors in the shortest time period.

3.2.3. Interviews with Stakeholders

City morphology has been studied, and interviews have been conducted in the conserved areas to get the residents' feedback and understand the interests of the main stakeholders. Photographic data has been collected to propose a Digital Conservation Framework for the Historic City of Lahore. The key stakeholders include conservation experts, historians, residents, visitors, and representatives of various institutions.

3.2.4. Digital Data Acquisition Techniques

Finally, in order to conceptualize the architectural, historical, and socio-cultural significance of the historic city of Lahore, digital maps based on inventory (prepared by the author, identifying various types of building categories), following the urban morphology of the Mughals, have been prepared to locate central spines (Bazaars & Chowks), streets, mohallahs, koochas, havalies, mosques, temples, gurdwaras, open spaces enclosed by groups of houses (katras), etc., for all nine Guzars (Kamran et al., 2016).

3.3. DATA ANALYSIS TECHNIQUES

Developing a digital conservation framework for the historic core of Lahore necessitates a comprehensive approach that integrates quantitative and qualitative data analysis techniques. The mixed method approach ensures a holistic understanding of the heritage assets, including physical attributes, historical significance, and socio-cultural contexts.

3.3.1. Quantitative Analysis Methods

3D Spatial Data Processing and Modelling

The 3D models of the heritage structures have been developed using Total Station and Terrestrial Laser Scanner, and these 3D virtual models facilitate the detailed analysis of architectural features, structural conditions, and deterioration patterns (Guidi et al., 2014). For instance, the digital documentation of Barood Khana in Lahore Fort, using Total Station to develop a wire-frame model and digital documentation of Sheesh Mahal, Lahore Fort, can help to assess the need to integrate digital technologies to conserve and manage heritage sites.

Historic Building Information Modelling (HBIM)

HBIM integrates 3D models with historical data, enabling comprehensive analysis of building components, materials, and construction techniques. This method supports the simulation of the restoration process and manages conservation interventions (Diara & Rinaudo, 2018). In the case of Barood Khana and Sheesh Mahal in the Lahore Fort, HBIM was instrumental in evaluating the impacts of virtual methods on conventional methods.

Statistical Analysis of Environmental Data

The application of statistical tools to analyse environmental data helps to understand the impacts of environmental factors, such as air quality indices, humidity levels, and temperature variations, on the deterioration of heritage structures. The mitigation strategies are developed with the help of such techniques.

3.3.2. Qualitative Analysis Methods

Thematic Analysis

This technique includes identifying, analyzing, and reporting patterns (themes) within qualitative data. By examining interviews, focus group discussions, and archival texts, cultural significance, community perception, and historical narratives can be assessed (Vitae, 2010).

Content

Analysis

Content analysis systematically categorizes textual data to identify patterns, themes, or biases. In the context of urban heritage conservation, this method can be applied to historical documents, policy papers, and media reports to understand the evolution of conservation practices and public discourse.

Narrative Analysis

This analysis focuses on the narratives from the community members, historians, other stakeholders, and researchers to gain a deeper understanding of the intangible heritage and collective memory associated with these sites.

Participatory Mapping and Community Workshops

Engaging local communities through participatory mapping exercises and workshops enables the incorporation of indigenous knowledge and community perspectives into the conservation framework. This participatory approach ensures that the framework is culturally sensitive and locally relevant.

3.3.3. Integration of Qualitative and Quantitative Analyses

Integrating qualitative and quantitative data analyses provide a comprehensive understanding of Lahore's historic core. For instance, quantitative spatial data from 3D modeling contextualized with qualitative insights from thematic and narrative analyses. This integrated approach ensures that conservation strategies are informed by empirical measurements and socio-cultural considerations, leading to more effective and sustainable heritage management (Temple, 2008).

3.3.4. Spatial Analysis and Mapping

Architectural Drawings & 3D AutoCAD Modeling

Architectural Drawings, such as plans, elevations, etc., can be prepared from the data. These drawings will be helpful for the area calculation, to preserve the historic fabric of the city. From Point cloud data, 3D AutoCAD models have been developed, with the help of different software. These 3D models can present a complete picture of the project and the environment surrounding the site (Jouan & Hallot, 2020).

Laser Scanning Time Cost

Dr. Murtaza Taj describes the time consumption to complete the project, stating that the scanning is less time-consuming than the preparation of Architectural drawings and 3D Models. He explains that scanning consumes almost 35% of the time to complete the project. On the other hand, the most laborious job is to extract views from the point cloud data, and it is more time-consuming. Almost 65% of the time has been consumed to prepare the Architectural Drawings and CAD model (Taj & Hashmi, 2016).

3.3.5. Key Methodological Phase

Table 3-1 : List of Key Methodological Phases, Process, and Outcomes

(Source: Developed by Author)

Phase	Objective	Methods/Approach	Tools/Techniques	Expected Outcomes
1. Preliminary Research	Establish historical and theoretical foundation	Literature Review	Academic Journals, Books, Charters (e.g., Venice Charter, Burra Charter)	Identification of knowledge gaps and theoretical framework
2. Contextual Analysis	Understand Lahore's historic core and its conservation context	Archival Research, Site Visits, Field Surveys	Historical maps, archival photos, government reports	Detailed contextual profile of the historic core
3. Stakeholder Analysis	Identify roles, challenges, and perspectives of key actors	Semi-structured Interviews, Questionnaires	Interview guides, survey forms (government institutions, local communities)	Insight into governance structure, conservation efforts, and community perception
4. Digital Documentation	Create accurate digital representations of the study area	Digital Survey, Photogrammetry, 3D Laser Scanning, UAV (Drone) Imaging	LiDAR, Total Station, UAVs, Photogrammetry Software, Laser Scanners	3D models, digital maps, and photorealistic documentation of heritage assets
5. Data Integration & Analysis	Analyze spatial, structural, and qualitative data	GIS Mapping, HBIM Modelling, Condition Assessment, SWOT Analysis	ArcGIS, Autodesk Revit, BIM 360, Condition Survey Templates	Comprehensive digital database and heritage inventory
6. Framework Development	Propose a digital conservation framework for Lahore's historic core	Conceptual Modelling, Stakeholder Feedback, Comparative Case Study Review	Flowcharts, Comparative Matrices, Case Study Analysis Tools	Proposed Digital Conservation Framework
7. Pilot Implementation	Test framework in a real-world scenario (Mai Eidan Courtyard)	Field Application of Digital Tools, BIM and GIS Integration, VR Simulation	Reality Capture, Revit, Unity/Unreal Engine for visualization	Working prototype and digital plan for the Mai Eidan Courtyard
8. Evaluation and Validation	Assess the effectiveness and scalability of the framework	Expert Reviews, Community Feedback, Cost-Benefit Analysis	Evaluation Forms, Interview Protocols, Feedback Surveys, Economic Analysis Tools	Validated and refined conservation framework
9. Policy and Future Proposals	Recommend policies and directions for large-scale adoption	Synthesis of Findings, Strategy Formulation	Policy Brief Templates, Framework Guidelines, Capacity Building Modules	Guidelines for implementation, future research directions, and digital conservation policy suggestions

3.4. ETHICAL CONSIDERATIONS

Nothing is perfect in this world; there are always challenges, and also techniques and methodologies to meet these challenges within the limits of ethics of research and conservation. The application of modern technologies in conserving built heritage also has a few limitations and challenges.

Budget Constraints

The required tools and equipment are costly compared to the traditional manually operated tools. Terrestrial Laser Scanners are available in the global market, but Pakistan has a small number of scanners, owned by public authorities. It will take time to reduce costs when it becomes available in local markets.

Technical Expertise

As the use of digital technologies is not yet widespread in conservation projects, there is a shortage of technical experts who can operate this equipment and process the scanned data from point cloud registration to the development of a panoramic view.

3.5. RELIABILITY AND VALIDITY

a. Reliability

It refers to the consistency and dependability of the data and analysis methods. To ensure reliability:

Standardized Data Collection Protocols

Uniform data collection methods, such as consistent scanning techniques and survey instruments, help us to compare data across different sites and periods.

Inter-Observer Reliability

Training multiple researchers to apply the same methodologies reduces the subjective conflicts and enhances the consistency of qualitative analysis.

Pilot Testing

Conducting preliminary studies and refining data collection tools and methods identifies potential issues and improves the reliability of research design.

- b. Validity pertains to the accuracy and truthfulness of the findings. To ensure validity:**

Content Validity

It must be ensured that the instruments used for the data collection comprehensively cover all aspects of the heritage sites, including architectural features, historical significance, and community values.

Construct Validity

Verifying that the methods assess theoretical constructs such as cultural significance or conservation needs.

Triangulation

By applying multiple data sources and methods to cross-validate findings and enhance the credibility of the results and for example, combining 3D modelling with archival research and community interviews.

Member Checking

Involving community members and stakeholders in reviewing and validating the findings ensures that the interpretation accurately shows the local perspectives and experiences.

By applying these data analysis techniques meticulously and rigorously, ensuring reliability and validity, the digital conservation framework (DCF) has been developed with a strong foundation. It will ensure preservation of its rich cultural heritage for future generations.

Chapter 4: The Historic Core of Lahore: Context and Significance

4.1 HISTORICAL DEVELOPMENT OF LAHORE

- 4.1.1. Pre-Mughal era
- 4.1.2. Mughal period
- 4.1.3. Colonial era
- 4.1.4. Post-independence Developments
- 4.1.5. Post-independence Urban Policies
- 4.1.6. Cultural Revival and Tourism Integration
- 4.1.7. Challenges and Continuing Traditions

4.2. ARCHITECTURAL HERITAGE OF THE HISTORIC CORE OF LAHORE

- 4.2.1. Typology of Historic Buildings
- 4.2.2. Significant Monuments and Structures
- 4.2.3. Urban Fabric & Streetscapes

4.3. CULTURAL AND SOCIAL SIGNIFICANCE

- 4.3.1. Intangible Heritage
- 4.3.2. Living Traditions and Practices

4.4. ECONOMIC VALUE OF HERITAGE

- 4.4.1. Tourism Potential
- 4.4.2. Traditional Crafts and Industries

4. THE HISTORIC CORE OF LAHORE: CONTEXT & SIGNIFICANCE

The historic core of Lahore is known as the Walled City of Lahore and represents the most significant and enduring urban settlement in South Asia. The city has a history of almost 1000 years and was fortified during the reign of the Mughal emperor Akbar. The ancient fortification wall has been embodied with thirteen historic gates to connect the city with its neighborhood and trade routes. It was famous for political authority, cultural identity, and architectural monuments (Tufail, 1962b). The old Lahore has played a key role in shaping the historical and cultural identity of the region and secured its position as a vibrant locus of trade and craftsmanship. The city has witnessed three periods: the Mughals, the Sikhs, and the British Colonial, with a pre-Mughal historic background. Its urban fabric comprises narrow alleys, courtyard houses, mosques, temples, Gurdwaras, Havelis, traditional bazaars, and chowks / urban squares (Physical and cultural centers), spanning from the Mughal to the post-independence period (AKCSP, 2012).

Despite facing the challenges of rapid urbanization and modernization, the city remains the center of trade and commercial activities and maintains its identity in the collective memory and heritage discourse. It is essential to understand the significance of the context for heritage conservation and sustainable urban development strategies in contemporary Pakistan (Rana & Bhatti, 2018a).

4.1 HISTORICAL DEVELOPMENT OF LAHORE

4.1.1. Pre-Mughal era

The historic core of Lahore is now part of modern Lahore. It has been developed by the “Loh” son of Ram Chander, and it has been ruined many times, facing external forces. In the pre-Mughal period, the city was located at the place of the present-day “Ichra”, and it is also narrated in the history that the old city was where, today, Nawankot is located. Before the Mughal period, the old city had a strong historical background dating back more than 1000 years. (Hankey, 1999). Similarly, it continued its development after 1947.

4.1.2. Mughal period

Historical evidence proves that Mughal Lahore was located where the historic city is. (Shuja, 1988). The city continued to develop, expand, and evolve. During the period of Emperor Akbar, when Lahore was declared as the Royal Throne, Emperor Akbar fortified the

city and laid the foundations of the Royal Residence, “Lahore Fort” on a high mound in the northwestern part of the city on the bank of the river Ravi (Tufail, 1962). Emperor Akbar also divided the historic core of Lahore and its neighborhood communities into thirty-six (36) administrative zones. Nine (09) were in the Walled City of Lahore. The city is 2.5 kilometers in size and has a population of 200,000 people. The city has a wealth of historic monuments and open urban spaces.

4.1.3. Colonial era

The colonial city was established on the periphery of the old Lahore, introducing a new civic life that had never been experienced by the residents of Lahore. The colonial city introduced new life patterns, focusing on academic and social upgradation. Considering the modern needs and facilities, residents of old Lahore started to shift towards new localities developed by the British. (Din, 2018). The shift of residents from the old Lahore to the colonial city created multiple issues, such as commercialization, vehicular movement, congestion, deterioration of historic assets due to the negligence of stakeholders, and modern constructions. (Kaur, 2019).

4.1.4. Post-independence Developments

The post-independence development in the historic core of Lahore shows broader patterns of urban transformation, heritage neglect, and socio-political shift. In the later period, conservation was initiated in Pakistan. The historic core of Lahore, a thriving political and cultural nucleus, experienced significant changes after 1947, driven by demographic shifts, modernization pressures, and developing governance frameworks. The 1947 partition triggered one of the largest migrations in history, and Lahore, including its historic core, faced a massive influx of Muslim refugees from India. The most important were:

- The most significant challenge was property abandonment and reallocation as Hindus and Sikhs fled, leaving behind havelis, temples, and commercial establishments. These properties were reallocated to the Muslim refugees without taking care of their historical and architectural significance by the Evacuee Trust Property Board (ETPB).
- The historic core of Lahore became heavily congested due to the reallocation of landmark structures to various families. The densification of the historical urban area resulted in informal additions, horizontal and vertical encroachments, and unplanned constructions compromising spatial coherence and the built heritage of the region.

Despite its rich repository of Mughal, Sikh, and colonial architecture, the Walled City suffered decades of human neglect after independence. The result is structural dilapidation and loss of urban fabric. Iconic monuments like Shahi Hammam, Wazir Khan Mosque, and various havelis were deteriorated due to the lack of maintenance, encroachments, and environmental pollution (Baig, 2011). The commercialization, vehicular intrusion, and piecemeal upgradation of infrastructure disrupted the traditional urban hierarchy characterized by mohallah-based layout with narrow Galis and cul-de-sacs (Jodidio, 2019) .

4.1.5. Post-independence Urban Policies

Post-independence urban policy in Lahore prioritized expansion and modernization over preservation. The Walls around the city, with its Gates, were demolished during the British period for administrative purposes, and the circular road around the Walled City was compromised due to the traffic interventions. (WCLA/PEPAC, 1993) The areas like Delhi Gate, Lohari, and Bhatti Gate experienced intrusive interventions that fragmented the historic fabric. Moreover, unplanned installations of electricity, gas, and sewerage lines destroyed the structural integrity of historic monuments and disfigured heritage facades.

After facing the challenges and subsequent impacts of Partition, the attention was diverted to the protection of the built heritage of Lahore. The initiative was taken by Lahore Development Authority (LDA), which was an extension of Lahore Improvement Trust (LIT), the conservation works were started under the legislation of Antiquities Act 1975 and Punjab Special Premises Ordinance 1985. However, the major contributions towards protecting the historic core of Lahore began during the last decade of the 20th century. In the early 21st century, attention was directed towards conserving the urban fabric, instead of individual buildings. Lahore Development Authority (LDA) contributed towards heritage protection within the Walled City of Lahore, in collaboration with the Pakistan Environmental Planning and Architectural Consultants (PEPAC), Aga Khan Cultural Services of Pakistan (AKCSP), USAID and other international funding agencies since 1975 and Walled City Lahore Authority was established in 2012 to systematic documentation, preservation, and community-engaged revitalization of the historic core of Lahore. The most significant projects were Rehabilitation of the Shahi Guzargah (Royal Trail) from Delhi Gate to the Wazir Khan Mosque focusing facade restoration, undergrounding of utilities, street paving with traditional materials, and relocation of encroachments. The second most significant project was Conservation of Shahi hammam and Wazir Khan Mosque with its neighbourhood, in collaboration with AKCSP and

supported by international donors. This conservation project was completed according to the international standards and got multiple international awards.

4.1.6. Cultural Revival and Tourism Integration

Conservation efforts introduced cultural revival and transformed the historic core of Lahore as a tourist destination. Public engagement with historical spaces within the Walled City of Lahore was enhanced through cultural activities such as the Lahore Literary Festival and guided heritage walks. Adaptive reuse of historic monuments was enhanced, such as Havelis, which were adapted into Restaurants, art galleries, educational institutes, and cultural centers (City, 2007).

4.1.7. Challenges and Continuing Traditions

Despite continued efforts to conserve the urban fabric and historic environment of the concerned authorities, the historic core of Lahore is still facing grave challenges.

- Balancing modern interventions with heritage integrity, as commercialization and the intrusion of vehicles have marginalized the historic identity, and traders resist conservation measures that threaten their economic activities or require relocation.
- The relocation of traditional residents to modern Lahore and the redevelopment of the heritage site changed the socio-cultural character of the area, increasing gentrification risks.
- Fragmented institutional responsibilities and an inadequate legal framework hinder sustainable development.

The status of the historic core of Lahore evolved from a lived historic environment into a contested site of memory, identity, urban renewal, and regeneration. The greatest challenge is to create a balance between heritage preservation and modernization. Recent conservation efforts, while admirable, emphasize the need for inclusive, culturally sensitive, and legally grounded urban heritage management.

4.2. ARCHITECTURAL HERITAGE OF THE HISTORIC CORE OF LAHORE

The historic core of Lahore, one of South Asia's oldest and most culturally vibrant cities, stands as a living testament to centuries of architectural evolution, urban development, and socio-political transformation. Nestled within the Walled City, this area is home to a rich tapestry of heritage that reflects the city's diverse history, from the grandeur of Mughal imperial structures to the layered influences of Sikh, British colonial, and post-independence

architecture. The intricate urban fabric of narrow alleyways, bustling bazaars, and monumental landmarks such as the Lahore Fort, Badshahi Mosque, and Shahi Hammam offers invaluable insight into the artistic, religious, and functional aspirations of past eras (Gulzar, 2017). Today, while the historic core continues to pulse with daily life, it faces growing challenges related to preservation, modernization, and urban pressure, making the study and conservation of its architectural heritage more critical than ever.

4.2.1. Typology of Historic Buildings

Mughals introduced art and architecture in the area, and Sikh rulers blended Mughal and pre-Mughal architectural elements. On the other hand, the British introduced a new typology, including educational institutions, office buildings, railway stations, and other structures (Sheeba & Dhas, 2018).

- City Wall and its Gates
- Guzars / Districts

The old Lahore was originally a pedestrian city, and the provision of carts was limited on the main spines, termed as Guzars. The rest of the city network is based on the narrow, windy streets and small houses.

The city was comprised of a city wall with thirteen (13) gates, nine (09) guzars, main bazaars, mohallahs, galies, katras, heritage sites, and urban spaces/gardens. (Goulding, 1924). The main spines are used for commercial and wholesale traders' activities. As the historic city has been transformed into a central Business District, residential quarters have been transformed into a commercial hub (Mumtaz, 1985). Due to increased commercial activities, the pedestrian streets have been replaced by vehicular roads, and the vehicular movement has ultimately created a congested environment.

To understand the urban hierarchy and morphology, it is necessary to study the significant context of the historic city, including the urban hierarchy of the Mughal Lahore and the nine guzars. The city has been studied as evolving during the Mughal period.

a. City Wall and its Gates

The historic Core of Lahore was a fortified city with thirteen gates, and these gates are named after the trade route at which they are located, such as Delhi Gate, which links a road to Delhi, and so on. The fortification was removed during the British rule for administrative purposes, and gardens were developed around the city wall, named as circular gardens. During

these intrusions, most of the city gates were ruined and destroyed (Seraj, 2019). However, six gates were reconstructed during the British colonization, and the rest have vanished. The gates are named as Delhi Gate, Roshnai Gate, Akbari Gate, Yakki Gate, Bhati Gate, Sheranwala Gate, Lohari Gate, Kashmiri Gate, Mori Gate, Masti Gate, Shahalam Gate, Taxali Gate and Mochi Gate.

The Mughal Emperor Akbar, during his stay at Lahore (1584-1598 A.D.), constructed a wall of appropriate height with mud bricks around the city. He also laid the foundations of the palace, which were later extended by his followers. The walls were decaying, and Ranjit Singh reconstructed these falling walls in 1812, up to a height of 30 feet, with the addition of bastions, to strengthen. He also excavated a ditch for security purposes (Goulding, 1924). The height of the surrounding wall was reduced to 15 feet due to political and military functions. After the British annexation, this city wall was removed, and the moat was filled with mud, and gardens were laid at that place (Latif, 1892). These gardens were termed as circular gardens in modern times.

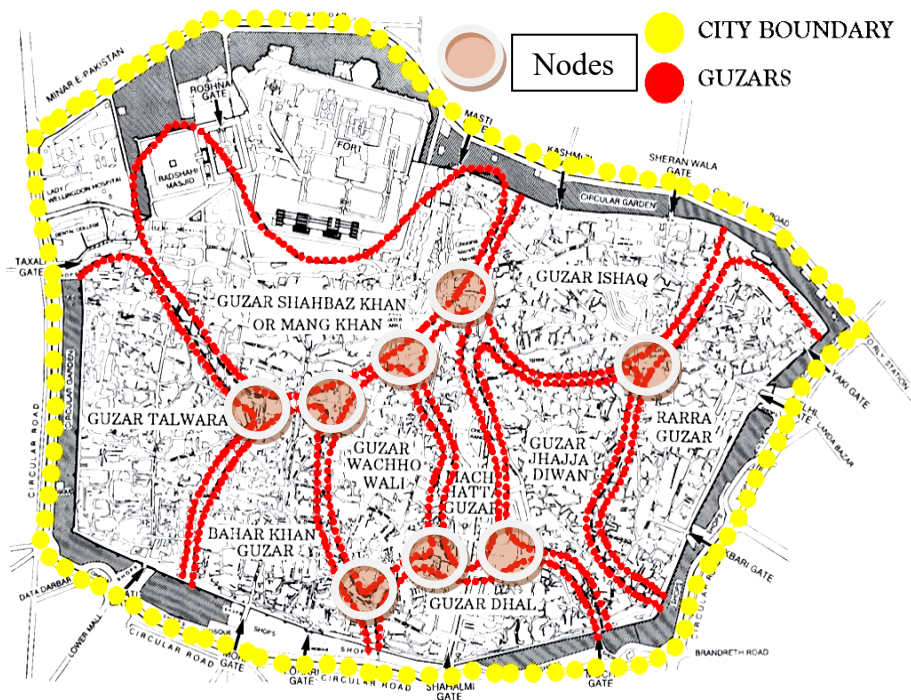


Figure 4-1: Administrative Areas / Guzars, City Boundary and Nodes of the Historic Core of Lahore
(Source: WCLA, 2009 (edited by Author))

There were thirteen (13) entrance points to the city, linking it with the surrounding area.

- On the North: Roshani, Masti, Kashmiri, Sheranwala
- On the east: Yakki, Delhi, Akbari,
- On the South: Mochi, Shahalam, Lohari, Mori, Bhatti
- On the West: Taxali Gate

As the city was located on the bank of the River Ravi on the North-western corner, three (03) gates on the North side opened into the waters of Ravi, and the remaining ten (10) opened on land linking the city with neighborhood localities. The Roshnai gate is the principal gate, the entrance to the palace. This gate is not located within the city wall but serves as an entrance to the city through the palace, and therefore, it is named after the gates. Kashmiri Gate, also known as Kashmiri Darwaza, is named after its connection to Kashmir; therefore, it is named Kashmiri Gate. Delhi Gate is named after its link to the city of Delhi. The rest of the gates were named after the names of Royal family members and nobles of the Mughal Court (Hindi, 1882). At present, only six (06) gates, Roshnai, Kashmiri, Sheranwala, Delhi, Lohari, and Bhatti, are surviving (WCLA, 2009).

Delhi Gate: Delhi Gate is one of the well-known gates of old Lahore, built by the Mughal Emperor Akbar. The gate is situated on the east side and opens onto the road, leading to the Mughal city of Delhi, capital of the Mughal Empire. It was destroyed by the intruders and reconstructed during the British Colonization. Delhi Gate is linked with the Royal Throne, Lahore Fort, through road, previously known as Delhi Gate Bazaar, and currently part of the Royal Trail (Qureshi, 2018).

Roshnai (Light) Gate: In Mughal Lahore, it was the main entrance to the old city of Lahore, and numerous lights were placed at the gate to guide visitors; therefore, it is named Roshnai Gate. This gate is still in its original form and structure. It is located in the close vicinity of Lahore Fort and Shahi Mosque (UNESCO, 2011).

Akbari Gate: The gate is named after the name of Emperor Akbar, who built it with the reconstruction of the city wall. The gate was destroyed during the British rule and was never restored. The area was allocated for the sales of grains during Akbar's rule; therefore, it is termed as "Akbari mandi" meaning Akbari Market. (Iftikhar, 2019).

Yakki Gate: The original name of the gate is "Zaki" gate and Zaki was a royal saint who faced Mughals for the protection of his city. Afterwards, it was termed Yakki gate.

Bhati Gate: The city was repopulated with the Bhatti tribe, and the area around this gate is one of the oldest areas of the city (Shuja, 1988). The gate is named Bhatti Gate after the Bhatti tribe, and it was reconstructed during British rule.

Sheran (Lions) Wala Gate: The gate is named after the lions, placed at the gate which were placed in cages during the Rule of Ranjit Singh. The lion is called “Sher” in the Urdu language; therefore, gate is named as Sheranwala gate, and the gate where the Sher (lion) are placed.

Lohari Gate: The gate is located near the Bhati gate and is enclosed by commercial activities. The area is one of the oldest areas of the old city.

Kashmiri Gate: The gate is famous as Kashmiri Gate due to its location, as it is situated on the road connecting to the Kashmir Valley, north of Old Lahore. As it was an entrance gate for the visitors from Kashmir, most of the population in this area belonged to Kashmir.

Mori Gate: It is a small entrance to the city, unlike the other 12 gates. The gate is termed the Mori Gate, as it serves to remove waste from the city to the outside. As the drain is referred to as Mori in local terminology, it is named Mori Gate.

Masti Gate: The original name of the gate was Masjidi Gate due to its location, as it is near the Maryam Zamani Mosque, one of the oldest mosques within the Historic Core of Lahore. With time, it is named Masti Gate, and unfortunately, it has vanished.

Shahalami Gate: The gate is termed Shahalam Gate in the name of the Mughal Emperor, a successor of Aurangzeb, whose name was Muhammad Mo’azzam Shah Alam Bahadur. He died in Lahore in 1712. The area is surrounded by wholesale markets for cosmetics, electronics, and other toys. There is no gateway left, only the name remains in the memories of residents.

Taxali Gate: The gate is named Taxali Gate because there was a Taxali (mint) in the Mughal era, and the gate is only remembered in words. There is no physical existence of the gate. The gate leads to the Shahi Mohallah and Sheikhpurian Bazaar, renowned for the shoe-making industry.

Mochi Gate: There is one story about the nomenclature of the gate that this name is due to the profession of residents, they were cobblers, and the other story states that gate is named after the name of a guard “Moti”. The transformed version is Mocha.

At present, only Roshnai gate is in original condition, Delhi, Sheranwala, Kashmiri, Bhati, Lohari and Mori gate were reconstructed and rest of the six Masti, Taxali, Mochi, Akbari gates were demolished in British period (Noe, 1980).

b. Guzars / Districts:

The Mughal Emperor Akbar divided the newly constructed brick-Walled City into nine ‘guzars’. Each of the nine ‘guzars’ – or areas of movement – has a ‘mansab’ as an administrator, in the present Walled City of Lahore, Punjab, Pakistan. The nine ‘guzars’ inside the Walled City, being part of the 36 ‘guzars’ of the Lahore region, each one of which had to generate a minimum pre-determined income for the emperor. The division of each ‘Guzar’ was into ‘mohallahs’, each ‘mohallah’ had ‘s’ comprised of several ‘Galis’ and Katras (Sheikh, 2016b).



Figure 4-2: Guzars and Gates of the Historic Core of Lahore

Source: (WCLA, 2009) (edited by Author)

Guzar Shahbaz Khan

Shahbaz Khan Kamboh, a distinguished military leader under the Mughal Empire, was honored with the naming of the Guzar Shahbaz Khan area, encircling Lahore Fort, signifying its strategic importance. Recognized as one of Akbar's most capable generals, Shahbaz Khan's Rajput Kamboh lineage and military acumen earned him admiration and respect.

During Akbar's rule, Shahbaz Khan played a pivotal role in organizing the newly constructed brick-Walled City of Lahore, dividing it into nine 'guzars', with Guzar Shahbaz Khan as the primary district. Despite being popularly known as Guzar Mang Khan due to his legendary generosity and ability to fulfill requests, Shahbaz Khan's staunch Sunni beliefs clashed with Akbar's 'Deen-e-Elahi', leading to his imprisonment for nearly three years (Sheikh, 2016b).

Shahbaz Khan was a committed military officer in Akbar's army, and he was promoted from a rank of "Mansab" to lead a group of 100 soldiers, owning 5000 horsemen. His military expertise was proven through his bravery and honesty. He was entitled to "Dagh-e-Mahali" due to the control of corruption in the Mughal army.

However, the Governor of the Mughal Empire had differences with the Mughal Emperor Akbar regarding their religious ideology. Despite his generosity, he was punished, forgetting all his contributions to the Mughal Empire. In the refusal to follow the emperor's wishes, he was stripped of his wealth and land during the period of Jahangir. His contribution to securing the Province of Punjab was his pivotal role in favor of the Mughal Empire.

While Abu Fazl's 'Ain-e-Akbari' extensively mentions Shahbaz Khan's achievements, his name gradually disappeared from official records, symbolizing the shifting political dynamics within the Mughal court. Shahbaz Khan's legacy serves as a reminder of the complex intersections between loyalty, religious beliefs, and political power during the Mughal era.

Guzar Shahbaz primarily consists of a 70 percent residential area, and the remaining 30 percent is commercial, educational, religious, and recreational areas.

Table 4-1: Inventory of Monuments and Urban Areas of Guzar Shahbaz Khan
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/Gardens	Dominant Feature
Guzar Shehbaz Khan / Guzar Manag	Taxali Gate	Kali Beri Baazara	Shahi Mohallah	Tehsil	Jamadar Gali	Badshahi Mosque	Greater Iqbal Park	Badsahi Mosque
	Masti Gate	Baazar Barood Khana		Astana Sharif	Gali Droga Nazoor	Haveli Barood Khana	Jahangiri Fawara	
		Said Mitha Baazar			Fgali Ktri Sikandar Khan	Haveli Teja Singh	ShahJahan Fawara	
		Tibbi Baazar				Maryam Zamani Mosque	Lahore fort Park	
		Anarkali Baazar				Haveli Ram Gopal	Hazuri Bagh	
		Hira Mandi				Choona Mandi Haveli		
		Moti Baazar						

Moti Bazaar: The bazaar's name, "Moti," reflects its historical association with pearls and precious gemstones, although today it offers a much broader range of products. Moti Bazaar is a renowned shoe market in the heart of Lahore. This is the wholesale market where shoes are supplied all over the country and in other countries. During the Sikh Monarch, the locality was known as Bazaar Hassan and with time, it was re-termed as Shahi Mohallah (backroad of Lahore Fort), and a shoe market was established in the area.

Kali Beri Bazaar: The Bazaar is composed of narrow streets and busy lanes, with vendors selling a variety of goods, including fabrics, clothes, jewelry, accessories, spices, and articles related to traditional crafts. The market was filled with live activities and comprised a vibrant environment through sights and sounds. The best-selling item of the market was black barries, perhaps, for this reason, the market has been named “Kali Beri Bazaar”.

Naya Bazaar: The market offers a diverse range of products and services for buyers coming to this market. There is a diverse range of visitors dealing with a wide variety of goods, including household items, accessories, spices, traditional crafts, and many other items. This bazaar, like the other bazaars in the historic core, is composed of narrow streets and bustling roads with vendors displaying their goods and bargaining with clients. This bazaar reflects the

cultural life of the old city and serves as a hub of cultural exchange, presenting a blend of traditional and modern trends.

Tibbi Bazaar: In the Arabic language, “Tibbi” means health related. The name Tibbi (meaning medical in English) indicates associations with health-related issues, and the Bazaar is renowned for its traditional healthcare practices. In the absence of certified doctors, Hakeem and Homeopathic doctors treated the patients. This market offers a wide range of healthcare products, including herbs, spices, and natural remedies. The market remained a hub of medical practitioners, including Unani, Ayur Vedic, Herbalists, and local healers. In addition to medicines, the market also focuses on other items such as textiles, clothing, and everyday household items of daily use.

Heera Mandi Bazaar: The bazaar was developed in the Sikh period by a Sikh Hero “Heera Singh” brother of Gulab Singh, and because of his name, it was named Heera Mandi Bazaar. It is also a congested space, like the other commercial areas of the Walled City. It serves as a hub of commercial activities, catering to the area near the Taxali gate. It was famous for its colorful articles related to clothing and beauty products for women. There are shops, stalls, and markets selling a variety of objects. It is associated with the entertainment industry (Shahi Mohallah), but it still offers a flavor of traditional lifestyle and crafts. During the period of President Zia ul Haq, all such entertainment activities were banned, and the hustle and bustle of bazaars was reduced; now, it serves as a commercial space for the local neighborhood.

Gumti Bazaar: Gumti Bazaar is one of the oldest bazaars in the historic core of Lahore, renowned for its diverse range of goods related to women’s clothes and embroidery. The bazaar is situated on narrow streets with commercial activities taking place. The lovers of traditional dresses visit this place in search of a diverse range of articles, including Meena Kari, Gota Kinari, leather products, mirror work on clothes, wooden fabrics, and artificial jewelry items. The market can be accessed from various directions, through Bhatti, Roshnai, and Lohari Gates. On entering through the Taxali gate, via “Pani Wala talab”, moving towards Gomti Bazaar, the focus is Gomti Bazaar Chowk. This chowk divides the commercial area into two sections. The left side of Gomti Bazaar is a vibrant display of colors featuring glass bangles, wedding dresses adorned with artificial jewelry, and pre-wedding celebration items. It always remained a favorite place for families engaged in wedding activities.

Before independence, the area was predominantly inhabited by Hindus, as proved by the names of nearby localities such as Kocha Bali Ram and Gali Kali Mata. The market is associated with famous Indian actors, including Om Parkash, and is also renowned for its connection to the famous painter, Abdul Rehman Chughtai. Being a residence place for Hindus, the area has several temples and Shivala buildings, including Pandit Radha Kishan and Kali Maata temple. Due to non-operational status, they have been developed.

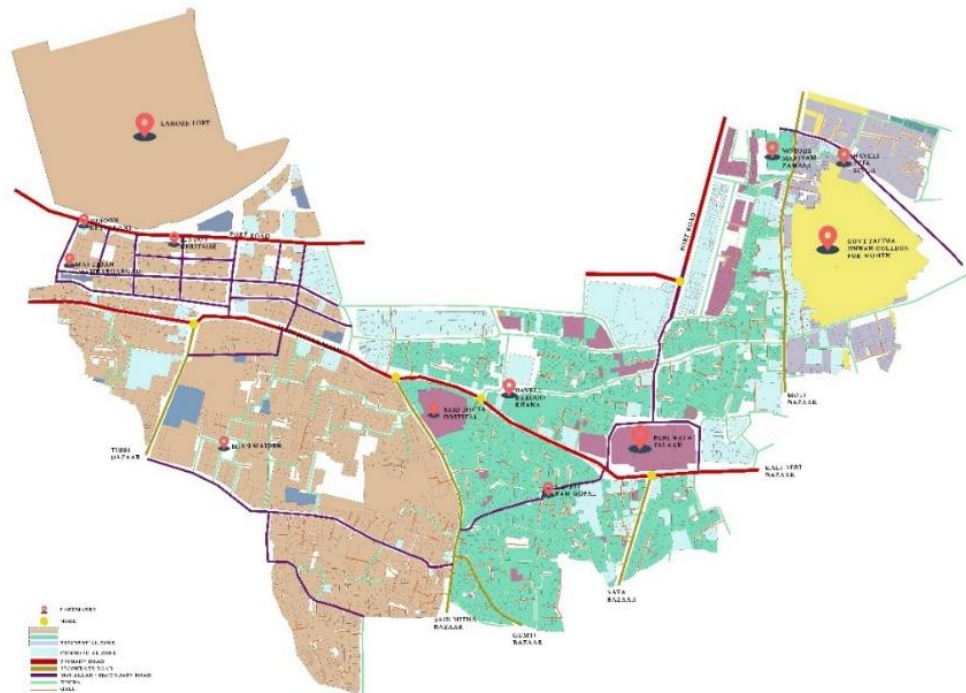


Figure 4-3 : Guzar Shahbaz Khan showing Urban Morphology and Landmarks

Areas of red color hues are the districts, and the black dotted line represent the main spines of the Guzars.

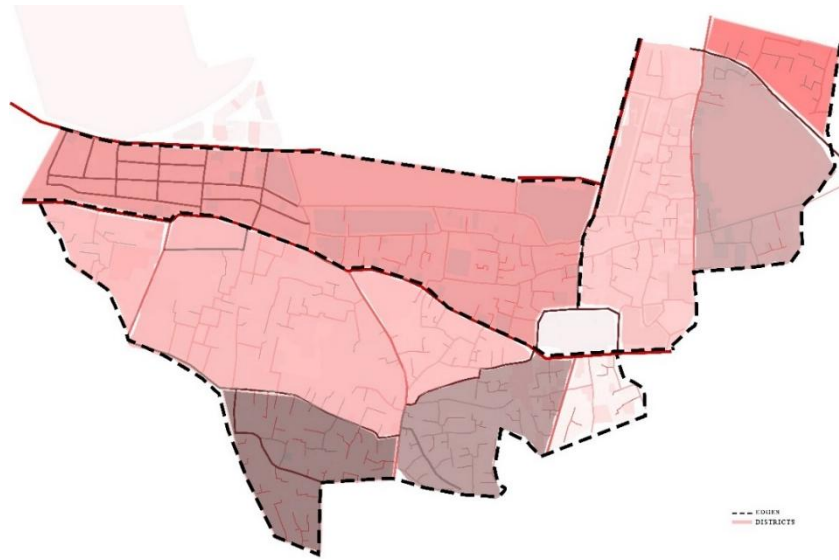


Figure 4-4 : Guzar Shahbaz Khan showing Districts

Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar Bahar Khan

The 'Guzar' of Bahar Khan holds a unique historical background, as Bahar Khan Lohani served as the Mughal 'subedar' (governor) of Bihar. He had a distant familial tie to Akbar through a Rajput wife. Following Bahar Khan's demise, his minor son ascended to rulership with Sher Shah Suri acting as regent. Despite facing initial Mughal opposition, Sher Shah Suri consolidated power and eventually emerged victorious over the Mughals. Akbar, born during this tumultuous period, harbored a deep respect for Bahar Khan Lohani, feeling his son had been wronged by Sher Shah Suri.

The 'Guzar' of Bahar Khan spanned the region east of the present-day Bhati Gate, incorporating the oldest gateway known as Lohari Gate. (Shuja, 1988). Its boundaries extended to the midpoint of the wall between Lohari and Shahalami, demarcated by the 'nullah' still present in the area. Initially, this 'nullah' flowed within the old mud walls to the east. To its north lay the 'Guzar' of Shahbaz Khan, while Guzar Waacho Wali and Guzar Talwara bordered its east and west, respectively. This 'Guzar' encompassed the oldest gateway and served as the primary residential area for the elite of the time (Sheikh, 2016a).

Guzar Bahar Khan consists of 20 percent commercial area, with the remaining 80 percent is residential.

Table 4-2: Inventory of Monuments and Urban Areas of Guzar Bahar Khan
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Guzar Bahar Khan	Lohari Gate	Mori Gali Bazaar	Mohalla Sathan	Dogran	Pani Wala Talab	Pani Wala Talab	Chowk Matti Square	Paalyan Wala Maidan
	Mori Gate	Lohari Mandi Bazaar	Mohalla Chiri Maran	Baili Ram	Mori Gali	Lohari Mosque (Muslim Masjid)	Qadimi Shehar	
				Kharak Singh	Fasial Street	Victoria School (Haveli Naunehal Singh)	Chowk Lohari Mandi	
				Kababian	Chapra Gali	Neevin Mosque	Mori Gate Park	
				Darzain		Masjid Kharasian		
				Sachain				

Lohari mandi: Lohari Gate leads to Lohari Mandi, one of South Asia's oldest markets, where caravans from Multan once entered the city. Historically, it connected the Guzar Bahar Khan and Guzar Machi Hatta divisions during Mughal rule. Most of the gates were destroyed by the British, and six of them were rebuilt. Sir Robert Montgomery rebuilt this gate in 1854, and the Bazaar associated with the Lohari Gate is renowned for its diverse range of products, including groceries, kebabs, and traditional-style cooked food from Lahore. It directs to Lohari Mandi including Haji Nehari House and Shafeeq Grocery store. When moving from Bukhari Chowk to Pani Wala Talab and Roshnai Gate, the area is flavored with music and dance. On further moving to Hazoori Bagh, the Lahore Fort and Badshahi Mosque are accessible through this courtyard.

Mori Bazaar: Mori Gate is in the west of Walled City Lahore, and the gate is smaller than the other twelve gates of the city, and the function is also different as the gate is used to get rid of the waste of the city. However, the gate has a significant and historic value, in addition to commercial value. The gate is famous for its fish market, which sells a variety of products; another important item is surgical equipment. In addition to its commercial value, the area is

renowned for its manufacturing potential. It is distinguished by the furniture polish, locally termed as “Lakh”, which is famous for its specific value and effective role in furniture products. The favorite hobby of the residents of this area is kite flying; therefore, the sales figures become higher during the Basant (a native festival).

Sathaan Bazaar: Sathaan Bazaar is a significant commercial hub, offering a diverse range of products, including household items, daily wear, fabrics, spices, and food stalls. The Bazaar is in the central part of the historic core of Lahore.

Said Mitha Bazaar: Said Mitha Bazaar is also a hub of commercial activities, serving neighborhood communities. The special features are shopping, dining, and social activities. The selling goods are daily necessities, clothing, and textiles, as every Guzar has its bazaar. This bazaar is famous for its Food Street and delicious Pakistani food.

Awami Bazaar: Awami Bazaar (People’s Market) is a term frequently used in Pakistan to refer to local markets that serve the neighborhood communities for the daily usable products. In this bazaar, fresh food is available and is famous in and around the area for typical products, such as Jaida Lassi in Sheikhan, Baili Ram located in the Walled City of Lahore. The main products include groceries, textiles, fabrics, household items, and a variety of miscellaneous products.

A circular road divides and enters the Walled City of Lahore through Mori Gate and Lahori Gate. From Mori Gate, Mori Bazaar Road continues, while from Lahori Gate, Lahori Bazaar Road continues, forming a junction that creates a node. From this node, the road continues and further divides into Sathaan Bazaar, Said Mithan Bazaar, and Awami Bazaar. On Lahori Bazaar Road, a road from Bokhari Road joins, creating another node there as well.

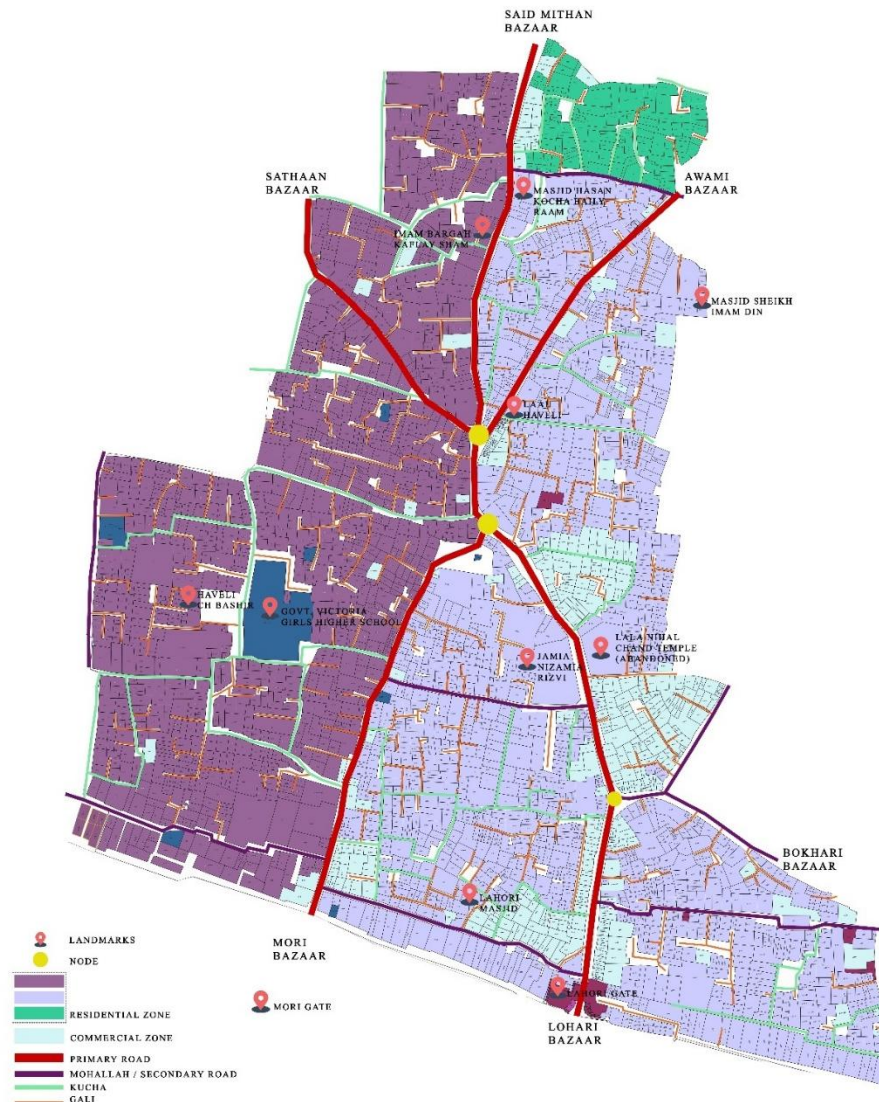


Figure 4-5: Guzar Bahar Khan showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Districts: Green hues represent the districts, and the black dotted line represents the main spines of the Guzar.

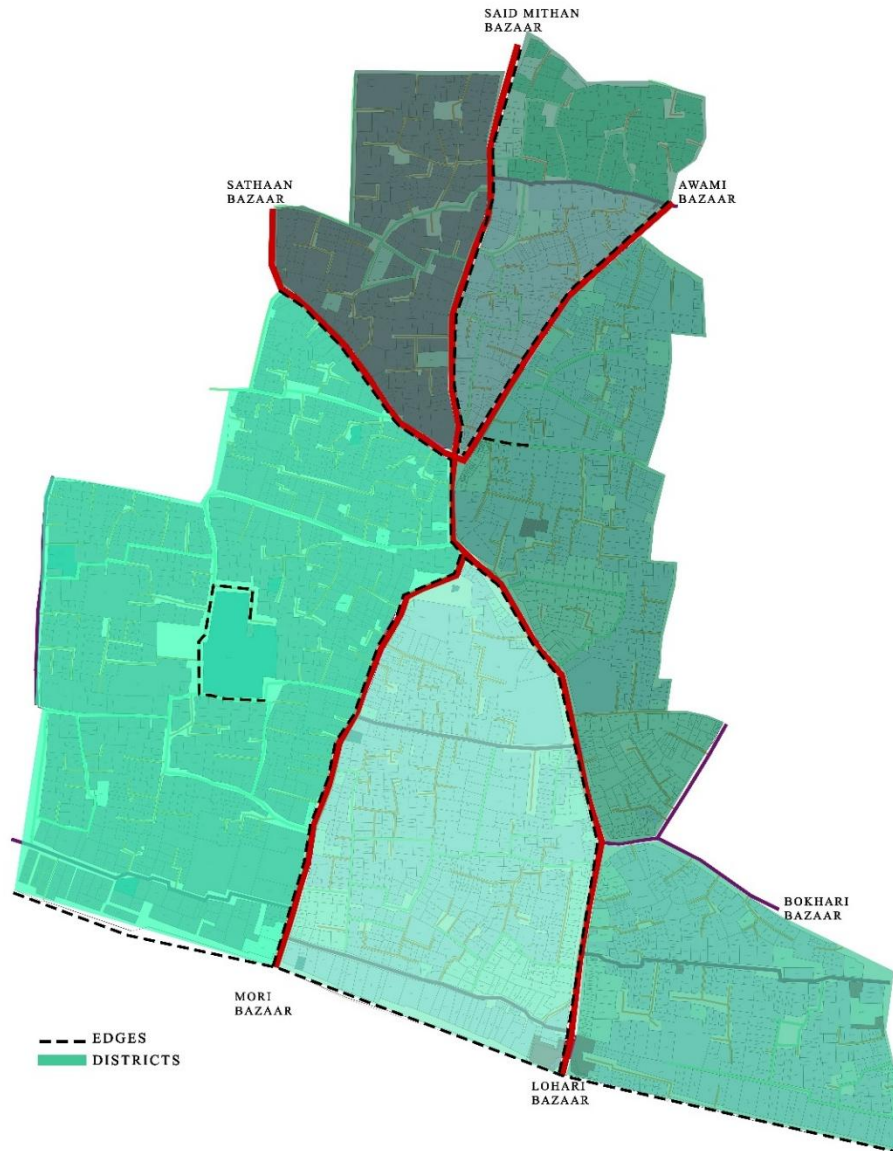


Figure 4-6 : Guzar Bahar Khan showing Districts and Bazaars

Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar Waacho Wali

To the east lies Guzar Waacho Wali. The name 'Waacho Wali' has two probable sources, as the exact origin remains uncertain. Firstly, before Akbar's time, this area bordered the eastern edge of the mud-walled ancient city and was home to a significant population of buffaloes and cows, serving the local community. Exploring the term 'Waacho', my friend Mushtaq Soofi referred to Sardar Khan's 'Punjabi-Urdu Dictionary,' which defines 'Waach' as

derived from the Punjabi word 'baach', implying a place where buffaloes are kept, with 'Waachhan Wali' indicating such a location.

This association likely persisted even after Akbar's city was established, although the buffalo colony temporarily relocated to 'Guzar Rarra' at the city's easternmost corner, as it was an open space. Eventually, with the construction of buildings during Shah Jehan's reign, the cattle colony shifted to 'Gowal Mandi' just south of the Walled City. Today, it is renowned as a culinary hub due to the influx of Kashmiris during the Mughal and Maharajah Ranjit Singh's era.

The second possible origin of the name 'Waacho Wali' could be attributed to Kashmiri families that migrated here during Akbar's reign. Prominent among them were the Kaul, Dar, and Waacho families, affluent Kashmiris who settled in Lahore during the Mughal era. Although these families resided in the mohallah until 1947, fleeing to India during the Partition riots, it is likely that the name 'Waacho Wali' stemmed from the long-standing presence of the cattle colony in the area for centuries.

This Guzar consists of 25 percent commercial area and the remaining 75 percent residential area.

Table 4-3: Inventory of areas of Guzar Waacho Wali
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Guzar Wachho Wali	No gates to it's boundary	Sarafa Baazar	Jori Mori Mohallah	Katilan	Gali Kabli Maal	D-Plaza	Wacho Wali Chowk	Fawara Chowk
		Chatta Baazar		Khurasian		Fawara Chowk	Chowk Baba Habib	
		Wacho Wali Baazar		Ram Diwara		Govt. Forman Girls High School		
		Jori Mori Baazar		Sheikhan				
		Sonr Mandi Baazar		Mehtay				
		Chatta Baazar						

Sooter Mandi is famous for its production of cotton yarn and commercial activities. After entering Sooter Mandi, there are two streets, Neeli Gali and Rang Wali Gali.

Neeli Gali: It is derived from Neel or Indigo, a famous and highly prized dye globally renowned for its quality and rich color. The historical significance of Neeli Gali lies in the indigo trade, which contributed significantly to Lahore's international trade.

Rang Wali Gali: It derives its name from the multiple colors used in the dyeing of fabrics and textile-related products.

Waacho Wali Bazaar: The shrine of Pir Shirazi, Jamia Masjid al-Wahab, Jamia Masjid Anas Ahle Hadees, Government. Forman School for Girls, Jamia Masjid Mahajreen, and Masjid Sheikh Imam Din are the landmarks of the area.

A road from the paper mandi bazaar continues and splits into the Sutar Mandi Bazaar Road. Here, it makes a junction. Further, when we move this road, a road from the Awami Bazaar merges with it, creating a junction point. This road further splits into roads and makes a junction point. This one road is directed towards Maia Bazaar, and the other is directed towards Waacho Wali Bazaar.

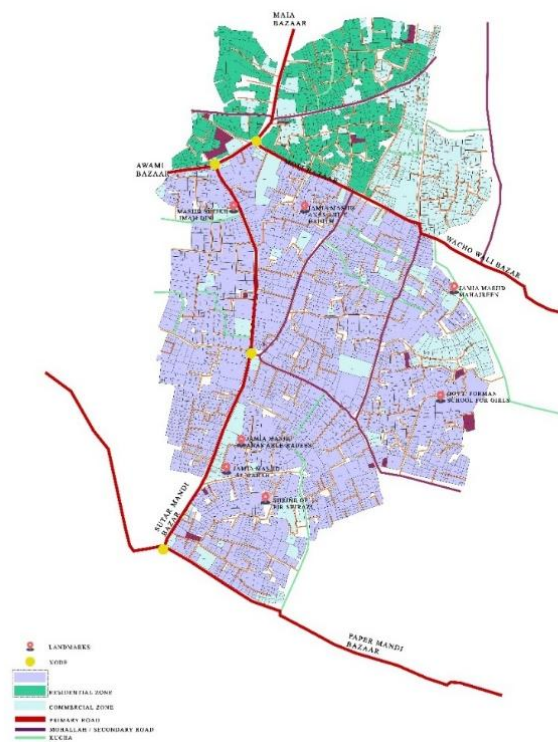


Figure 4-7: Guzar Waacho Wali showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Purple hues represent the districts, and the black dotted line represents the boundaries of the Guzar.

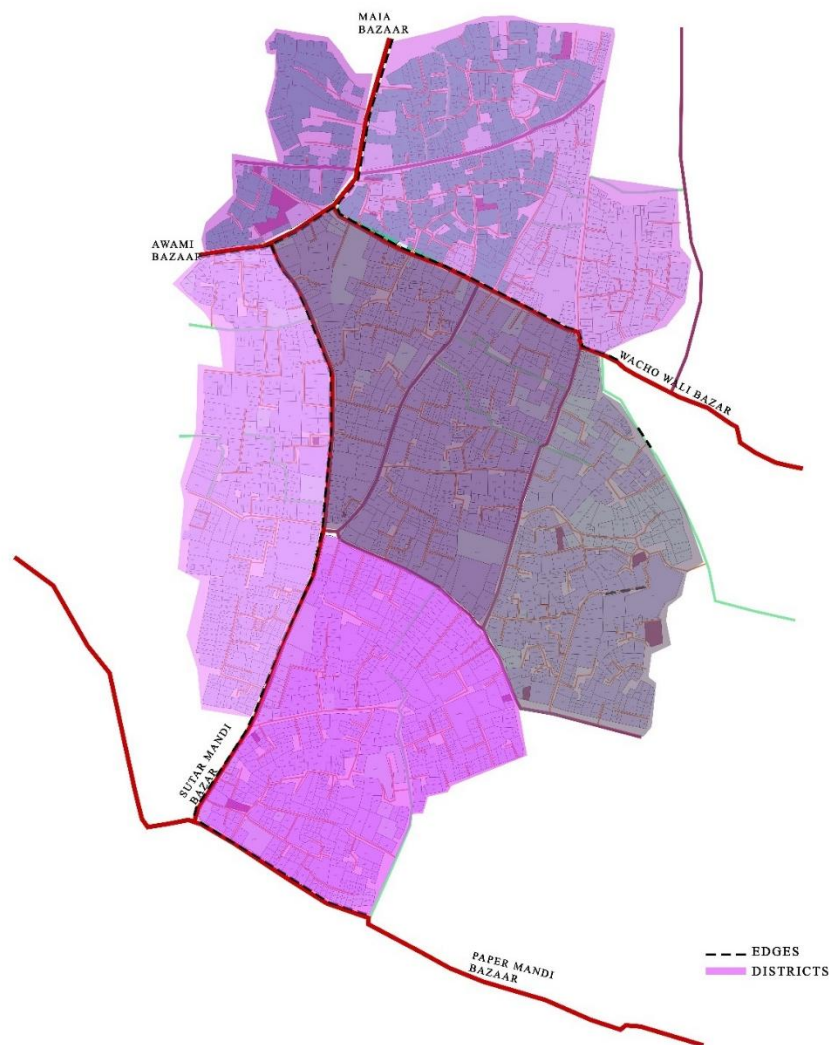


Figure 4-8 : Guzar Waacho Wali showing Districts and Bazaars

Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar Dhal

The third thoroughfare connecting Mochi Gate to the outskirts of Guzar Bahar Khan was famously called Guzar Dhal, or the 'Guzar' of the shield, an intriguing name steeped in historical significance. Both Guzar Dhal and its western counterpart, Guzar Talwara, symbolized the shield and sword of the Mughal Army, a fact often overlooked. The infantry,

predominantly composed of Rajput warriors from the Bhats, embodied the sword, while the 'dhal' comprised Turkmen or Kakayzai horsemen who served as the vanguard.

In adherence to the Mongol tradition of agile horsemen adept in archery, Guzar Dhal evolved into a center for bow and arrow manufacturing during the reign of Akbar. Even today, we see neighborhoods named after archers ('Mohallah Teerandazan' or 'Mohallah Kamangaran'). To the south of Guzar Dhal, expansive tracts of land functioned as training grounds for these riders, a tradition dating back to Qutbuddin Aibak's fatal accident during a polo match, underscoring the importance of equestrian skills.

With the advent of the British era, Qizilbash horsemen settled in this area, perpetuating a tradition that spanned centuries. The division of areas based on professions remained apparent, with the western part of Guzar Dhal representing the historic city. At the same time, the expanded Akbar-era walls provided ample space for horsemen and their weapon industry to flourish. This Guzar comprises 80% commercial area and 20% residential area.

Table 4-4: Inventory of Spaces Guzar Dhal

(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Guzar Dhal	Shahalam Gate	Said Mitha Baazar	Mohallah Kamangaran	Pirshirazi		Laal Haveli	Mochi Bagh	Shalami Baazar & Laal Haveli
	Mochi Gate	Naya Baazar		Sultan Mehmood		Iqbal Mansion	Shalimi Gate Baazar	
		Bukahari Baazar		Gulzariwala		Bikan Khan Mosque	Papar Mandi Chowk	
		Sadakaran Baazar		Dogran Baniyan		Peer Dhal Mazar		
		Kamangaran Baazar				Saat Pak Daman Bibian		
		Papar Mandi Baazar				Masjid Saleh Kambooh		
		Danna Market						

Papar Mandi Bazaar: Located between the Shah Alam and Lohari Gate, it serves the community with a wide range of products, including herbs, jams, perfumes, and plastic bottles. There are almost 250 shops, making it a significant commercial hub in the area. The bazaar has its roots in the pre-partition period of India and Pakistan.

Kamangaran Bazaar: This market is known for its handicrafts and offers a diverse range of items, including household utilities, clothing, and fabric

Peer Shirazi : It is also known as Noori Manzil, a street or alleyway located within the Walled City of Lahore, Pakistan. It is named after the renowned Sufi saint, Hazrat Peer Syed Ghulam Mohiuddin Gilani Shirazi. The shrine of a Sufi Saint is in the close vicinity.

The area is known for its historical significance and cultural heritage. Peer Shirazi/Noori Manzil is characterized by its narrow lanes, traditional architecture, and vibrant atmosphere. It is home to various shops, residences, and historical landmarks, contributing to the rich tapestry of Lahore's Walled City.

Jeddah Tower, Jamia Masjid Hafiz Khawaja Din Naqshbandi, Government Vocational Training Institute, and government girls' primary school Joray Mori are some.

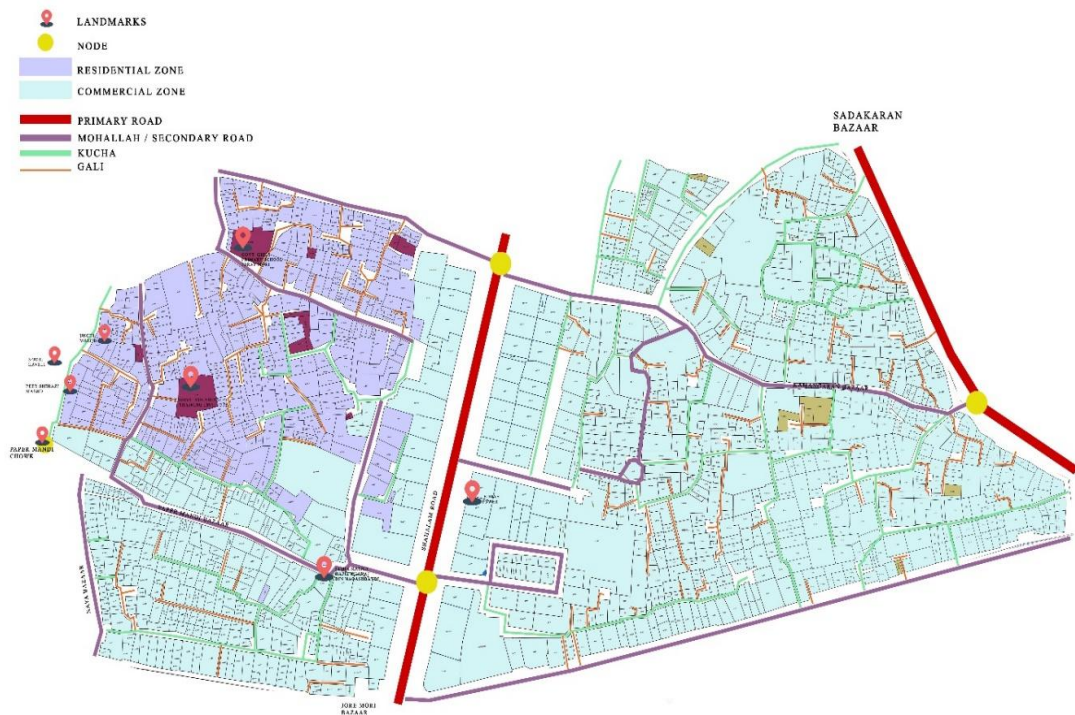


Figure 4-9 : Guzar Dhal showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Brown hues represent the districts, and black dotted line represents the edges of the Guzar.

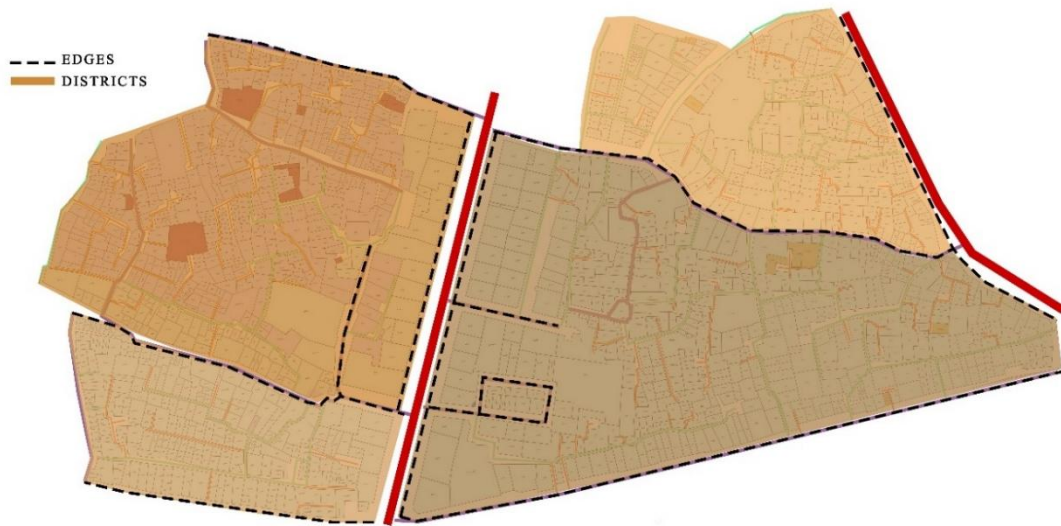


Figure 4-10 : Guzar Dhal showing Districts and Bazaars
Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar Talwara

To the west, where Bhati Gate exists and its entire inner area, the new wall created, was named as 'Guzar Talwara'. To the east, again outside the original walls, came Guzar Rarra', and to the north-east came Guzar Ishaq'. All of these have very interesting origins.

Guzar Talwara, the name derived from 'Talwar', meaning sword of the Mughals, to 'Guzar Dhal', which denoted the shield near the present-day Mochi Gate area. However, the true origins of 'Talwara' reveal a surprising narrative, one that unfolded during the reign of Emperor Akbar.

Akbar, born in Umerkot, Sindh, in October 1542, faced tumultuous times during his early years. His father, Humayun, was in exile after Sher Shah Suri's victory over the Mughal army. In Lahore, Akbar's brother Mirza Kamran's refusal to aid him compelled Akbar to journey towards Sindh. Upon Humayun's reconquest of Delhi in 1555, Akbar ascended the throne, albeit under the regency of Bairam Khan.

As Akbar matured, he sought to diminish Bairam Khan's influence over him. By 1559, Akbar began to assert his authority, leading to tensions between him and Bairam Khan. Eventually, Akbar dispatched Bairam Khan on a military campaign, which culminated in Bairam Khan seeking refuge in the fortress of Talwara, Hoshiarpur. Despite Bairam's resistance, he surrendered to Akbar's forces in October 1560. Although Akbar pardoned him and ordered him to perform Hajj, Bairam Khan was assassinated enroute by a commander of Alwar's ruler, Haji Khan Mewati, a Lohani Pathan.

Thus, 'Talwara' came to symbolize a place where the mighty submitted to Akbar's authority. It is widely believed that this association led to the naming of the Bhati Gate area as 'Guzar Talwara.' Another account suggests that Akbar's successful quelling of the Bhat Rajput, who settled in Lahore and primarily wielded swords, contributed to the name 'Talwara.'

During this period, the renowned Mughal financial expert Todar Mal erected his residence in Bhati Bazaar. Many believe that the present-day Fakir Khana stands on the site of his original house. Subsequently, during Aurangzeb's reign, the area was renamed Bhati Gate to honor Lahore's Bhat Rajput, underscoring Lahore's historical connection with the Rajput since ancient times.

Guzar Talwara consists of around 8% commercial space, and the rest, almost 92%, is residential.

Table 4-5: Inventory of Spaces Guzar Talwara
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares / Gardens	Dominant Feature
Guzar Talwara	Taxali Gate	Faseel Road	Jogi Mohallah	Koocha Mota Singh	Khajoor Gali	Naqsh Arts Academy	Samian Chowk	Fakir Khana Museum
	Bhatti Gate	Data Darbar Road		Koocha Moti Tibbah	Gali Chomala	Haveli Wajid Ali Shah	Tibbi Chowk	
		Bazaar Sheikhpuri		Koocha SheikhIqbal	Gali Pir Taj	Qamar Manzil		
		mela RamGali		Koocha kaghzan	Gali Hakeemdin	Faqir Khana Museum		
		Hakeema Bazaar			Thandi Gali	Pakistan Takies		
		Shish Mahal Road			Aurangzeb Street			

Heera Mandi: Heera Mandi is situated in the Shahi Mohallah, in the close vicinity of Lahore Fort and Badshahi Mosque. Initially, the market was established during the Mughal era for the trading of precious stones and jewelry for the community engaged in the courtesan ship. However, with time, the hub of cultural activities transformed into an entertainment center during the Mughal, Sikh, and British periods, and it became notorious as a red-light district. President Zia-ul-Haq banned all these activities, and the area has been established as a commercial area.

Hakeeman Bazaar: The bazaar was established by Hakeem Khuda Buksh, who resided inside Bhati Gate. The name is believed to be related to a mosque, constructed by Hakeem Abdullah Ansari during the Sikh era. The salient feature of the area is Unchi Masjid (High Mosque), and it is believed that Hazrat Shah Inayat Qadri led the prayers. There is a link road which connects Bazaar-e-Hakeema with Maidan Bahian. There were several famous “Tib” in the bazaar, offering treatment for health issues.

Fakhir Khana Museum: The Faqir Khana Museum in the Walled City of Lahore is one of the oldest private museums, established by Fakir Azizuddin in the 18th century. The articles span from the Mughal, Sikh, and British periods, including miniature paintings, calligraphy, arms, jewelry, and textiles. The museum has been famous for ages due to its articles, and it remains in the family of Hakeem Azizuddin.

Haveli Wajid Ali Shah: Haveli Syed Wajid Ali Shah was built between the Akbari and Mochi gate of the historic core of Lahore. It was constructed by two brothers Syed Abbas Ali Shah and Syed Dilawer Ali Shah whose ancestors migrated from Iran. Since its construction, it has been a center of Azadari (Mourning) ritual for Imam Hussain. The haveli is owned by his descendants and is still a place for Azadari.

Unchi Masjid: The mosque is also famous as the High Mosque and is in the Walled City of Lahore. The mosque is referred to as Unchi Masjid as it has been constructed on a raised platform, elevating it above the surrounding area. The mosque reflects high cultural value, and its salient features are associated with the Mughal era, such as beautiful arches, ornate domes, and delicate, intricate calligraphy. The mosque has served as a place of worship and spiritual reflection for centuries, attracting visitors and worshippers from around the world. Shaikhupurian Bazaar, Bazaar Samian, Pakistan Talkies Cinema, Hazrat Baba Masoom Shah, Darbar-e Ali, Haveli Wajid Ali, and Tibbi Chowk are the historic landmarks of Guzar Talwara.

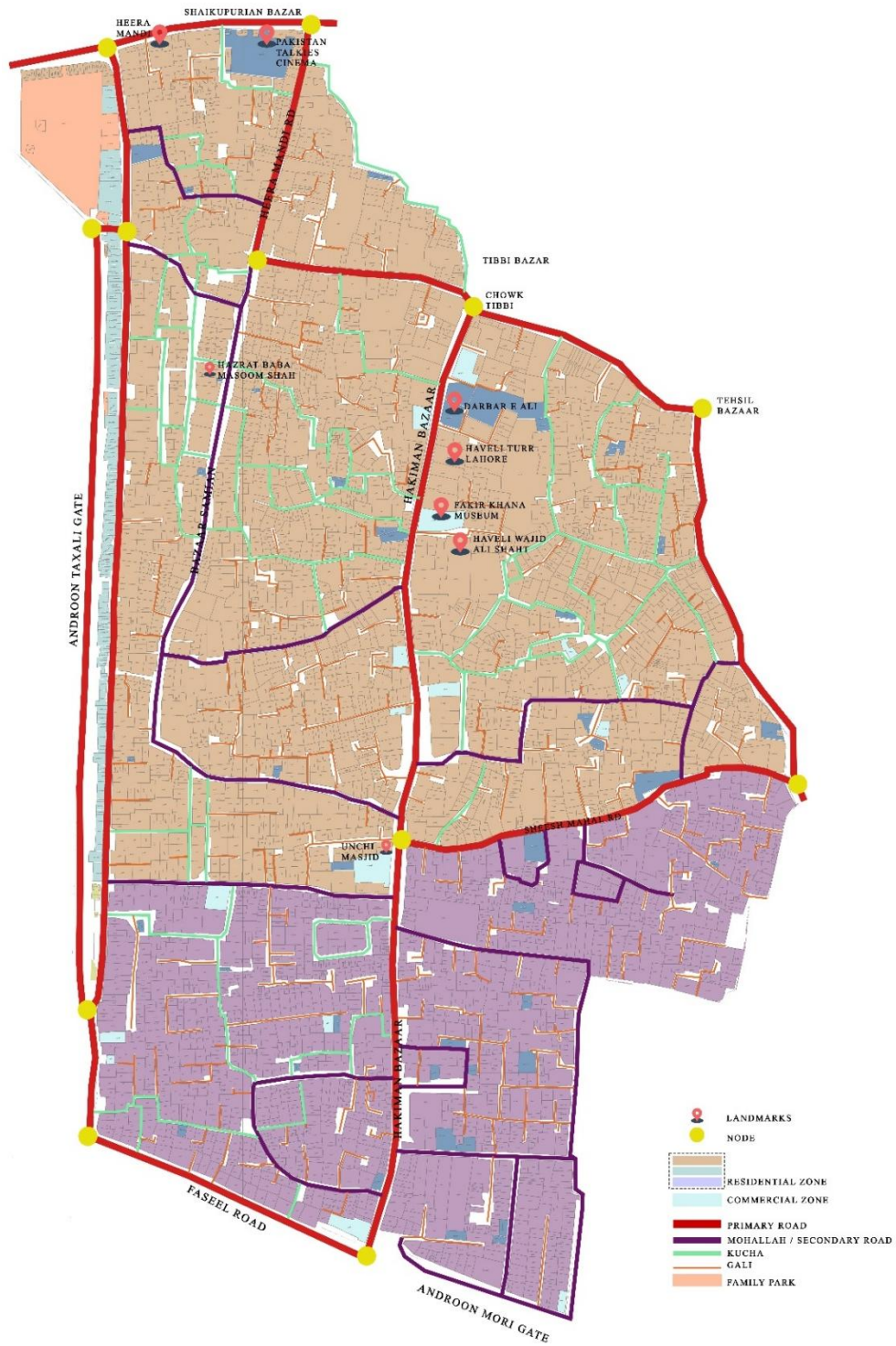


Figure 4-11: Guzar Talwara showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Brown hues represent the districts, and the black dotted line represents the edges of the Guzar.

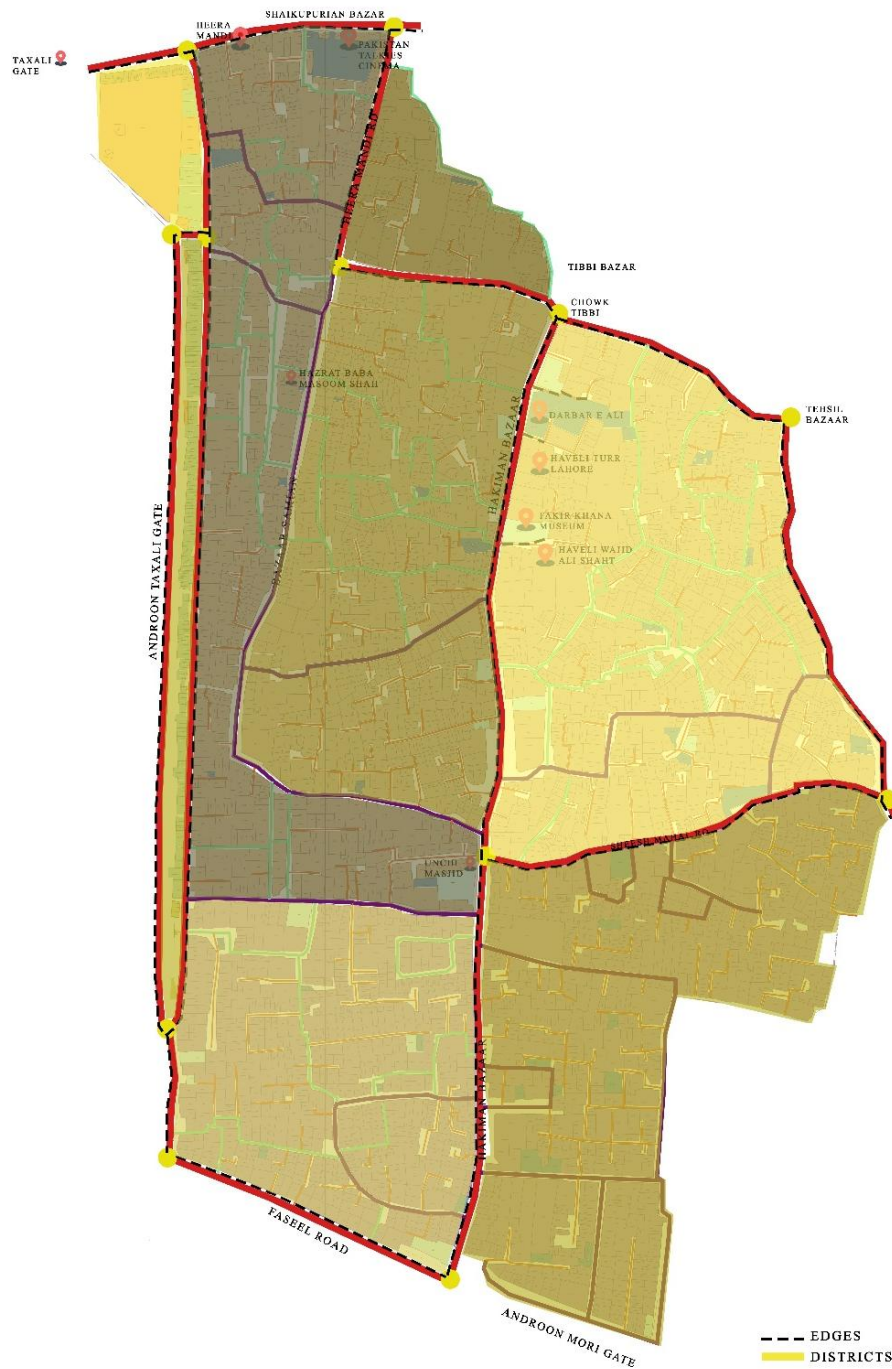


Figure 4-12 : Guzar Talwara showing Districts and Bazaars
Source: Basemap is from WCLA, 2009 (edited by the Author)

- On entering from Bhatti gate through the route of circular road, a road directed straight to Bazaar-i-Hakeeman, left for Faseel Road, and right towards Androon Morri Gate. At this point, it reaches a junction point. On this straight road, the road splits into two, one directed towards Sheesh Mahal Road and the other continue straight further towards Tibbi Chowk. At this point, a node is formed.
- From the Tibbi chowk junction, a road is directed towards Tibbi bazaar, on the right to the tehsil bazaar, on the left to the Heera mandi road.
- A sheesh mahal road next makes a junction with the road of Said Mitha Bazaar Road. A Faseel Road on the left side makes a node with the Androon Taxali road, and on the top, makes one more node with Androon Taxali Gate Road coming from the Taxali Gate.

Guzar Ishaq

Guzar Ishaq encompassed the northern expanse of the newly walled city from Masti Gate to Sheranwala. Initially known as Guzar Khizr, it was named after the esteemed saint Khwaja Khizr, aptly so, given the river's port at today's Sheranwala Gate, which served as the conduit for all trade flowing into Lahore. The evolution of the name Guzar Ishaq reveals a captivating tale.

The entirety of the land stretching from beyond the old mud-walled city to the present Shalimar Gardens was the domain of the Arain family and bore the appellation Ishaqpura, named after its proprietor Mian Ishaq Uddin Arain. Among his descendants, Mian Misbahur Rehman remains noteworthy.

Akbar designated the area as 'Guzar Ishaq' after it was transferred to the emperor by the Arain family. Subsequently, during the reign of Akbar's son, Shah Jehan, the exquisite garden emerged, leased from the Ishaqpura territory. The Mian family maintained ownership of the gardens until 1958, when General Ayub assumed control due to the family's opposition to his dictatorship.

The Guzar Ishaq consists of more than 85% of the commercial zone, and the remaining 15% is a residential zone.

Table 4-6: Inventory of Spaces Guzar Ishaq

(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Guzar Ishaq	Kashmiri Gate	Nugaran Baazar	Mohalla Bazurg Shah	Kund Rawan	Gali Mian Ghous	Katri Bawa		Kashmiri Baazar Chowk & Gurdwara Janam Asthan
	Sherawala Gate	Sheranwala Baazar	Farooq Gung Mohalla	Haji Pir	Gali Pathan	Jamia Masjid Maulana Ahmed Ali Lahori	Shrine of Syed Baba Haji Pir Sarkar Lajpal	
		Sawaran Bazaar		Khair ud Din	Sheranwala Gali	Gurdwara Janam Asthan Guru Ram	Shrine of Pir Zaki Head Burrial	
		Kashmiri Gate Bazaar			Gali Rajputan	Nur Inam Wali Mosque		
						Govt Islamia High School Sheranwala Gate Lahore		
						Shrine of Syed Baba Haji Pir Sarkar Lajpal		

Choona Mandi: There are three historic havelis in the Choona Mandi: Haveli Jamadar Khush Khal Khan, Haveli Teja Singh, and one more Haveli. The most significant is Haveli Khush Khal Khan, which is now adaptively reused as Government Fatima Jinnah College for Women. Access to the haveli is restricted due to security concerns, despite its cultural values. The area also features another notable landmark, the Gurdwara Janam Asthan Sri Guru Ram Das. The haveli can be a great tourist place for foreign and local visitors.

Kotwali Wala Bazaar: It is a busy market in the Walled City of Lahore, developed in history and tradition. It is situated near Kotwali Chowk and is famous for its vibrant activities featuring a diverse range of items, including textiles, fabrics, jewelry, spices, and local delicacies. The area is characterized by narrow streets and cul-de-sacs, which present historic values.

Azam Cloth Market: The Pakistan Cloth Market was established in the 1950s by Lieutenant Azam Khan, serving as a hub of textiles with approximately 12,000 shops featuring imported

products from China, India, Iran, and Afghanistan. Therefore, the market is referred to as the Azam Cloth Market. 1300 shops are renowned for their international trade.

Gurdwara Janam Asthan Guru Ram: Kotwal Wala Chowk, Govt. Islamia High School, Sheranwala Gate, the Shrine of Syed Baba Haji Pir Sarkar Lajpal, and Government Girls High School, Choonna Mandi, are historic landmarks of this area.

Shahi Guzargah is split into two roads, one of which is directed towards the

Kotwali Bazaar and other areas towards the Kashmiri Bazaar. At Chowk Kotwali, there is an exit that forms a junction of roads, known as a node. The road Kotwal Wala Bazaar next directed towards the Choonna mandi. A road from the Yakki Gate is directed towards the Sheranwala Bazaar, which then intersects the road from the Naugaran Bazaar. A Maulana Obaid Ullah Anwar Road is made a junction point with the road coming from the Kashmiri Gate that leads towards the Kashmiri Bazaar, and this road further makes a node with the Kotwal Wala Bazaar Road and Choonna Mandi Road.

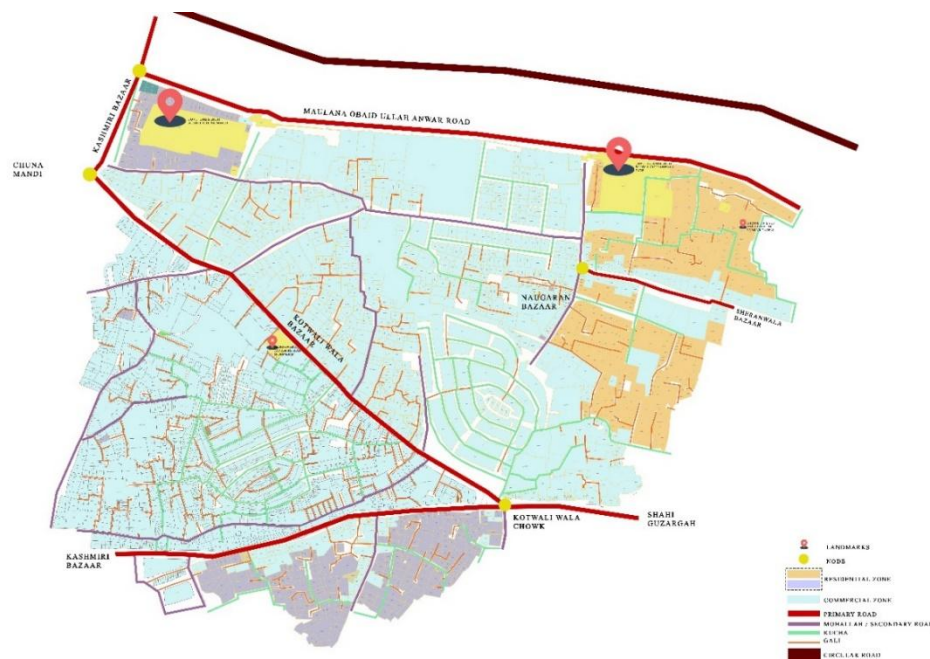


Figure 4-13 : Guzar Ishaq showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Green hues represent the districts, and the black dotted line represents the edges of the Guzar.

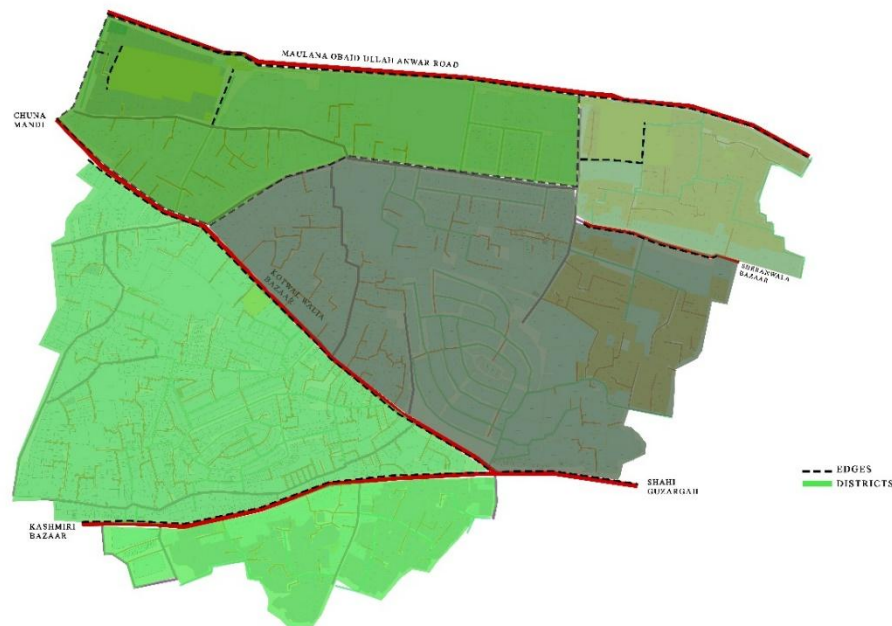


Figure 4-14: Guzar Ishaq showing Districts and Bazaars
Source: Basemap is from WCLA, 2009 (edited by the Author)

Machi Hatta Guzar:

Machi Hatta, now a part of old Lahore, holds historical significance rooted in its name and function. In Punjabi, 'Machi' denotes a water supplier, with origins traced back to Sanskrit, a language of ancient India. While linguistic debates speculate that Punjabi predates Sanskrit, the term 'Machi' remains integral, also appearing in Urdu/Hindi as 'Mashkee,' with 'Mashak' indicating an animal skin for water storage.

During Akbar's era, Lahore lacked a centralized water supply system. Instead, most homes relied on wells, with some alleys sharing communal ones. Machi Hatta, situated at the eastern edge near the river, housed water carriers and multiple wells. These carriers supplied water to residents who lacked wells, a practice that continued until the introduction of piped water from Paniwalla Talab in 1880.

Following Akbar's expansion, Machi Hatta became its own Guzar (neighborhood) within the Walled City, situated west of Shahalami Bazaar. Despite changes, the name and locality endured. Notably, 'Machi' denotes a Hindu caste, viewed pejoratively, though caste

distinctions hold less sway among Muslims. However, communal approaches often disseminate inequitable terms.

Moreover, Machi is often referred to as a proper name, such as Machi Singh or Machi Ram. The places are also named after the personalities or the functions. Machi Hatta's legacy presents an intricate tapestry of language, social dynamics, and social identity.

The Guzar Ishaq is one of the Guzars, comprising almost 99% commercial area. perhaps 1% can be residential.

Table 4-7 Inventory of Spaces Guzar Machi Hatta
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Machi Hatta Guzar	No gates to it's boundary	Gumti Baazar	Mohalla Kakezian	Gulzariwala	Mahjreen wali gali	Tomb of Malik Ayyaz	Shah Aalm Chowk	Rang Mahel Chowk
		Awami Baazar		Killi Khan		Rang Mahal		
		Sada Karan Baazar		Gul Begum		Haveli Kabuli e Maal		
		Kasaria Baazar		Garan		Rang Mahal Christain High School		
				Atana Shari				
				Chobak Sawarn			Gawalmandi	

Suha Bazaar: Suha Bazaar is one of the most expensive markets in old Lahore dealing with gold and precious stones, situated between Shahalami and Lohari Darwaza (Gates). The area was famous for its trading of gold, silver, and precious stones, which were used to make jewelry. Currently, it consists of almost 55 floor shops, presenting a legacy of 30 years. Each shop is offering a dazzling array of stones in fascinating patterns.

Shahalam Market: The Shahalam Market is one of the largest and the most famous markets of the Walled City dealing with goods and services. Shahalam market is the hub of electronics, handicrafts, stationery, crockery, fabrics, items of decorations, sports goods, household utilities, fashion articles. The market consists of almost 1200 shops where visitors can explore the articles from lowest range to the highest. The area plays a pivotal role in the trading of

goods in national and international markets. You can get almost every necessity of life, here in this market as a wholesale dealer.

Dabbi Bazaar: Dabbi Bazaar, nestled between Lohari Darwaza and Shahalam Darwaza, is steeped in Lahore's rich history and spiritual tales. That is the place where Guru Arjan visited Sodhi family and Chajju Bhagat presented him a bag, full of 282 gold mohars to pay homage to the Guru. The amount was used in the construction of Baoli Sahib, an expression of divine. The Guru Arjan's visits to this Bazaar with Adhi Granth enriched the area with cultural reflections. The site continues to draw the attention of visitors and buyers. Despite the passage of time, Dabbi Bazaar remains a cherished landmark, inviting contemplation and respect from those who visit its sacred grounds. Pani Wala Talab Bazaar, Pani Wala Talab, Fawara Chowk, Fawara Park, Al Nazir hotel and Restaurant and tomb of Malik Ahmad Ayaz are the landmarks.



Figure 4-15 : Guzar Machi Hatta showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

A road named Shahalam Road, located on the circular road, passes through the Shahalam Gate and is directed towards Shahalam Market. At this center, Fawara Chowk makes a Road junction, and further on this road, a semicircular road “D” plaza also makes another road junction. The main spine of Shahalam Road forms further junction points with roads coming from the Sadakaran Bazaar, Wachoo Wali Bazaar, Suha Bazaar, Dabbi Bazaar, Masti Gate Bazaar, and Pani Wala Talab Bazaar.

Red hues represent the districts, and the black dotted line represents the edges of the Guzar.

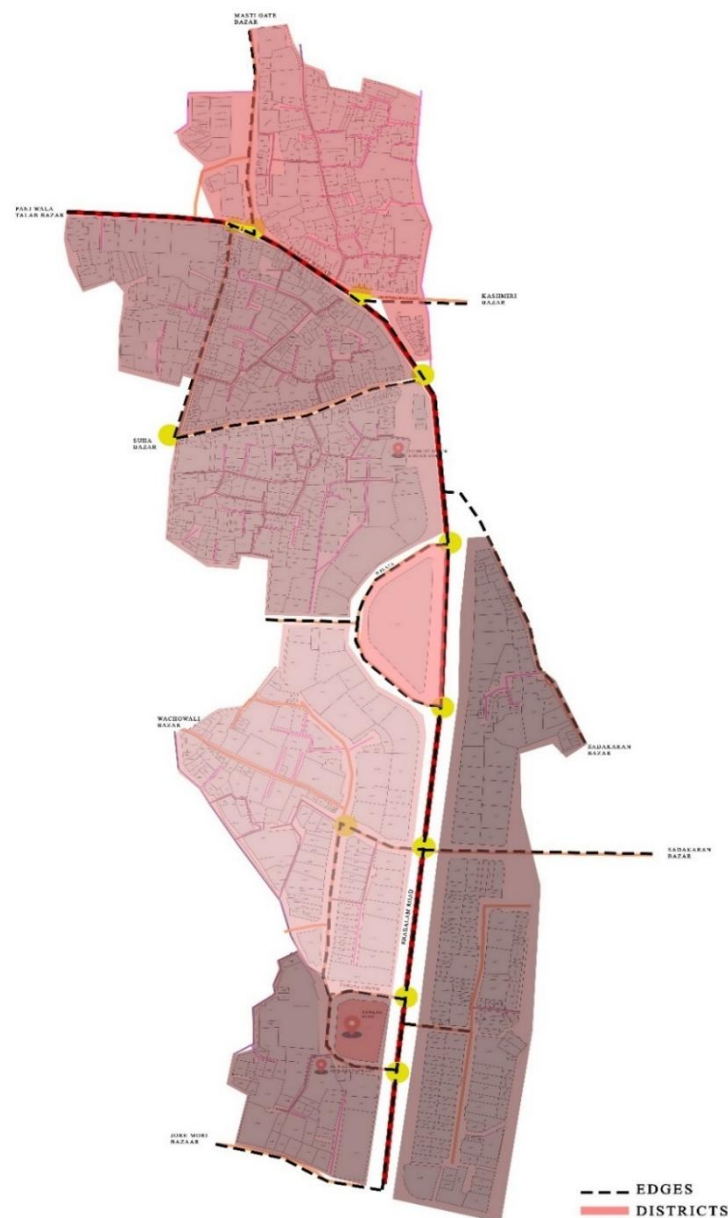


Figure 4-16: Guzar Machi Hatta showing Districts and Bazaars

Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar Rarra

The eastern expanse of the expanded Walled City of Lahore was designated as 'Guzar Rarra,' meaning 'empty space' in simple Punjabi. Following the wall's completion, this area remained vacant, with a cattle colony emerging to the south. Mughal manuscripts often referred to this region simply as 'Rarra,' while early accounts noted the existence of the village of 'Rarra Telian' in this vicinity.

Despite being incorporated into the village within the walls, it retained its name as Rarra Telian in early records. It was later formalized as Rarra Guzar. The question arises: how could an area near the River Ravi be termed 'Rarra'? One plausible explanation is that, as suggested in subsequent accounts, no village settlement was permitted within one 'kos' for security reasons. Furthermore, historical descriptions characterize the village of Rarra Telian as an uninhabited settlement, further adding to the intrigue surrounding its designation as 'Rarra.'

The Guzar Rarra consists of more than 18% commercial zone, and the remaining 82% is a recreational zone.

Table 4-8: Inventory of Spaces Guzar Rarra

(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/Gardens	Dominant Feature
Rarra Guzar	Yakki Gate	Akbari Mandi	Nawan Mohalla	Qasaban	Hukke Wali Gali	Gali Surjan Singh	Shahi Guzargah	Wazir Khan Mosque & Maatam Siraai Imam bargah (Asif Shah)
	Delhi Gate	Yakki Gate Baazar		Deputy Alam Shah	Gali Gulbar Chain	Haveli Mian Sultan	Shrine of Pir Zaki Shaheed	
	Akbari Gate	Dehli Baazar		Meher Ghous	Gali Drazian	Wazir Khan Hammam	Wazir	
				Bitnaal	Gali Surjan Singh	Wazir Khan Mosque	Chowk Wazir Khan	
					Gali Bootay Shah	Dina Nath haveli	Shrine Dedar Ali Shah	
					Gali Mian Sultan	Haveli Baij Nath		
					Galli Nalkay Wali	Haveli Mian Sultan		
						Mualana Taj Din Masjid		
						Haveli Alif Shah		

Haveli Alif Shah: The historic Haveli Alif Shah, now an Imam Bargah, stands as a revered monument along Lahore's Royal Trail near Delhi Gate. Dating back over three centuries, it hosts significant Muharram processions and holds symbolic importance during the month Safar. The procession route, shaped by Syed Ghulam Ali Shah and Mai Aghia, has remained unchanged since the early 1800s, ending at Karbala Gamay Shah. Restored in 2011 by the Walled City of Lahore authority, the haveli welcomes visitors seeking cultural and spiritual insights, offering prayers under the Nochandi Jumerat tree for matrimonial blessings.

Gali Surjan Singh and Usman Ki Baithak: Gali Surjan Singh, the prominent boulevard adjacent to Delhi Gate, features a collection of historical residences and quaint storefronts bearing architectural significance. Named after Hakeem Surjan Singh, a notable 19th-century physician who resided there, the street underwent restoration in 2012 through collaborative efforts by the WCLA and the Aga Khan Culture Service-Pakistan, funded by the German Embassy. The restoration involved burying the electricity network, separating sewage and stormwater pipes, and enhancing telecommunication services and gas supply. Usman Ki Baithak, established within Gali Surjan Singh, serves as a resting spot for tourists. In 2021, the street received a botanical makeover with plant and flower adornments facilitated by the Akhuwat Foundation and WCLA.

Dina Nath Well: Beside the Wazir Khan Mosque lies the walled well of Diwan Dina Nath, the only one within Lahore's Walled City. Diwan Dina Nath, honored by Maharaja Ranjit Singh, faced challenges when constructing the well in opposition to a saint's well. Despite warnings, the well remained dry, becoming a dead monument. Presently, conservation efforts led by the Walled City of Lahore Authority and the Aga Khan Trust for Culture aim to restore and open the well to the public. Adjacent stands the dilapidated Haveli of Dina Nath, a significant site reflecting Sikh architecture, urging immediate preservation and promotion of Lahore's heritage.

Dina Nath Haveli: Haveli Dina Nath, named after Hindu courtier Raja Dina Nath of Ranjit Singh's Sikh court, was later transferred to the family of Khursheed Sahib after partition. Originally home to five families, now only two reside there. A part of the Haveli is under Auqaf and hosts a vocational training center for girls. The structure, featuring typical Sikh/Hindu architecture with 19 rooms and two basements, spans 47 Marla.

Wazir Khan Mosque: The Wazir Khan Mosque, constructed between 1634 and 1641 AD in Lahore, Punjab, is celebrated for its intricate Kashi-kari tile work and elaborate Mughal frescoes adorning its interior. Commissioned by Wazir Khan, the chief physician and later Subedar of Punjab, the mosque encloses the tomb of Sufi Saint Miran Badshah. It replaced the Maryam Zamani Mosque as Lahore's primary congregational mosque. The mosque complex includes shops for calligraphers and bookbinders, situated around a town square. Built on an elevated plinth, it spans 279 ft. by 159 ft., with the main entrance facing Wazir Khan Chowk. The material of construction is bricks and kankar lime, the dimensions of the prayer hall 130' by 42', the space is divided into five segments, each with a separate dome, and the central dome is the largest one. These five domes, central large and four smaller, give a sense of dignity and Turkish style to the mosque with multiple domes. The salient features in terms of interior ornamentation are fresco work, Arabic and Persian calligraphy, and intricate mosaic designs. The mosque has been declared a protected document due to all its architectural and historical significance, under the Directorate of Archaeology, Punjab, as per the Punjab Special Premises Ordinance 1985. It was also added to the tentative list of UNESCO World Heritage Sites in 1993. The mosque has been protected by the Aga Khan Cultural Services Pakistan (AKCSP) with international funding agencies under the "Sustainable Development Walled City Lahore (SDWCL)" project.

Akbari Mandi: Akbari Mandi is one of the largest wholesale markets in Asia for the trading of grains, spices, herbs, and chemicals. The market was established during the Mughal Emperor Akbar; therefore, it is named Akbari Mandi in honor of the emperor. It is located in the close vicinity of Delhi Gate and is famous for its variety of products. It offers services to merchants and small-scale buyers. Being located at the prime place in the old city, it is the busiest commercial place.

Nisar Haveli: The haveli serves as the central place for Azadari and is located near the Mochi Gate Bazaar. In this haveli, Azadari traditions are observed every year in Moharram. In the Moharram processions, the memories of Muslim Bin Aqeel and other martyrs are revealed. The whole procession is hosted by the Abbas and Haider Qizibash, who are custodians of the Haveli, being descendants of the family. It was constructed during the Mughal period, almost 300 years ago, and it has survived all the intrusions of the Sikh and British periods. Currently, it is a focal point, hosting ceremonies of the Moharram processions.

Shahi Hamam: Shah Hammam was built during the 17th century for the Royal court and nobility members and is a great landmark in the historic city of Lahore. It is also termed as the

Royal Bath. It was constructed during the period of Mughal Emperor Shah Jahan, to serve as a lavish public bath. There were separate sections for males and females, featuring stunning elements such as intricate tile work, frescos, marble carvings, and a distinctive style of Mughal constructions. The royal bath was equipped with advanced heating systems and possessed a highly technical hydraulic system for the heating chambers of the bath. The royal bath was also preserved by the Aga Khan Cultural Services, Pakistan (AKCSP) under the SDWCLP and has been converted into a tourist attraction. The adaptive reuse of Shahi Hammam has transformed it into a dynamic space, contributing to enhancing the socio-economic value of the neighborhood due to the visits of tourists, either national or foreign. The monument is of significant value due to its architectural, social, and historical features.

Tomb of Baba Mastan Shah, Lal Khoo Bazaar, Tung Bazaar, Azad Bazaar, Nohriya Bazaar, Lakar Mandi Bazaar, and Government Mian M. Nawaz Hospital are the landmarks of this Guzar.

The main node is a circular road intersection through Yakki Gate, and another intersection with a secondary road beside Mian Muhammad Nawaz Sharif Hospital. This node generates a link with Moulana Obaidullah Road. A road from the Delhi Gate is directed towards the Wazir Khan Mosque. This road forms a junction with Akbari Mandi Bazaar, Tung Bazaar, and Naurian Bazaar from right to left. A road of Akbari Mandi Bazaar makes a road node point with the Tung Bazaar, Naurian Bazaar, next in the southwest direction it makes a node with Azad Bazaar node and divides into two, one directed towards Nisar Haveli and the second directed towards Lal Khoo Bazaar.

Following Akbar's relocation to Lahore, historical Mughal manuscripts indicate that he designated a special 'haveli' for the Dewan's family in the area. This residence was named 'Jhajjar Dewan ka Guzar,' a title gradually adopted by the people of Lahore as 'Guzar Jhajja Dewan.' Over time, subsequent manuscripts continued to use this designation.

In the context of Lahore's history, the term 'Jhajja' refers to a Rajput hailing from Jhajjar. Notably, Lahore has long been predominantly influenced by Rajput culture, a characteristic that persisted during Akbar's reign and beyond.

The Guzar Rarra consists of more than 25% commercial zone and the remaining 75% is recreational zone.

Table 4-9: Inventory of Spaces Guzar Chajja Diwan
(Source: Author)

Name of Guzar	City Gates	Main Spine Bazaar	Mohallas	Koochas	Cul-de-sac/Gali	Heritage Sites	Urban Squares/ Gardens	Dominant Feature
Guzar Jhajja Diwan	Mochi Gate (Only Entrance)	Bara Market	Mohalla Ghonghat	Katra Porbian	Galai Arayan	Nisar Haveli	Kashimiri Chowk	Imam bargha Syed Syede Shah
		Kashmiri Baazar	Mohalla Chillah Bibian	Jarhan	Gali Dhobian			
		Laal Khoo Baazar		Pir Gilalanian	Nur Gali	Mirza Nabi Bakash Laal Haveli	Shrine of Hazrat Syed Ahmed Tokhta Tirmizi	
		Sawaran Baazar	Mohalla Takia Sadhu			Imam bargha Syed Syede Shah		
		Lakar Mandi Baazar	Mohalla Zeeshan			Imam Bargah Darbar e Ameer Khawajgaan Narowali	Chowk Baazar Gazi Ilam Din Shaheed	
		Murain Baazar				Hussainian Hall		

Gurdwara Baoli Sahib: Baoli Bagh, formerly the site of Gurdwara Sri Baoli Sahib in Lahore, holds historical significance dating back to 1599 AD when it was built with 142 gold coins by Bhai Chajju Bhagat and Pathan. This was in response to a truthful revelation about the forgotten money. The Baoli was later filled with earth in 1685. It was restored by Maharaja Ranjit Singh in 1834 AD, who constructed a new building and shops around it. After partition, it faced desecration, and today only a small garden remains with shops. Gurdwara Sri Baoli Sahib evolved Baoli Bagh, now a leafy garden and park, marking its transformation over time.

Sunehri Masjid: The Sunehri Mosque was built in 1753 A.D. during the Mughal Empire, and it was designed by Nawab Bekhari Khan. Ranjit Singh elevated the mosque to a 16-step high raised platform, generating space for shops, to meet the financial needs of the Mosque. During the Mughal Period, mosques were often constructed alongside Bazaars to create an income source for the mosque. It is in the Kashmiri Bazaar, on the Royal Trail, and was part of a conservation project undertaken for the “Conservation of Shahi Guzargha” and stands in the close vicinity of Masjid Wazir Khan. Initially, it was converted into a Gurdwara during Sikh rule, and it was again converted into a Mosque with the efforts of Fakir Azizuddin. A Baoli is also located on the backside of the mosque. The Mosque has a courtyard with a tank, and a prayer Chamber 40’ x 16’ with four minarets.

Kasera Bazaar: The bazaar is also known as Bazaar Van Watan, and its main products include iron, copper, brass, steel, as well as home and commercial utensils, along with rare decorative items for sale. The market was established over a century ago and features more than 100 shops selling a variety of goods inspired by traditional designs. The Bazaar serves wholesale clients and offers a range of products, including cotton, plastic, bamboo, and traditional beds. It is one of the largest wholesale markets in Asia.

Rang Mahal: The Rang Mahal is located in the Chowk Rang Mahal and was constructed by Nawab Saad Allah, a minister to Mughal Emperor Shah Jahan in the 18th century. The building is unique in its style and has historical significance. It was designed as a Royal residence, but it was converted into an educational institute during the British period. It was the first place of Atchison College until 1947, when the Institute was relocated to its current site, Shahrah-e-Quaid-e-Azam. After the relocation of Aitcheson College, the building was used as the Government Rang Mahal Christian High School, and a part of it is being used by a local post office.

The Rang Mahal Chowk is one of the busiest chowks in the Walled City of Lahore, linking Shahalam market to the Kashmiri and Chatta Bazaar, on the other side, it is also linked with Delhi Bazaar, and in a third direction, it is towards Taxali Gate. It holds a central place in the old city of Lahore, providing direction to move to any part of the old city. Due to the Rang Mahal, the Chowkis are named Rang Mahal Chowk.

Sada Karan Bazaar, Chunian Mosque, Swaran Bazaar, Chilgatta Bazaar, Government Rang Mahal Christian High School, Tehzeeb Ul Binat Takia Sadhuan, Al-Imran Hospital, and Imam Bargah Syed Akbar Ali Shah are the landmarks of this area.

A road from the mochi gate is directed towards the Sada Karan Bazaar. In this war, a secondary road serves as a junction point that directs towards the Al-Imran hospital. This Sada Karan Road is next in the north direction directed towards Rang Mahal Bazaar, and next in the right direction towards Kesara Bazaar, and in the left direction towards Suha Bazaar, and the east direction towards the Govt Rang Mahal Christian High School, and made a secondary node. On the Kasera Bazaar Road, a route heading southeast to Sawaran Bazaar.

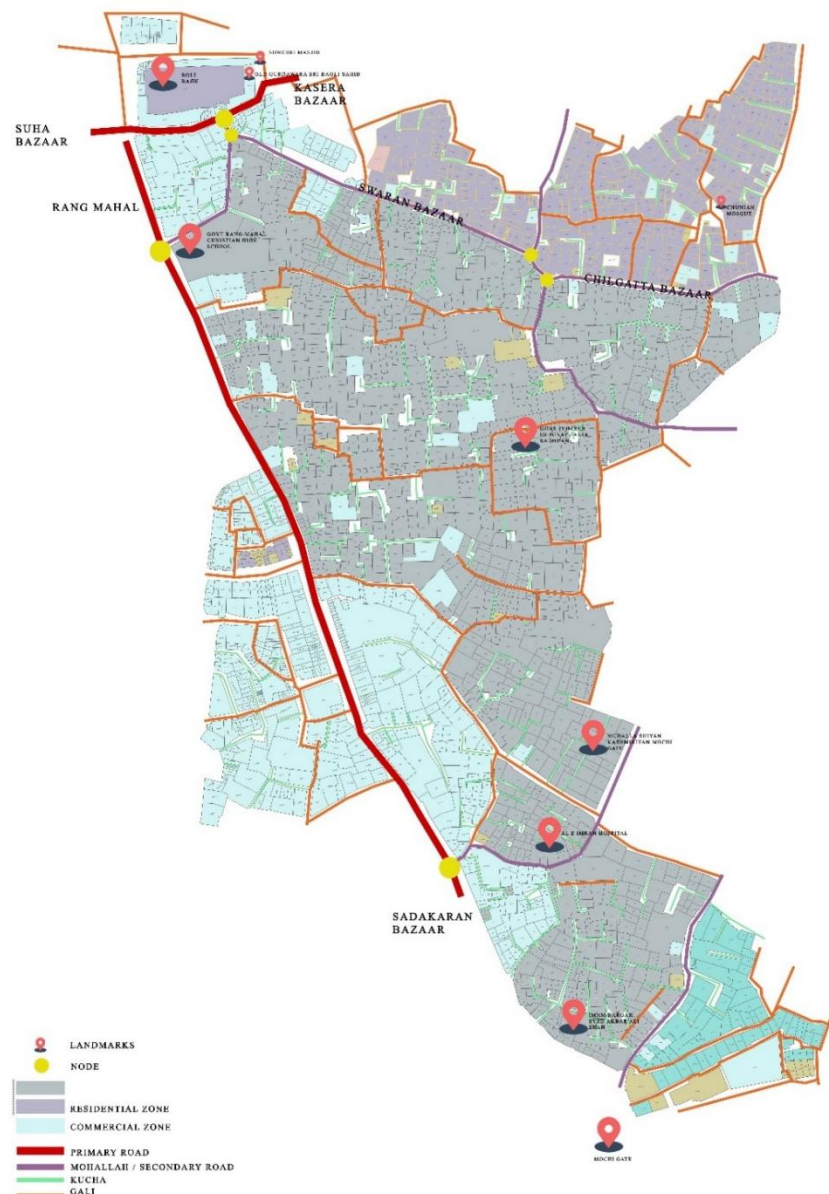


Figure 4-19 : Guzar Jhajja Khan showing Urban Morphology and Landmarks

Source: Basemap is from WCLA, 2009 (edited by the Author)

Guzar.

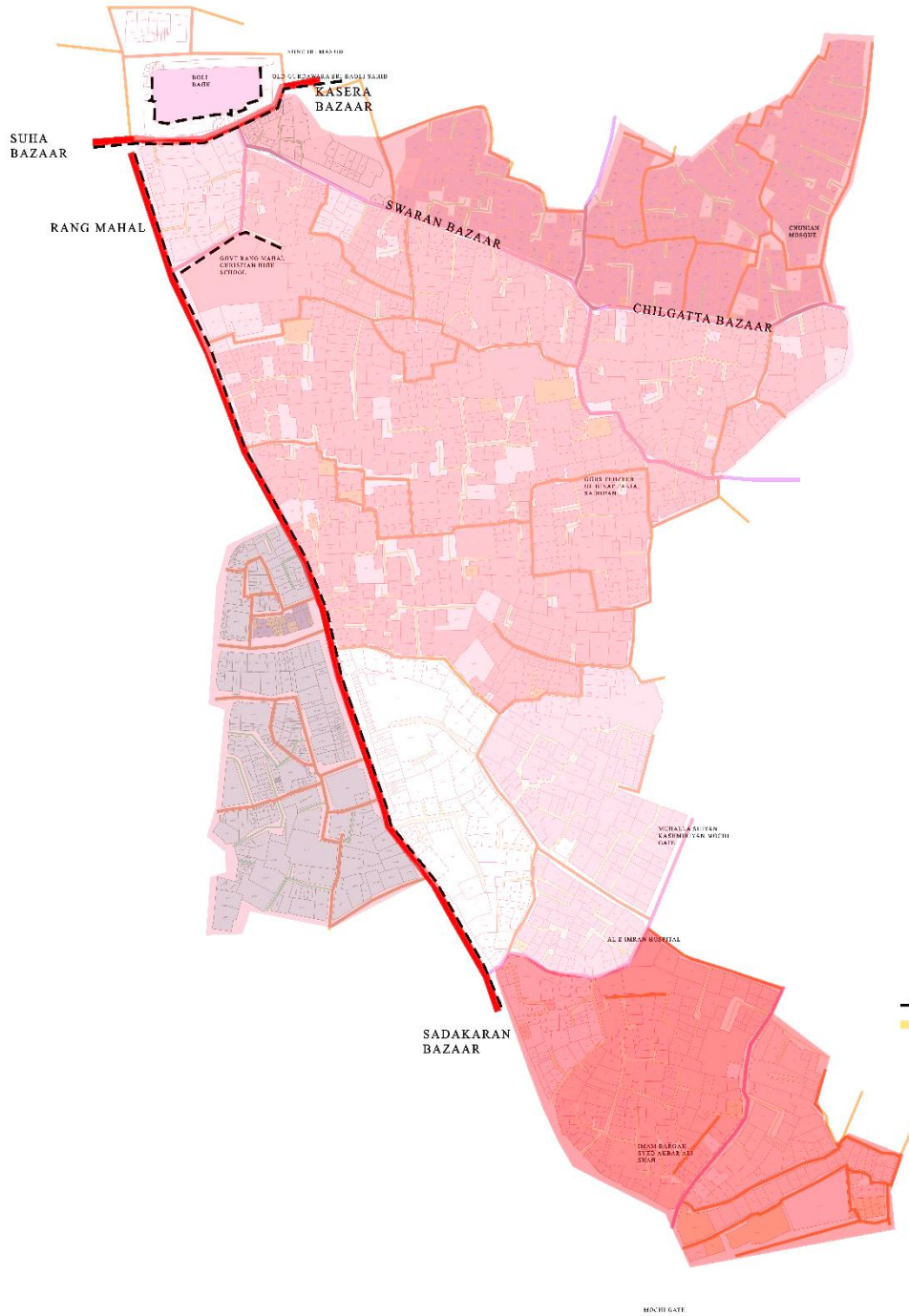


Figure 4-20 : Guzar Jhajja Khan showing Districts and Bazaars

Source: Basemap is from WCLA, 2009 (edited by the Author)

4.2.2. Significant Monuments and Structures

Many monuments were deteriorated or damaged and could not be seen afterwards. Precious metals and stones were removed from the monuments and occupied by the invaders. The old Lahore was treated mercilessly and lost not only its tangible but also its intangible assets. (Ali, 1990b). A detailed inventory has been prepared showing the significant and historic monuments and urban spaces. The junction of the two central spines is termed a Chowk /urban square. There are two types of urban squares, one is in a religious environment, such as Wazir Khan Chowk, and the other is for commercial activities, including Chowk Jhanda, Chowk Sooter Mandi, etc.

There are historic structures with significant architectural elements such as wooden Jharokas, wooden balconies, arched doorways, and arched windows, as well as fresco decorations, Kashi Kari, and geometrical patterns in decorative works.

Landmarks

UNESCO World Heritage Site (Lahore Fort) is in the northwest of the old Lahore, and Badshahi Mosque was added to the tentative World Heritage Sites in 1993. Haveli Barood Khana, Haveli Teja Singh, Maryam Zamani Mosque, Haveli Ram Gopal, and Choona Mandi Haveli are the major heritage sites that are tourist attraction points.

Choona Mandi Haveli (Fatima Jinnah College)

The Haveli Jamadar Khush Khal Singh, also known as Choona Mandi Haveli, is in the precincts of Masti Gate. The monument was constructed by a courtier of Maharaja Ranjit Singh, and it was the most spacious haveli within the Walled City. The havelis within the walled cities are being used adaptively. There are three types of adaptive reuse of havelis: one for art lovers, used for performing arts; the second for academic purposes; and the third for residential purposes. This haveli is being adaptively reused as a girls' college. It is performing its new function properly due to its spacious rooms.

Haveli Barood Khana and Haveli Dhiyan Singh

There are two Havelis located on the premises of Taxali Gate: Haveli Barood Khana (now Mian Salu's Haveli) and Haveli Dhiyan Singh. The Haveli Barood Khana was built in the 17th century in the Mughal architectural style. Haveli is now performing its function for the shooting of dramas and films. The present family purchased this Haveli in 1870, and it has been under their ownership since 1870. The other haveli is Haveli Dhiyan Singh, which was

owned by Dhiyan Singh. Major parts of it have been damaged during the independence movement. It was first place for Government College and Oriental College in 1864.

Laal haveli

Lal Haveli is famous as “Mai Daru De haveli” and was built by Maharaja Ranbir Singh. It was one of the famous residences of Lohari Gate. Maharaja housed the courtesan, Mai Daru. The haveli survived partition but was subsequently neglected and is now in a dilapidated condition. Mai Daru was a woman deeply in love with culture, and her cultural contributions are remarkable. Maharaja Partap Singh also contributed to the rich cultural values of Haveli. The salient feature of the haveli is the Kashmiri woodwork. It was divided into two parts. The building's past grade is gone, and now it is awaiting attention.

Nau Nihal Singh haveli / Victoria school:

The haveli was constructed by Maharaja Ranbir Singh for his beloved son Kharrak Singh, on the birth of his grandson, Nau Nehal Singh. The building is located between the Bhati and Mori Gate at Maidan Bahian. Haveli Nau Nehal Singh is famous for its intricate architectural style and ornamentations. It reflects a variety of architectural elements within Rang Mahal with colorful decorations.

Jamia Nizamia Rizvia:

Jamia Nizamia Rizvia is a religious institute within the Walled City of Lahore, named after Maulana Syed Muhammad Rizvi, a prominent Islamic Scholar. The institute has been developed to promote Islamic teachings.

Lala Nihal Chand Temple (abandoned):

The Lala Nihal Chand Temple was constructed between 1876 and 1877, reflecting the Hindu rituals in the Walled City of Lahore. It was named after Lala Nihal Chand. The temple maintained its glory despite all urban developments. Ragav Nayyar, a family member of Lala Nihal Chand, attempted to preserve the memories of the temple, but it is now non-operational due to the migration of Hindus to India.

Haveli Ch Bashir, Masjid Sheikh Imam Din, Masjid Hasan Kocha Baily Raam, and Imam Bargah Kaflay Sham are also the landmarks of this Guzar.

Pani Wala Talab:

Pani Wala Talaab, situated in Lahore's Walled City, is the oldest water reservoir built by the British in 1883-84 and inaugurated by Sir Charles Umpherston Aitchison. It marked a significant engineering feat, introducing modern water supply systems, including tube-wells and pipelines, to the region. Initially powered by steam, it transitioned to electricity in 1965 while retaining its original mechanisms. Positioned strategically atop the city's highest mound, it distributed water across Lahore.

4.2.3. Urban Fabric & Streetscapes

The city suffered damage during the invasions and revolts, resulting in the loss of its historic urban fabric. It was developed in a hierarchical structure based on the city wall featuring gates and central spines, which linked the gates to the royal throne. The global trends of urbanization and modernization pushed the city towards chaos, replacing traditional structures with modern ones to meet the contemporary needs of the residents, thereby altering the historic environment of the old city.

The Walled City of Lahore is a historic, architectural, and cultural marvel often referred to as the "Heart of Lahore". The city was fortified with its gates, and these walls were removed by the British due to administrative and political reasons. It also witnessed the rise and fall during multiple dynasties, with a focus on the Mughal, Sikh, and British colonial periods. The historic core of Lahore has strong roots in the pre-Mughal era. Each invader has left its marks on the face of the city: Mughals introduced palaces, royal gardens, tombs, and mosques, Sikhs added havelis, Gurdwaras, temples, baolis and Samadhs, while British opened the gates towards civic life and changed the urban profile and now all the past interventions are part of the cultural assets.

During the Period of Mughal Emperor Akbar, Lahore expanded towards the northeast along the Grand Trunk Road, and Akbar divided Lahore and its neighborhoods into thirty-six Guzars (Districts) for administrative purposes, nine of which were within the Walled City of Lahore. These guzars are named after their administrator or the function they performed. The Walled City has been a center of splendid art and architecture since its inception, featuring structures ranging from small housing units to grand Havelis, bazaars, and small public spaces as well as a grand Fort. Apart from these structures, a variety of mosques have been built, ranging from small mosques in the streets to the Royal Mosque (Malik et al., 2020). The central spines were hubs of commercial activities and were termed as bazaars. The connecting points

of these main spines are termed as chowks, which were the center of cultural and religious activities (Jabeen, 2021). These guzars linked various districts to each other. They are subdivided into

- Main Bazaar / Guzar
- Secondary / Mohallas Bazaar
- Intermediate Private Street / s
- Galies / Streets/Cul-de-sacs/Katries
- Chowks / Urban Squares

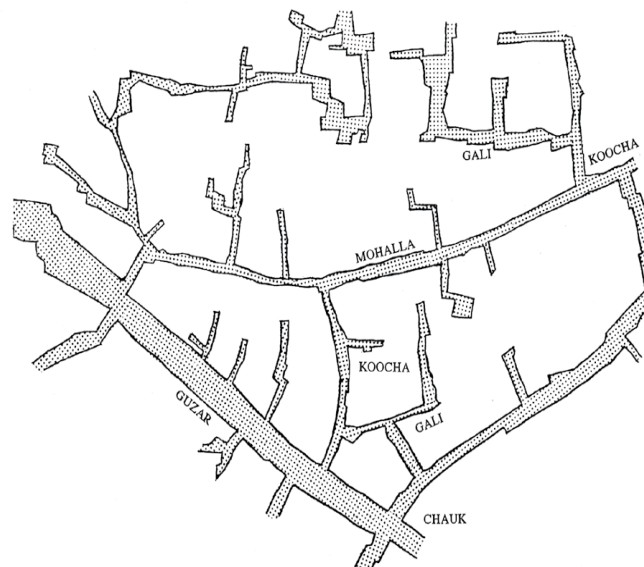


Figure 4-21: Guzars, Mohallas, Galies, Chowks / Urban Squares

Source: WCLA, 2009

The administrative zones during the period of Emperor Akbar were known as Guzars. The names of the Guzars are Guzar Shahbaz Khan/ Guzar Mang Khan, Guzar Rarra, Guzar Ishaq, Guzar Machi Hatta, Guzar Talwara, Guzar Jhaja Diwan, Guzar Waacho Wali, Guzar Bahar Khan, and Guzar Dhal (Sheikh, 2016b).

The notion of the inner city as ‘suffocating’ and claustrophobic rested on distinctive features of inner-city life. These included high population density, a maze of neighborhoods linked by narrow alleyways, market areas (mandis) that opened from the narrow alleyways (Galies) demarcated by the occupations and communities of their inhabitants (Khalid, 2018). Narrow entranceways led to prominent havelis, featuring traditional internal courtyards and fountains, which were overlooked by double-storied balconies. Individual mohallas also possessed their distinctive socio-spatial organization and cohered internally. Several mohallas

and Galis were named after the economic activity that was concentrated in them. There was Doctran-da-Mohalla in the Hindu locality of Waachowali, where medical practitioners, including Dr. Gopichand Bhargava (1889–1966), later a chief minister of divided East Punjab, ministered to their patients. In Bhati Gate, there was a street, Naiyon ki Gali, named after the barbers who worked there (Din, 2018).

With time, these structures faded, and their architectural significance deteriorated. In 2006, fortunately, the Government of Punjab signed an agreement with the World Bank to conserve the historic core of Lahore under the Sustainable Development Walled City Lahore (SDWCL) project, in collaboration with the Aga Khan Trust for Culture (AKTC). Gali Surjan Singh and Mohammadi Mohallah were the significant projects. The Walled City Lahore Authority revolutionized the conservation of the historic urban landscape of the historic core of Lahore, and area conservation was initiated. Historic zones were identified, and the Bhatti Gate area was conserved, focusing on Bazaar-e-Hakeema and its neighboring communities.

During the British colonial period, new constructions were done at the outskirts of the Walled City of Lahore, which was termed British Lahore. The historic monuments, urban areas, and vibrant bazaars made the city a hub of various cultures. During the invasion and expansion, the historic core of Lahore faced multiple challenges such as increased poverty, out-migration, encroachments, demolition of historic structures, pollution, inclusion of vehicles within the city, provision of infrastructure, and loss of privacy. The city is trying to develop a balance between heritage conservation and the provision of modern facilities for its residents. The conservation efforts began with the restoration of the Pakistan Cloth market, which was burnt and damaged, and these efforts are continued and fragmented by various institutes. Despite all interventions and transformations, there are still many structures that are in their original state and can be restored for future generations. They can transfer the human activities of the past. There is a need to develop an integrated approach for sustainable development within the historic core of Lahore by including digital technologies to attain integrity, identity, and interior balance.

4.3. CULTURAL AND SOCIAL SIGNIFICANCE

The historic core of Lahore is one of the most historically layered urban cores in South Asia, which represents a confluence of cultural, spiritual, and social identities that have evolved over centuries. Its significance transcends architectural grandeur or urban morphology and owes equally to the intangible dimensions of heritage and the continuity of living traditions.

This intricate urban fabric is not only a reflection of past activities but also a dynamic site of cultural production and socio-spatial negotiation. Understanding its social and cultural significance requires exploring the intangible characteristics and living experiences that animate spaces, sustain communal identities, and resist homogenizing narratives of modernization and development.

4.3.1. Intangible Heritage

The intangible heritage of the Walled City of Lahore is deeply rooted in its oral histories, religious rituals, linguistic diversity, artisanal knowledge, and traditional performing arts. These elements are contextually interwoven with the physical spaces. Each Mohallah (neighbourhood), haveli (mansion), and bazaar (marketplace) serves as a spatial typology and a repository of lived memories. Festivals such as Basant, religious processions during Muharram, and Sufi practices at shrines like that of Mian Mir and Data Darbar tell the story of the living patterns of the Walled City of Lahore. These intangible practices are spatially situated, often linked to physical nodes of the city.

In addition, the vernacular knowledge systems associated with traditional building crafts, such as fresco painting (Naqashi), lime plastering (Choonai), and intricate woodwork (Jharoka), represent technically sophisticated and culturally rooted practices. These practices are expressions of the region's aesthetic values, cosmological beliefs, and social structures. In the face of rapid urbanization and modernization, the intangible heritage dimensions are at risk of being diluted or lost. Therefore, their recognition is imperative for a culturally sensitive conservation approach.

4.3.2. Living Traditions and Practices

The historic core of Lahore boasts a diverse array of living traditions, including traditional crafts, community rituals, informal economic systems, and socio-spatial interactions that have endured despite significant socio-political transformations. The *baithak* culture (informal gatherings), street performances, storytelling traditions, and shared courtyard life illustrate the ways in which social cohesion is maintained, and cultural continuity is enacted in situ. Economic practices in areas like Kashmiri Bazaar, Lohari Gate, Gawalmandi and Shahi Mohallah demonstrate the persistence of indigenous livelihood and localized knowledge economies. Architecturally, adaptive reuse of historic monuments reflects a pragmatic and culturally rooted response to urban pressures that shape its spatial future while respecting historical continuity. Preserving these living traditions requires participatory strategies that

empower local stakeholders and integrate community voices into heritage governance. By doing so, the historic core of Lahore can be safeguarded as a vibrant hub of cultural resilience and socio-spatial innovation.

4.4. ECONOMIC VALUE OF HERITAGE

The economic significance of the Historic core of Lahore extends far beyond its historical and architectural importance. As a living urban heritage site, it has the potential for sustainable economic development through heritage -led regeneration, cultural tourism, and the reviatlization of traditional crafts and industries. The economic value of this heritage is multidimensional as it encompasses direct and indirect income generation, employment opportunities, skill preservation, and enhancement of urban identity. It requires an understanding of local economics, socio-cultural systems, and the interplay between heritage conservation and urban development.

4.4.1. Tourism Potential

The historic core of Lahore has immense potential as a cultural tourism destination for both domestic and international tourists. Key attractions such as the Lahore Fort, Badshahi Mosque, Shahi Hammam, and wazir Khan Mosque and other historic monuments contributes to a layered urban narrative.

A more holistic tourism development model would emphasize community engagement, local entrepreneurship, and the integration of intangible cultural assets such as traditional music, cuisine, and festivals. Moreover, sustainable tourism planning must address infrastructural inadequacies, visitor management, and the potential risks of gentrification and cultural modifications. Heritage tourism with inclusive urban development goals will reposition the historic core of Lahore as a platform for cultural dialogue, economic resilience, and community empowerment.

4.4.2. Traditional Crafts and Industries

The historic core of Lahore functioned as a hub for artisanal production, with a wide range of traditional crafts and cottage industries, rooted in socio-economic fabric. It includes wood carving, brass work, calligraphy, miniature painting, Chunri and gota textile work, leather crafting, bookbinding, and culinary arts, among others. Such industries are economically productive, enhance the preservation of intangible heritage, and transmit indigenous knowledge systems.

Integrating traditional industries into broader economic development frameworks could involve:

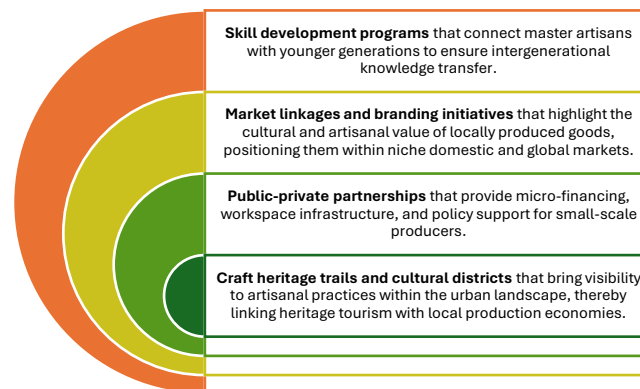


Diagram 4-1 : Flow Chart showing Traditional Industries and Economic Development Framework

Source: Drawn by the Author

The economic value of heritage in the historic core of Lahore thus lies in its ability to attract capital but in its capacity to generate equitable, culturally embedded, and socially inclusive development. Recognizing heritage as an economic asset requires a shift from extractive models of tourism and development toward participatory, locally rooted strategies.

Chapter 5: Current State of Conservation and Comparative Case Studies

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5. CURRENT STATE OF CONSERVATION AND COMPARATIVE CASE STUDIES

The conservation of urban built heritage is a challenge for conservation experts, architects, engineers, and stakeholders in the global South due to the rapid and unplanned urbanization. Rapid urbanization and modernization have marginalized historic urban environments due to a shift in socio-cultural values (Waqar, et al., 2016). The Walled City of Lahore has multifaceted socio-cultural, architectural, and urban heritage, evidence of its historical and architectural significance. It has witnessed a dynamic and historical evolution through the Mughal, Sikh, Colonial, and post-colonial periods (Rehman & Arshad, 2012). Despite its cultural and historical significance, the historic core of Lahore grapples with complex challenges in conservation due to socio-economic pressures, urban neglect, institutional disintegration, and contending development priorities (Rana & Bhatti, 2018b).

There is a need to develop a holistic approach to meet the current conservation challenges within the historic core of Lahore, following the guidelines provided in the international charters and within the scope of National and provincial legislations (Haroon, et al, 2019). Walled City Lahore Authority has transformed its conservation techniques from traditional to digital, collaborating with international agencies such as Aga Khan Trust for Culture (AKTC), the Norwegian Embassy, and USAID (AKCSP, 2010). The projects, under the umbrella of Lahore Development Authority (LDA) and WCLA, focused on the restoration and adaptive reuse of heritage sites. Shahi Guzargah (Royal Trail) comprises four packages and is one of the pilot project (World Bank, 2005). However, these projects operated within narrow scopes and were an initiative to address the issues of informal housing, gentrification, and community participation (Ahmed & Khalid, 2021). Therefore, a critical evaluation of current conservation strategies and practices is required to assess the socio-spatial implications.

In this chapter, the present conservation status of the Walled City of Lahore has been studied, and a comparative analysis has been done with the other historic cities in South Asia, such as As-Salt, Jordan, Dubai, UAE, and Edinburgh from Europe., It has provided valuable insights into heritage conservation with community livelihoods, sustainable urban management, and decolonial approaches. The case studies within the context of the Walled City of Lahore, compared to global practices, underscore the parallel divergence and transferable lessons.

The chapter's goal is to contribute to a comprehensive review of urban conservation strategies and practices within the context of the historic core of Lahore by investigating it through the lens of a broader framework. It aims to explore the architectural identity, historical evidence, tourist values, local legacy, and global heritage regimes.

5.1. ASSESSMENT OF EXISTING CONSERVATION EFFORTS IN LAHORE

The historic core of Lahore remains an attraction for conservation experts due to its significant historical and architectural value. The primary goal of the authorities is to protect the cultural heritage for future generations as a source of learning. It is one of the architecturally significant cities in South Asia. The current projects are initiatives towards transforming conservation methods from conventional to virtual. They faced the challenges of uneven progress, conflicting methodologies, and unreliable degrees of institutional support. The evaluation of these projects reveals the dynamics between conservation practices and international collaborations, local encouragement, and socio-economic factors (Rizvi, 2011b).

The conservation practices within the historic core of Lahore (HCL) are primarily managed by the Department of Archaeology (Punjab) and the Walled City Lahore Authority (WCLA) in collaboration with international agencies such as UNESCO, AKTC, and NGOs. The Royal Trail (Shahi Guzargah) project marked a shift towards integrated approaches for sustainable urban development, focusing on the physical restoration of historic buildings and the socio-economic uplift of communities through enhancement of the tourist value of historic areas. (AKCSP, 2010).

Despite all the conservation efforts, a school of thought also believes that the conservation of the historic core of Lahore is influenced by technocratic approaches with limited public engagement. Scholars are also of the opinion that conservation efforts aim at the aesthetic values; instead, the intangible aspects, such as traditional craftsmanship, community memory, and lived cultural experiences, are emphasized (Tyler & Dilcher, 2010). Moreover, the conservation practices that focus on the monumental architecture, often determined by tourism potential and international visibility, have marginalized vernacular and historic cities, and many remain undocumented and unprotected. (Gomez, 2008).

Legal frameworks such as the Antiquities Act of 1975 and the Punjab Special Premises Preservation Ordinance of 1985 provide the legislative basis for conservation activities. However, execution remains inconsistent, and many historically valuable structures fall outside these legal protections due to political priorities and outdated inventories (Qadeer, 1996).

Furthermore, rapid urbanization, provision of infrastructure, and real estate continually threaten the historic environment. For instance, constructing the Mass Transit System, such as the Metro Train Project, endangered heritage sites such as Shalamar Garden and Chauburji, which raised the question of heritage site integrity (Iftikhar, 2019). Another challenge is the lack of integration of education and training within architectural pedagogy in Pakistan. Conservation efforts lack the mandatory interdisciplinary input from history, anthropology, and urban studies, resulting in culturally isolated but technically sound Projects (Cody & Fong, 2017a).

Without public participation and community-led projects, a gap has emerged between the conservation efforts and socio-cultural activities of the historic neighborhoods. The historic core of Lahore has witnessed commendable conservation projects under collaborative international frameworks, but conservation efforts remain elusive (Haroon et al., 2019). There is a need for comprehensive, integrated, participatory, interdisciplinary, and contextually grounded conservation strategies that go beyond monument-centric models and capture the self-motivated, complex character of the historic urban landscape (HUL) of the heritage site of Lahore.

5.1.1. Government Initiatives

The Federal Department of Archaeology and Museums (DOAM) is taking significant initiatives to protect the cultural heritage (CH) and historic cities. The Walled City of Lahore has witnessed a wealth of tangible and intangible heritage that must be protected for future generations as a learning resource. The projects done under the umbrella of the National and provincial governments played a key role in the restoration of the historic core of Lahore. These initiatives are supported by legislative frameworks, preservation practices based on political priorities, and administrative and development pressures (Warraich et al., 2014). Despite admirable progress in specific domains, a significant gap remains in terms of policy coherence, resource allocation, and community participation.

The legal frameworks guiding heritage conservation in Lahore include the Antiquities Act of 1975 and the Punjab Special Premises (Preservation) Ordinance of 1985. The Antiquities Act primarily addresses the protection of monuments and archaeological sites at the federal level. At the same time, the Special Premises Ordinance authorizes the Punjab government to notify and protect historically significant structures and sites (Mughal, 1995).

The laws exist to protect antiquities, but their implementation is hindered by bureaucratic inertia, a lack of technical expertise, and insufficient financial investment.

The Walled City of Lahore is one of the most significant historic cities in Pakistan, with cultural assets that reflect the influences of the Mughals, Sikhs, and British. The Walled City of Lahore is facing ongoing challenges to its conservation practices due to limited funding resources, a lack of technical expertise, weak legal frameworks, unbalanced conservation priorities, and inadequate public engagement (WCLA, 2016) . The WCLA is a state-driven entity that has completed several valuable projects for safeguarding historic assets, ranging from individual sites to urban areas, utilizing digital technologies. In the legal frameworks, the concept of urban conservation was added by the WCLA in the WCLA Act 2012 (WCLA, 2009).

The conservation of urban squares is also the initiative of the WCLA, and Chauk Wazir Khan is the most significant project. The Wazir Khan Chauk is the forecourt of Wazir Khan Mosque and serves as a cultural node for the surrounding neighborhood communities (AKTC, 2017).

The Chauk is the forecourt of the Wazir Khan Mosque and remains a cultural node of the neighborhood area. The area was encroached by neighborhood shopkeepers, government authorities such as WAPDA and WASA, damaging the historic environment and the visual impact of the mosque. The WCLA took the initiative and conserved the monument as well as the courtyard of the mosque (AKTC, 2017). The project is unique due to its innovative conservation practice, which involves the application of digital technologies for documentation and the development of conservation plans (Jodidio, 2019) . In Punjab, specifically in Lahore, WCLA and the Punjab Archaeology Department are responsible for the maintenance and listing of heritage sites. The legal frameworks need to be amended according to contemporary requirements. Moreover, there is a lack of interconnection between the various institutions working towards conservation, and an integrated approach is needed to create a holistic platform that avoids overlaps, delays, and policy fragmentation.

The authorities' role in conservation practices defines the future of heritage sites, often prioritizing them over built heritage sites. The Orange Line Metro Train (OLMT) project is one of the prominent cases that has drawn the attention of critics and heritage bodies, including UNESCO, due to its proximity to World Heritage Sites such as Shalimar Gardens and many other Mughal-era monuments (Sajjad, 2009). The project highlighted the authorities'

priority: modernization of infrastructure, rather than a heritage-sensitive development paradigm.

Another significant issue with government-led conservation efforts is limited engagement of local communities and stakeholders. The top-down nature of most initiatives has led to a disconnect between the project's goals and the needs of the communities that frequently inhabit or interact with the monument. Moreover, a lack of sustained investment in professional training and capacity-building programs within governmental departments delayed the development of the conservation sector. Another constraint is the lack of evidence-based policymaking due to the absence of institutional research opportunities.

Currently, efforts are being made to address these challenges through the application of digital technologies, including the integration of heritage education in policymaking, as well as collaboration with funding agencies and international organizations. However, legislative reforms, independent collaboration, sustainable funding, and government efforts can result in long-term achievements.

5.1.2. NGO and Community-led Projects

The historic urban landscape of the historic core of Lahore is increasingly shaped by non-governmental organizations (NGOs), international cultural associations, and community-driven initiatives. These initiatives support filling gaps in funding, technical expertise, and public participation in response to the limitations of governmental bodies. Their approach is more inclusive, culturally grounded, and flexible, offering paradigms embedded in the socio-cultural dynamics of local communities.

One of the most dominant organizations is Aga Khan Cultural Services of Pakistan (AKCSP) under the supervision of Aga Khan Trust for Culture (AKTC), and it has completed large-scale projects under the umbrella of LDA and WCLA, such as the conservation of Shahi Hammam and the Conservation of the Picture Wall of Lahore Fort. Conservation of the Wazir Khan Mosque and its courtyard is another large-scale project. The primary goal of the projects is to maintain the cultural authenticity and local craftsmanship.

Smaller-scale NGOs, such as the Lahore Conservation Society (LCS) played their role in creating awareness about the need to save national assets. These organizations handle illegal demolitions, unauthorized alterations, and neglect of historically significant buildings. Their contribution is significant towards the protection of non-monumental and vernacular architecture. In various historic neighborhoods within the historic core of Lahore, residents

have organized to protect shrines, havelis, and marketplaces through collective and individual actions. Haveli Barood Khana, Haveli Mir Awais, and Haveli PeriMahal are examples, including voluntary repair and cultural festivals that sustain intangible heritage practices. Haveli Nisar is another example of a regulating annual ceremony of the Shia sect. Such grassroots initiatives represent custodial ethics that differ from institutional conservation efforts, privileging lived experience and memory over formal restoration.

However, these community-based conservation initiatives are marginalized in the official planning process due to a disconnection between authorities and local communities. At the same time, conservation is often considered an externally imposed agenda rather than a collaborative responsibility. These NGOs facilitate participatory workshops, heritage education campaigns, and collaborative planning sessions. Moreover, the role of academia and civil society in heritage protection has grown in recent decades. University Departments, such as the Lahore University of Management Sciences (LUMS), under the supervision of Dr. Murtaza Taj, have initiated projects to digitally document six heritage sites using a 3D laser scanner and proposed alternative conservation models within local contexts. This project was done with the USAID program (Taj & Hashmi, 2016). Despite all the efforts, the role of such organizations is limited due to the legal constraints in decision-making. There is a need to develop a framework that supports participatory planning, capacity-building, and meaningful community engagement in the conservation process.

5.1.3. International Collaborations

International collaborations have supported the conservation efforts, bringing technical expertise, financial resources, and a global discourse to local preservation practices. These partnerships facilitated the restoration of some iconic monuments and introduced best practices in heritage management, sustainability, and community integration. The role of UNESCO, AKTC, USAID, the German Government, and the Royal Norwegian Embassy has catalyzed a shift from monument-centric preservation to more holistic and contextual urban conservation. These initiatives include rehabilitation of heritage monuments and urban squares, urban infrastructure upgrade, and tourism development. Conservation of the Shahi Hammam, Conservation of the Picture wall of Lahore Fort, Conservation of the Royal Kitchen, conservation of Barood Khana, conservation of Sheesh Mahal, Historic Zone of Bhatti Gate Action Area (Bazaar-e-Hakeema and its neighborhood areas), conservation of Wazir Khan Mosque and its courtyard, conservation of Dina Nath Well are the initiatives taken by LDA and WCLA with international collaborations, following the principles outlines in Venice

Charter and UNESCO's Historic Urban Landscape (HUL) approach, focusing minimal intervention, material authenticity, and multilayered historical interpretation (Seraj, 2019). The meticulous craftsmanship and revival of glazed tilework techniques, while conserving the Picture wall of Lahore Fort, were also appreciated on international forums.

In addition, capacity-building programs are supported by donor agencies such as the World Bank and UNDP in collaboration with government bodies and local authorities. These programs focus on disaster risk management for heritage assets—urban resilience and digitizing cultural inventories, integrating heritage preservation within frameworks of sustainable urban development.

Moreover, the long-term sustainability of the internationally funded projects depends on local institutions for maintaining the conservation standards established during the conservation project after its completion. The process underscores the dependency on external support and the need for institutional strengthening and policymaking. A comprehensive approach is needed for the sustainable development of the historic core of Lahore, which respects global standards and local identity.

5.2. CHALLENGES AND THREATS TO HERITAGE CONSERVATION IN LAHORE

Various challenges, including the sustainability, authenticity, and integrity of the heritage assets, threaten the urban fabric of the historic core of Lahore. These challenges are associated with the complex convergence of socio-economic, political, institutional, and environmental factors. It highlights the urgent need to reassess the conservation paradigms and governance mechanisms to ensure the meaningful preservation of the historic city of Lahore's tangible and intangible heritage. The key challenges are.

- Rapid Urbanization and Development Pressures
- Institutional Fragmentation and Governance Gaps
- Inadequate Documentation and Research Infrastructure
- Socio-Economic Displacement and Gentrification
- Neglect of Intangible Heritage and Community Participation
- Environmental Degradation and Climate Change
- Financial Constraints and Donor Dependency

Addressing these challenges and threats, there is a need to develop a conservation framework based on project-based interventions, including legislative reforms, institutional restructuring,

community participation, and long-term investment to save the legacy of the historic core of Lahore for future generations.

5.2.1. Urban Development Pressures

Rapid urbanization and modernization influenced the historic environment of the Mughal Lahore, resulting in real estate expansion, a change in transportation means, enhancement of infrastructure, and a rise in commercial activities, marginalizing the historic and architectural values. All the phenomena produced complex challenges to preserving the historic urban landscapes (HUL) of the heritage site. This tension between preservation and modernization reflects postcolonial dynamics, wherein modern developments frequently compromise cultural and historical imperatives.

Loss of historic urban fabric and encroachments are the most visible consequences of the urban expansion in the historic city of Lahore due to the densification, informal settlements, and commercial structures (vertical encroachments). Narrow and winding streets once lined with havelis and shrines have been overwhelmed by modern structures, violating building by laws and compromising architectural and historical integrity. Despite the legal protection offered by the Antiquities Act of 1975 and the Punjab Special Premises Ordinance of 1985, enforcement always remains weak, allowing real estate interests to supersede preservation efforts.

Infrastructural projects and mega-urbanism in the name of urban modernization are the most contentious threats to the heritage of the Walled City of Lahore. The most significant is the Orange Line Metro Train (OLMT) project, which impacted sensitive heritage zones such as Chauburji, Shalimar Garden, and General Post Office Mall Road, Lahore. Despite warnings from UNESCO and Civil Society Organizations such as Lahore Conservation Society, the project proceeded with limited observance of international heritage standards. Despite the mitigation ordered by the Supreme Court of Pakistan, the project exposed the weaknesses in heritage impact assessment protocols. The OLMT project is one of the significant examples of the heritage v/s development conflicts of Global South Asian cities, where infrastructure provision is prioritized over cultural sustainability (Tariq et al., 2020).

Commercialization and real estate speculation have turned heritage precincts into high-value real estate zones, particularly in the areas of Shah Almi and the peripheries of the historic core of Lahore. Historic buildings in private ownership are demolished to make way for plazas, apartments, and commercial complexes. In many cases, policymakers prefer to protect

economic returns over cultural retention. The speculation of land development resulted in the disappearance of heritage structures and the relocation of local communities, disrupting the socio-cultural ecosystems of heritage districts.

Fragmented urban planning across multiple tiers and departments, including LDA and WCLA is one of the causes of loss of heritage. Heritage planning is often neglected when preparing master plans, zoning regulations, or transport infrastructure strategies, resulting in piecemeal interventions rather than systematic preservation. The disconnection from the economic, environmental, and social dimensions of urban life can isolate conservation. Such siloed approaches are inadequate in the context of the historic core of Lahore, which is layered with urban identity, with the historical and contemporary intertwined.

Weak legal framework and policy enforcement for heritage protection frequently result in compromises over urban developments. Developers often misuse regulatory loopholes or obtain political favors to circumvent preservation laws, resulting in deregulation of historic zones, where unpermitted demolition, alteration, and new constructions. This situation shows a broader failure of urban governance in enforcing heritage-sensitive development, and the heritage of historic Lahore is sacrificed at the altar of unchecked urban growth.

5.2.2. Environmental Factors

Environmental degradation is an escalating and under-recognized threat to heritage conservation within the historic core of Lahore. The historical monuments, and urban areas in the Historic core of Lahore is exposed to environmental stressors, including air pollution due to the increasing vehicular movements, groundwater fluctuations due to the unplanned commercial activities resulting in densification, and urban heat island effects due to the blocking of air circulation and temperature difference between day and night. The heritage assets in the Historic core of Lahore range from pre-Mughal to post-colonial, and the environmental changes are the primary causes of decay of materials and structures. Complicated conservation methodologies and the sustainability of restoration interventions are adding to the current environmental challenges.

Vehicular emissions, industrial discharge, and seasonal smog are causing air pollution and atmospheric deposition that have become one of the most significant environmental threats to the built heritage (Tariq et al., 2020). The traditional materials like lime plaster, sandstone, and frescos corrode due to sulfur dioxide chemicals. Due to these activities, various historic materials show signs of discoloration, surface erosion, and salt efflorescence exacerbated by

exposure to polluting agents. Studies conducted on the surface cleaning of historic monuments revealed the presence of heavy metal pollutants and acidic components, confirming corrosive reactions in the neighborhood environment. These monuments remain exposed to irreversible material damage, without regulatory mechanisms to control air quality in historic zones. Microclimatic instability and seasonal changes such as intense monsoonal rains, heatwaves, and unseasonal humidity cause structural decay and damage to the aesthetic integrity of heritage sites. The expansion and contraction of moisture contents cause cracks, delamination, and biological colonization. Climate-induced stresses are particularly critical for open-air and partially ruined structures. Moreover, rising humidity levels in the post-monsoon season provide a favorable environment for the growth of algae and fungi, which deface surface ornamentation and increase maintenance costs.

Groundwater depletion and soil instability caused by unregulated extraction and plummeting water tables seriously affect heritage buildings whose equilibrium depends on stable subsurface conditions. This over-extraction of groundwater also caused the differential settlements of the foundations, cracking of walls, and increased capillary rise of salts into masonry walls. In some cases, salinity has crystallized on the surface of ancient bricks, causing spalling and progressive disintegration of the surface decorations of historic monuments. Notably, Wazir Khan Mosque and havelis exhibit significant salt-induced degradation due to the uncoordinated water management and defective sewage lines. Interdisciplinary conservation approaches integrating hydrogeology, materials science, and preventive conservation are required to address the challenges of subsidence and rising dampness.

Urban heat island effects and thermal stress are intensified due to the high-density concrete structures, replacing the traditional buildings in the historic core of Lahore. Historic structures, particularly those built with porous materials, are subjected to abnormal heat loads that degrade surface decorations: wood joinery and colored tiles. Traditional cooling mechanisms such as wind catchers, shaded courtyards, and water bodies have either been eliminated or compromised, thereby reducing the climate resilience of historic precincts. The use of inappropriate modern materials and construction techniques in retrofitting practices exacerbated the rise in thermal stress. As a result, thermal incompatibility between old and new materials accelerated physical deterioration and impacted the long-term viability of conservation efforts.

The absence of environmental impact assessment in conservation planning in the historic core of Lahore does not systematically address environmental resilience for climate

adaptation in heritage zones. Environmental impact assessments (EIA) and climate risk and vulnerability assessments (CRVA) should be included in the development of conservation frameworks for the historic core of Lahore.

5.2.3. Lack of Awareness and Resources

One of the key hurdles in conserving the historic urban landscape (HUL) of the historic core of Lahore is a lack of public awareness. At the same time, the other root causes are inadequate funding, insufficient technical capacity, and a fragmented concept of heritage (Pendlebury & Townshend, 1999). The enduring threats, particularly in post-colonial transformation, are the intersection of resource scarcity and a disconnection from cultural legacy. The persistent challenges for conserving the Walled City of Lahore are limited financial investments and prioritizations. Most of the projects initiated by the government and authorities in the past remained under-resourced and reliant on the support of intermittent donor agencies. Hence, the conservation projects face the challenges of low budget allocation, resulting in delays in restoration work, low-quality materials, and inability to apply long-term preventive strategies.

Moreover, the reliance on international collaborations underscores the need for an endogenous funding mechanism for heritage management within the context of the historic core of Lahore. The key funding international donor organizations are UNESCO, Aga Khan Trust for Culture (AKTC), World Bank, USAID, and the Royal Norwegian Agency. This dependency on international collaborations isolates the most well-planned interventions from the coherent conservation approach. Lack of technical expertise and human capital is the fundamental weakness of the conservation practices. The human capital includes architects, material scientists, urban heritage planners, and artisans skilled in traditional techniques. Educational institutions are equally responsible for the disconnection between the specificities of local materials, construction practices, and climatic conditions due to the existing curricula and limited specialized training in heritage conservation. This gap identifies the lack of technical expertise, which compromises the diagnosis of structural issues and the selection of an appropriate conservation strategy.

Furthermore, the environmental issues such as erosion of traditional materials have resulted in the loss of the physical fabric of the cultural heritage and weakened the authenticity of contemporary interventions. The absence of apprenticeship courses or heritage skills

development programs prevents the transmission of technical knowledge and skills to new generations, thereby aggravating the deficiency of resources.

Minimal Public awareness and cultural disconnect are the most menacing obstacles to the sustainable development of historic cities. The local communities conceive heritage as a burden irrelevant to contemporary life, rather than a sense of honor to possess the heritage assets. This is partly a legacy of the British colonial era, which compromised cultural memory in favor of economic productivity. The absence of systematic awareness campaigns, community outreach programs, and inclusive policymaking processes compounds the public neglect of historic structures. As a result, conservation efforts are top-down, technocratic, and disconnected from local stakeholders. The failure to frame heritage as a dynamic part of urban experience has led to active degradation by property owners or tenants.

Inconsistent documentation and inventory of heritage sites illustrate the resource constraints faced by the conservation authorities. Many historical structures not declared protected monuments remain unrecorded and unrecognized by formal conservation bodies. The absence of digital databases and condition assessment hinders the ability of planners, researchers, and conservation experts to develop preventive strategies. This documentation gap is due to the absence of interdisciplinary collaborations, insufficient policy integration, and the inclusion of digital technologies without a comprehensive framework. The lack of archival preservation culture in public institutions is also a hindrance.

The conservation proposals are delayed by procedural bottlenecks, lack of political will, and inconsistent regulatory enforcement, which catalyzes the challenges posed by limited awareness and capacity. These challenges cannot be resolved through isolated technical interventions. However, they demand a multi-scalar interdisciplinary approach. Building a sustainable conservation culture in the historic core of Lahore requires increased investment and professional training with an inclusive framework that bridges the gap between people and place. Without such efforts, it will not be easy to safeguard the legacy of the historic core of Lahore.

5.3. STAKEHOLDER ANALYSIS OF HERITAGE CONSERVATION IN LAHORE

The conservation of heritage within the historic core of Lahore involves a complex network of stakeholders working in various domains, ranging from international agencies and governmental bodies to community groups, private owners, and academic institutions. The stakeholder analysis identifies the roles, interests, and institutional gaps. Potential

collaborations shape the conservation goals in the context of the postcolonial city, influenced by rapid urbanization and modernization.

Private property owners and real estate developers manipulate the influence over the destiny of historic structures in Lahore, particularly in the absence of regulatory enforcement to restore neighborhoods such as Shah Alami and Anarkali. The lack of economic incentives, tax relief, or adaptive reuse frameworks discourages private owners from investing in restoration. Without integrating the private sector into heritage-sensitive urban development policy, conservation remains economically unviable and institutionally unsupported.

Academic institutions and civil society organizations, including universities, independent researchers, and civil society groups, contribute significantly to heritage discourse, documentation, and advocacy. The academic institutes such as the National College of Arts, the University of Engineering and Technology, Lahore, Lahore College for Women University, Lahore, Comsats, the Institute of Art and Culture, University of Management and Technology Lahore, and University of Punjab conduct valuable research on historic urban morphology, conservation Science, and heritage governance.

5.3.1. Government Bodies

The Government institutions and authorities, including the Punjab Department of Archaeology, LDA, Punjab Tourism Department, ETPB, and WCLA, are the primary stakeholders. WCLA stands out for its integrated model of urban conservation, combining heritage preservation with socio-economic development. International organizations and development partners such as UNESCO, AKTC, and the World Bank have had a significant influence on the heritage conservation of the historic core of Lahore. However, their long-term success depends on meaningful local partnerships and translating global conservation norms into culturally rooted practices.

5.3.2. Local Communities

Local communities and informal stakeholders, including residents, shopkeepers, caretakers of shrines and other religious monuments, and traditional artisans, form the informal yet key stakeholders. However, they are often excluded from the decision-making process, despite their custodial role in everyday monitoring and maintenance, cultural connectivity, and site-specific knowledge of the heritage site. There exists a significant gap between official narratives of conservation and local understanding of heritage value. It fosters resistance and, in some cases,

non-cooperation with top-down initiatives. The participatory approaches through awareness programs can incorporate community voices. Co-management frameworks remain a significant challenge and opportunity for inclusive heritage control.

5.4. SWOT ANALYSIS OF CURRENT CONSERVATION PRACTICES IN LAHORE

A comprehensive SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis approach provides an opportunity to critically assess the efficacy and effectiveness of heritage practice in the historic core of Lahore. The historic core of Lahore (HCL) has a wealth of historic assets of the Mughal, Sikh, British colonial, and postcolonial periods within the context of the vernacular legacy. This analysis synthesizes the key internal and external factors shaping the historic urban landscape, underscoring the institutional performance, community participation, and policy frameworks.

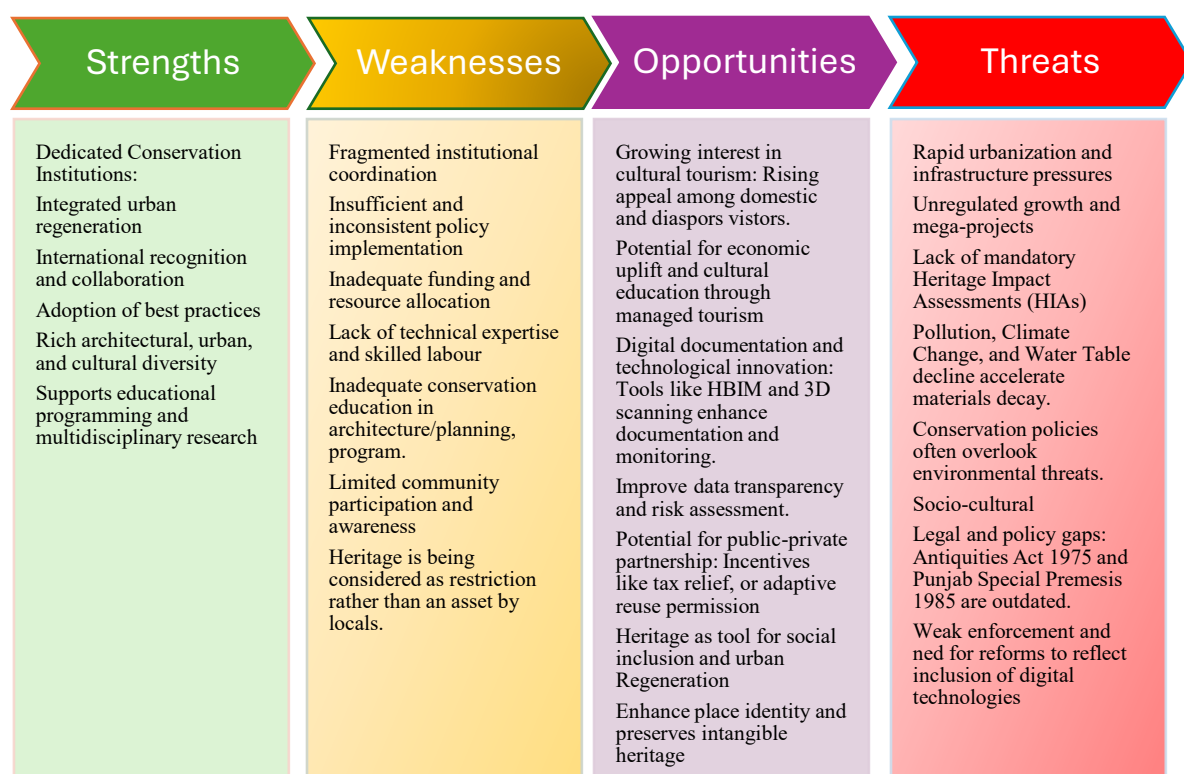


Diagram 5-1: SWOT Analysis of Current Conservation Practices in Pakistan

Source: Drawn by the Author

Strengths

- Dedicated Conservation Institutions: There are bodies like the WCLA, LDA, Punjab Archaeology Department, AKCSP, etc.
- Integrated urban regeneration combining conservation and economic development.

- International recognition and collaboration through international organizations such as UNESCO, AKTC, USAID, The Royal Norwegian Embassy, etc.
- Adoption of best practices in conservation science, participatory design, and cultural tourism
- Rich architectural, urban, and cultural diversity
- Supports educational programming and multidisciplinary research

Weaknesses

- Fragmented institutional coordination: Overlaps in mandates between WCLA, Punjab Department of Archaeology, LDA, and municipal bodies.
- Insufficient and inconsistent policy implementation.
- Inadequate funding and resource allocation: Heavy reliance on donor aid, insufficient public mechanisms
- Lack of technical expertise and skilled labour: Shortage of trained conservation professionals and traditional craftsmen.
- Inadequate conservation education in architecture/planning, program.
- Limited community participation and awareness: Top-down approach with minimal grassroots participation.
- Heritage is considered a restriction rather than an asset by locals.

Opportunities

- Growing interest in cultural tourism: Rising appeal among domestic and diasporic visitors.
- Potential for economic uplift and cultural education through managed tourism
- Digital documentation and technological innovation: Tools like HBIM and 3D scanning enhance documentation and monitoring.
- Improve data transparency and risk assessment.
- Potential for public-private partnership: Incentives like tax relief, or adaptive reuse permission
- Heritage as tool for social inclusion and urban Regeneration
- Enhance place identity and preserves intangible heritage

Threats

- Rapid urbanization and infrastructure pressures

- Unregulated growth and mega-projects like the Orange Line Metro threaten heritage sites.
- Lack of mandatory Heritage Impact Assessments (HIAs)
- Pollution, Climate Change, and Water Table decline accelerate materials decay.
- Conservation policies often overlook environmental threats.
- Socio-cultural disengagement: Heritage is often associated with elite or foreign interests.
- Lack of inclusive narratives alienates local communities
- Legal and policy gaps: The Antiquities Act 1975 and the Punjab Special Premises 1985 are outdated.
- Weak enforcement and a need for reforms to reflect the inclusion of digital technologies

The SWOT analysis reveals that conservation practices in the Historic core of Lahore have achieved remarkable successes, particularly through international collaborations and localized regeneration models. However, they remained hampered by systematic institutional weaknesses, socio-political fragmentation, and emerging environmental threats. Application of new technologies, the expansion of public-private partnerships, and fostering inclusive governance frameworks can be the key to transforming heritage conservation. Addressing the weaknesses and the strengths can reposition the value of the heritage as an asset for future urban resilience.

5.5. INTERNATIONAL CASE STUDIES IN DIGITAL CONSERVATION

In the age of rapid technological advancement and growing environmental and cultural changes, digital conservation has emerged as a vital field at the intersection between heritage preservation, information technology, and global collaboration. Globally, heritage professionals, architects, archaeologists, and digital technologists are the facts and historic sites at risk due to urbanization, climatic change, asking advantage of cutting-edge tools ranging from 3D scanning and modelling to virtual reality, to document, preserve, and even reconstruct cultural artefacts and historic sites at risk due to urbanization, climatic change, conflict and neglect.

This research presents a curated selection of international case studies that underscores the innovative application of digital technologies in the conservation of urban built heritage. By representing diverse projects from different geographic, cultural and institutional contexts,

these case studies explore the digital methods to enhance accuracy, accessibility and sustainability of conservation practices.

5.5.1. Selection Criteria for Case Studies

The selection of international case studies is based on the strategic framework developed, which includes varied approaches to heritage conservation through digital technologies and socio-cultural contexts. The three cases – As-Salt (Jordan), Dubai (UAE), and Edinburgh, Europe are selected based on the following criteria.

Relevance to Digital Heritage provides a district model of integrating digital tools such as digital documentation, historic building information modeling, and digital twins into the conservation and management of heritage sites. These case studies provided an opportunity for a comprehensive analysis of the role of digital technologies in the preservation of cultural heritage.

Representation of regional Diversity is a key factor in shaping digital heritage practices through local traditions, governance structures, and resource availability. As-salt Jordan and Dubai are using a different approach as compared to other Arabic countries, while the European examples explore the technologically advanced and institutionalized conservation frameworks.

The typological variety of built heritages includes a spectrum of architectural identity. As-salt focuses on the digital preservation of vernacular and traditional urban fabric, emphasizing community participation and local identity. Dubai describes the restoration and adaptive reuse of historical residential districts, highlighting state-led heritage in a rapidly modernizing city. In contrast, the European examples demonstrate the application of digital twins in managing complex heritage sites, including monumental buildings and urban ensembles, presenting a model for high-precision and data-driven conservation strategies.

Innovation in Methodology and Practice represents a range of digital interventions from 3D scanning to immersive visualization and predictive modeling. European case studies showcase the advanced application of digital twin frameworks, enabling real-time monitoring for heritage conservation.

The availability of documentation and scholarly discourse is a significant phase in critical analysis. The well-documented case studies ensure access to reliable datasets, reflective evaluations that enhance scholarly inquiry, and cross-comparison.

Potential for Transferability and Policy Insight considers the applicability of these practices to other sites or rapidly urbanizing contexts. The comparative analysis supports policymaking, capacity-building, and the contextual adaptation of digital heritage frameworks within socio-political environments.

5.5.2. Digital Preservation of Traditional Architecture in As-Salt, Jordan

Introduction

As-salt was declared a UNESCO World Heritage Site in 2021 for its cultural and historical significance. As-salt is also known as Al-salt and is located northwest of Amman, on the old main highway leading from Amman to Jerusalem. The city is an ancient trading and administrative center in west-central Jordan. The name Salt is derived from the Latin word saltus, which means forest, and it is situated in the Balqa highland, about 790 meters to 1100 meters above sea level. The city is built in the crook of three hills, close to the Jordan Valley (Shomali, 2020).



Figure 5-1: As-Salt City Centre with its Distinguished Yellow Stone Buildings
Source: Al-Shomali, 2020

Research Aim and Objectives

- To evaluate the current condition and documentation status of traditional architecture in As-Salt.
- To develop a digital preservation framework that integrates 3D scanning, photogrammetry, and GIS mapping.
- To create digital archive that enhances heritage conservation, academic research, and community engagement and can be accessible to public.

Methodology

The digital preservation strategy for As-Salt was rooted in interdisciplinary methods combining architecture, digital humanities, and cultural heritage conservation. The following technologies and tools were employed:

- Terrestrial Laser Scanning (TLS) was applied to gain high-resolution 3D scans on selected residential and civic buildings in Al-Hammam Street and the Al-Qala'a quarter.
- Aerial and ground-based photogrammetry was used to generate 3D textured models of facades, interiors, and streetscapes.
- Geospatial data was integrated to map architectural typologies and correlate them with historical growth patterns and socio-demographic data.
- Archival Research was conducted through historical maps, photographs, and building plans, which were collected from local archives and cross-referenced with digital models.
- Community Engagement through Oral histories and ethnographic interviews were conducted with long-time residents to enrich the digital archive with narratives of intangible heritage.

Site Selection and Survey

Three representative zones were selected for detailed documentation:

- Al-Qala'a (Citadel Area) features civic and religious buildings, including Al-Khader Church and the Great Mosque, which showcase a history of pluralistic coexistence.

- Al-Hammam Street is a bustling commercial axis lined with merchant houses featuring neo-classical and Ottoman stylistic elements.
- Residential Neighbourhoods of Al-Yasmin and Al-Khader, characterized by traditional stone houses with courtyard typologies, are often threatened by abandonment or alteration.

Each site was surveyed using a combination of laser scanning and photogrammetry, resulting in accurate digital replicas with millimetric precision.

Socio-cultural Context

Muslims and Christians have historically lived in harmony, demonstrating religious co-existence. Central Souq (Bazaar) serves as a cultural and commercial hub while traditional cafés and gathering spaces foster strong community bonds. The city was home to some of Jordan's oldest educational institutions, such as Al-Khader School and hospitals. The city's economy is based on trade, agriculture, and handicrafts, and it declined in the 20th century when it was declared the capital of Amman. The city got its current revival through heritage tourism and cultural preservation.

Historical Background

Salt, a city believed to have been founded during the reign of Alexander the Great, has a rich history shaped by various civilizations. Known as Saltus in Byzantine times and once the principal settlement on the East Bank of the Jordan River, it was later destroyed by the Mongols and rebuilt under Mamluk rule. The Romans, Byzantines, and Mamluks contributed to its growth, but Salt thrived most during the Ottoman era when it became a regional administrative center. By the 18th and 19th centuries, it was the only permanent settlement in the Balqa region and a hub of trade, agriculture, and tribal negotiation. The city developed with an influx of opportunities in the trade and construction industry. The British captured the city during World War I and served as the capital of the Emirate of Transjordan for a brief period. Subsequently, the capital was relocated to Amman at the orders of Emir Abdullah. Despite the shifting of the capital, the As-salt remained a significant urban center due to its heritage.

Urban Morphology

The city was built on hills and valleys, generating a terraced urban form. Dense central core with narrow, winding streets. Expansion occurred radially from the central market area (Souq), Neighborhoods are often clustered by extended families or tribes.

Architectural Characteristics

The city features large public buildings and private residences with a central hallway and three bays, constructed of yellow limestone, quarried locally. Load-bearing walls, wood-beamed ceilings, vaulted ground floors. Lime plaster finishes for insulation and longevity. These demonstrate a mix of vernacular and modern architectural influences and skillful craftsmanship. Adapted to the steep folded topography, the urban morphology of the historic urban core is characterized by a network of interlinked stairways, alleyways, public squares and spaces, and streets. The result is a dense urban fabric connecting the city's residential neighborhoods with public spaces and streets. These tangible characteristics have shaped the urban cultures of the city (UNESCO, 2021).

The fusion of vernacular and Ottoman architectural elements shaped the city. Arched windows, balconies with wrought iron railings. Symmetrical facade with central entrances. Courtyards with citrus and fig trees as passive cooling systems.

Notable Architectural Examples are:

- Al-Khader Church is an Orthodox church built in the 19th century, shared by Christians and Muslims.
- Al-Maidan Street Buildings with triple-arch windows, ornate balconies, and inscriptions in Arabic calligraphy are a landmark of the city.
- Abu Jaber House has now been converted into a museum, an opulent Ottoman mansion that highlights domestic architecture.

As-Salt demonstrates integrity through the continuity of its historic urban fabric, including historic buildings, landscape setting, the network and hierarchy of stairways that organize vertical movement between lower and upper levels, the presence of open spaces that support a multi-faith society, and the residential and religious buildings. The property is of adequate size, and its boundary and buffer zone are appropriately delineated. The spirit and feeling of the place reside in both the tangible (buildings, houses, churches, mosques, Madafas, urban nodes, steps) and intangible attributes (close habitation of different cultural and religious

groups, shared uses of public spaces, traditions of social welfare between neighbors). Integrity is vulnerable to development pressures and has been compromised by intrusive buildings and empty plots within the urban fabric, which affect the property's visual and intangible qualities (UNESCO, 2021).

Conservation and Declaration as UNESCO World Heritage

In 2012, UNESCO listed the city of As-Salt as a World Heritage Site. The city features approximately 650 significant historic monuments, a blend of European Art Nouveau and Neo-Colonial styles, and local traditions and customs . As-Salt is home to one of Jordan's most renowned churches, the St. George Orthodox Church/Al-Khader Church. Initially built in 1682 in an ancient cave, the St. George Church is one of the oldest and most visited churches in the city. Many believe Saint George appeared to be a shepherd inside a cave and told him and the villagers to build a church in a specific location. Saint George is also highly respected by Muslims and Christians alike, and worshipers from both religions are welcome to pray at the church. The local community renovated the holy site in 2004, and it remains open to the public every day (Trillo, et al., 2020a).

Protection and Management Requirements

Two laws are related to heritage conservation. The Law of Architectural and Urban Protection (No. 5, 2005) is the primary national law for the protection of cultural heritage in Jordan. The Cities, Villages, and Buildings Planning Law (No. 79, 1966) provides for the establishment of planning authorities and processes, including the regulation of construction. Implementation of protection is provided through the City Core Special Regulations, which were endorsed by the Ministry of Municipalities and Rural Affairs, the Higher City Planning Council of Jordan, and the As-Salt Greater Municipality in September 2014. This law encompasses the conservation of urban spaces, the grading of historic monuments, and provides guidelines for new interventions (Ali Al-Shomali, 2020).

There is a long-standing commitment to conserving the tangible and intangible attributes of As-Salt through the efforts of the As-Salt Greater Municipality. The management system was established by the As-Salt City Development Projects Unit, which was established in 2005 by the Municipality. The primary goal of the office is to safeguard the historic assets of the city. The development of the nomination and the ongoing property management have involved the city's communities.

Digital Preservation of Traditional Architecture

As-salt is famous for its traditional architecture, characterized by its golden limestone buildings with arched facades. The traditional architecture of the city reflects the harmony between the Muslims and Christians. The city has taken the initiative to document the monuments by using digital tools for long-term preservation.

Current Efforts in Digital Preservation

The involvement of UNESCO has improved the conservation efforts by documenting monuments digitally and creating awareness among the communities. They focused on the digital recording initiatives in the historic core.

Academic & Institutional Projects

Universities and heritage organizations (such as the Turath Foundation, German Jordanian University, and DAAD) have undertaken 3D scanning, photogrammetry, and GIS mapping to archive significant structures digitally. Example: Some projects used LiDAR and 360-degree photography to map and archive residential and public buildings.

- Local Initiatives were introduced by the Salt Development Corporation, and municipal bodies have partnered with researchers to digitize old maps and property records, especially in areas like Al-Jada'a and Ain Plaza.
- Technologies being used were Photogrammetry and 3D Scanning for creating accurate 3D models of buildings and streets.
- Virtual Reality (VR), Some pilot efforts for virtual walking tours of Salt's old city are being developed.
- Digital Archives, scanning of architectural drawings, land registry, and historical photographs.

Challenges

- Limited Funding is the key challenge for Digital preservation, which is expensive and often depends on external grants.
- Fragmented Data is another significant challenge as different institutions collect data in varied formats with limited interoperability.
- Lack of Public Access is the main hurdle, as many digital records remain unpublished or only partially accessible.

- The Technical Skills Gap is the dominant issue as local authorities often lack trained personnel for advanced digital documentation techniques.

Conclusion:

Jordan has emerged as a leader in the preservation of heritage in digital mode, taking As-salt as an initiative. With the application of 3D laser scanner, monuments were documented and virtual tours were developed to enhance the tourist value of the city. In As-salt, traditional architecture of the Ottoman period were focused, while promoting urban tourism and community engagement. The integration of digital technologies protected both tangible and intangible heritage in As-salt.

5.5.3. Restoration and Digital Preservation of Historical Residential Areas in Dubai

Introduction

The earliest beginnings of the region's history date back to approximately 6000 BC when it was inhabited by nomadic tribes that relied on hunting and agriculture for their livelihood. This era was characterized by pottery, as revealed by archaeological excavations. The United Arab Emirates (UAE) is a federal state established on December 2, 1971, consisting of seven emirates: Abu Dhabi, Dubai, Sharjah, Ajman, Umm Al-Quwain, Ras Al Khaimah, and Fujairah. The UAE is one of the most deeply rooted countries in modern history, known for its leadership in economic, social, and security stability. It has maintained its stability amidst the regional turmoil for many decades (Boussaa, 2014). The federal state authorities encompass the Supreme Council of the Union, including the President of the Union and his Deputy, the Cabinet, the Federal National Council, and the Federal Judiciary

Historical Background

Human settlement in the Dubai region dates to at least 3000 BCE, making it an ancient site. Officially established in 1833 when the Al Maktoum dynasty founded Dubai and grew as a small fishing and pearl-diving village during the 19th and early 20th century. The discovery of oil (1966) fundamentally shifted Dubai's economy and urbanization in the mid-20th Century. In 1971, Dubai became part of the United Arab Emirates, and its modern era transitioned from oil dependence to a diversified economy (trade, tourism, finance, real estate, technology) (Alsuwaidi et al., 2021).

From humble beginnings as a small fishing village first documented in the 18th century, the city grew rapidly as it became a major center of the pearl-diving industry. With its business-savvy ruling family reducing taxes and welcoming foreign merchants, the city continued to expand in the early 20th century. It soon became a re-exporting hub for Persia and India. Benefiting from modest oil wealth in the latter half of the 20th century, Dubai continued to focus on trade and attract investment, channeling oil surpluses into major infrastructure projects, including an international airport, dry docks, and a trade center. In the 1990s, the city began to diversify, building up its luxury tourism, real estate, and financial sectors. These all required skilled, educated foreign workers, and many moved to Dubai for its tax-free salaries and relatively stable politics (Alhasawi, 2019). With expatriates coming from elsewhere in the Arab world as well as from Asia, Europe, and North America, the city took on a rather cosmopolitan air. It was considered to have one of the most liberal societies in the region



Figure 5-2: Wooden dhows in Dubai 1 Creek, 2013

Source: F. Cristofoli cited by Ricca, 2018

Architectural Characteristics

Traditional Architecture of Old Dubai

Before the oil boom, Dubai was a small fishing and trading town. Its architecture reflected simple, climate-responsive design: Coral stone and gypsum for walls (both breathable

and cooling). Palm fronds (Arish) are used for simple houses and summer shelters. Mudbrick and plaster in small houses and souks (Ricca, 2018). The key features are:

- Barjeel (Wind Towers), famous for its traditional air-conditioning system. These towers capture the wind and direct it into the rooms below to cool the space — a crucial feature for surviving Dubai's extreme heat.
- Narrow alleys and dense buildings provided shade and protected streets from sun and desert winds.
- Homes had internal courtyards with trees and small water features for passive cooling and privacy.
- Al Fahidi Historic Neighborhood (Bastakiya) was preserved today as a symbol of Dubai's historic architecture.

Modern Architecture (Post-1970s Oil Boom)

When Dubai discovered oil in the 1960s and 70s, the money from oil transformed the city quickly. It shifted from traditional houses to modern concrete buildings and glass towers. Reinforced concrete, glass, steel. Imported marble, aluminum, and futuristic facade systems.

- Dubai sought to showcase its wealth and modernity through skyscrapers in the form of high-rise towers, which became the new identity.
- Sheikh Zayed Road is Dubai's main avenue, filled with modern skyscrapers, inspired by cities like New York and Chicago.
- Iconic designs are the key features as each new building tried to be bigger, taller, or more futuristic than the last.
- Burj Khalifa (2010), the tallest building in the world at 828 meters. Its design is based on the Hymenocallis flower and Islamic geometric patterns. Architect: Adrian Smith (Skidmore, Owings & Merrill).

Postmodern and Futuristic Architecture (2000s–Now)

Dubai now focuses on creating symbolic, futuristic, and theme-based architecture that grabs global attention. Theme-Based Projects: Palm Jumeirah (shaped like a palm tree), The World Islands (shaped like a world map). Mixed Styles: Combines Islamic motifs, high-tech structures, futuristic curves, and sustainable technology. Smart City Features: AI-driven systems and green technologies (e.g., the Museum of the Future). Burj Al Arab, shaped like a

ship's sail, is a global symbol of luxury. The Museum of the Future is a futuristic torus-shaped structure covered in Arabic calligraphy, created using advanced robotics and parametric design.

Architectural Fusion – Old Meets New

Dubai continues to blend traditional styles with modern architecture, as evidenced by the reinterpretation of Islamic patterns and mashrabiya screens in glass and steel facades. Arches, domes, and courtyards are used in shopping malls (like Souk Madinat Jumeirah) and hotels. Cultural villages like Al Seef recreate traditional waterfront markets using new materials.

Climate-Responsive Modern Architecture

Because of extreme temperatures, buildings use double-glazed glass and insulation to reduce heat; solar panels are used in new projects (e.g., Expo 2020 Dubai's Sustainability Pavilion). Intelligent cooling systems (district cooling) are used to manage entire neighborhoods sustainably.

Socio-cultural Context

In the early 21st century, Dubai's art and film industries blossomed, with the annual Art Dubai fair showcasing contemporary art and the Dubai International Film Festival promoting both local and international movies. The Dubai Museum, housed in an 18th-century fortress, displays artifacts and exhibits related to the area's early history and traditional culture. Dubai's public library system has several branches throughout the city, and there are many bookshops in the city's shopping malls.

Dubai is home to many international sporting events. These have significantly boosted their status as a tourist destination. The Dubai World Cup is the world's most lucrative horse race, and the city's Dubai Desert Classic is a popular fixture on the European Professional Golfers' Association (PGA) Tour. The city's media industry remains firmly divided between government-backed television and newspapers, and foreign media companies that operate branch offices.

Heritage Conservation:

The Al Fahidi Historical Neighborhood is preserved to showcase Dubai's 19th–to early 20th-century architecture. Museums like Etihad Museum narrate the UAE's founding. The discovery of oil in the 1960s transformed the emirate and its way of life. Dubai's first oil exports in 1969 were followed by a period of rapid development that laid the foundations for today's

modern society. Dubai was the first to establish Islamic banks worldwide with the opening of Dubai Islamic Bank (DIB) in the 1970s, in addition to launching the Dubai Financial Market (DFM), the first global Shari'a-compliant exchange .

In the 1980s and early 1990s, Dubai made a strategic decision to emerge as a major international tourism destination of high quality. Dubai's economy is now more diversified, relying heavily on trade, services, and finance sectors, with a thriving business community. Dubai's GDP reached around AED 115 billion during the first quarter of 2024. (DUBAI, n.d.)

Conservation and Management Requirements

Dubai Culture and Arts Authority manages cultural heritage sites. Al ShindAga Historic District Revitalization. Dubai 2040 Urban Master Plan aims for sustainable urban expansion. Balancing rapid modern development with preservation of traditional identity and managing environmental sustainability with extreme urban growth are the key challenges.

Digital Preservation of Traditional Architecture

Current Efforts were done through the application of 3D scanning and digital documentation of old districts (especially Al Fahidi and Al ShindAga)—VR experiences created for Dubai Creek and historic souks.

- Technologies such as Laser scanning and photogrammetry were used in blockchain for property and heritage asset management.
- Challenges are data fragmentation and limited public access, risk of "museum-ification" — turning living districts into mere tourist attractions.
- Opportunities were created through enhanced virtual heritage tours and educational programs in universities on digital heritage management.

Conclusion

Dubai's architecture, from traditional coral-stone wind towers to futuristic skyscrapers like the Burj Khalifa, reflects a blend of heritage and innovation. Through digital preservation methods like 3D scanning, GIS mapping, and virtual reality, the city is actively protecting both its historic neighborhoods and its modern landmarks (Haggag & Rashed, 2003). These efforts ensure that Dubai's unique architectural identity is documented and accessible for future generations while supporting sustainable tourism and cultural education.

5.5.4. Case Studies - Digital twin applications in heritage conservation in Edinburgh, Scotland

Introduction

The capital city of Scotland, situated on the southern shore of the Firth of Forth. Edinburgh, capital city of Scotland, is located in southeastern Scotland with its center near the southern shore of the Firth of Forth, an arm of the North Sea that thrusts westward into the Scottish Lowlands. The city and its immediate surroundings constitute an independent council area. The city and most of the council area, including the busy port of Leith on the Firth of Forth, lie within the historic county of Midlothian. However, the council area also includes an area in the northwest, around South Queensferry, in the historic county of West Lothian. The city is also known as "Athens of the North", "Auld Reekie" (Old Smoky) (Maxwell et al., 2004).

HISTORICAL BACKGROUND

During the medieval period, Edinburgh Castle was built, while old town was established in the 12th century that gradually extended around the Royal Mile. Edinburgh University was established in the Renaissance, opening the gates of learning to the city, developing it as a center of education and intellectual life. In the 18th century, the intellectuals like David Hume, Adam Smith, and James Hutton brought the city to the age of enlightenment: "Scottish Enlightenment".

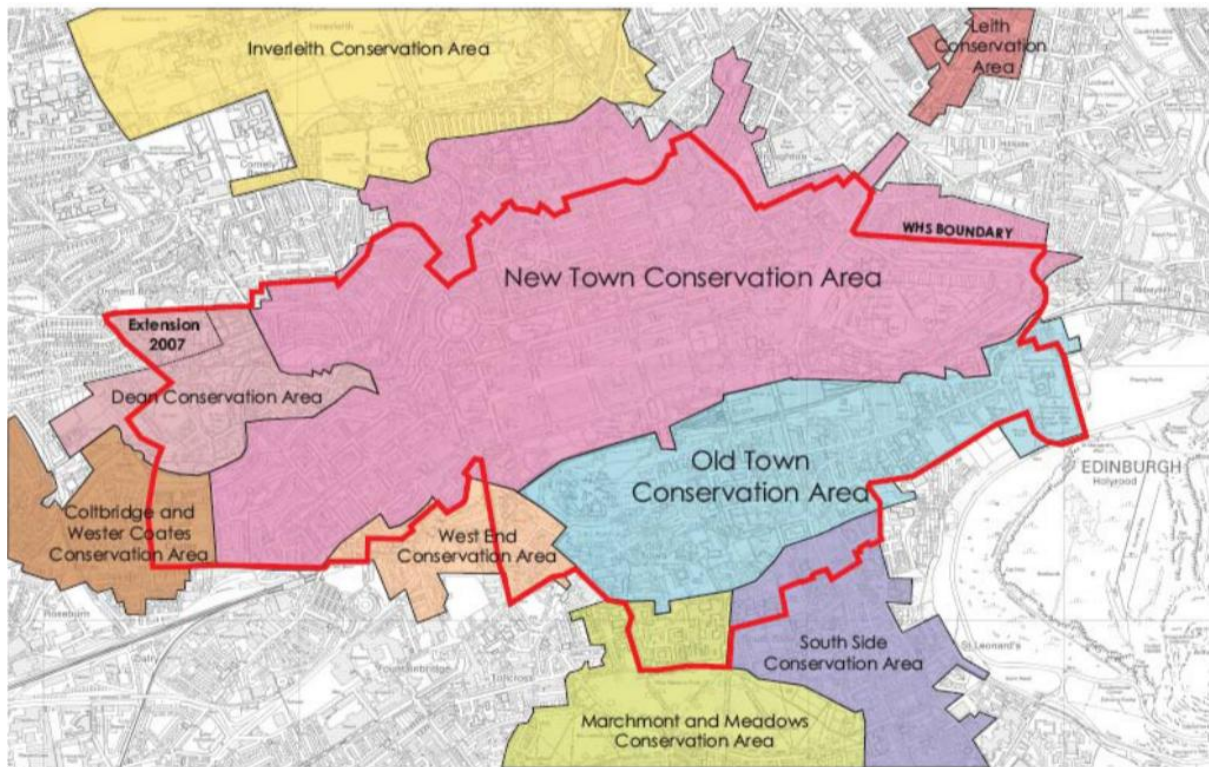


Figure 5-3: Old and New Edinburgh

Source: Edinburgh WHS: Annual Monitoring Report 2006–07, Appendix III. Cited in (Zappino, 2010)

URBAN MORPHOLOGY

The historic center has two distinct areas: the Old Town, dominated by a medieval fortress, and the neoclassical New Town, whose development from the 18th century onwards had a far-reaching influence on European urban planning. Significant town-planning components include the urban layout, buildings, open spaces, and views, which show the difference between the organic growth of the Old Town and the planned New Town .

Old Town: Organic growth was along the "Royal Mile" spine and dense medieval fabric with narrow wynds (alleys) and closes (courtyards). The topography-driven was built on ridges and valleys.(Rodwell, 2006)

New Town: Planned grid layout with large squares (e.g., Charlotte Square), wide streets (e.g., Princes Street). Neoclassical Architecture is based on symmetrical facades, grand urban scale, and green Spaces. Princes Street Gardens were created by draining Nor Loch.

Modern Expansion: Suburban growth radiates outward, blending with historical preservation and contemporary architecture.

Architectural Characteristics

Old Town was designed in medieval, Gothic, and early Renaissance styles. Examples are St Giles' Cathedral, of 12th-century **origins**.

New Town: Neoclassical and Georgian architecture reflects in Robert Adam's work at Charlotte Square.

Contemporary: Scottish Parliament Building with the deconstructivism style, a showcase of the dynamic blend of historic and modern styles in urban fabric.

Socio-Cultural Context

Capital is home to major festivals such as the Edinburgh International Festival, the Fringe Festival, and the Book Festival, which is among the world's leading institutions. The designated UNESCO "City of Literature" is home to writers such as Robert Louis Stevenson, Sir Walter Scott, and J.K. Rowling—diverse Population is due to significant international community due to tourism, education, and business.

Conservation and Heritage

World Heritage Status: Old Town and New Town together designated as a UNESCO World Heritage Site (1995).

Key Challenges: Managing modern development while preserving historical character.

Balancing tourism pressures with residential quality of life.

Notable Projects: Adaptive reuse of historic buildings. Strict guidelines on alterations within the World Heritage boundaries.

Key Landmarks

Edinburgh Castle is a historic fortress on Castle Rock. Holyrood Palace is the royal residence. The Royal Mile is a historic street linking the Castle and Holyrood. Arthur's Seat is an extinct volcano offering panoramic views. The Scott Monument is dedicated to Sir Walter Scott. The National Museum of Scotland shows extensive collections from natural history to art (Theodossopoulos, 2018).

Contemporary Challenges

Housing affordability is a significant challenge due to rising property prices, which are exacerbated by tourism and increased popularity. Tourism Pressure is another milestone in

managing visitor impact without damaging local life. Sustainability is achieved through retrofitting historic structures for improved energy efficiency.

Digital Preservation of Traditional Architecture in Edinburgh:

Edinburgh, a UNESCO World Heritage Site (comprising the Old Town and New Town), recognizes that digital preservation is crucial for protecting its fragile historic urban fabric. As the city faces challenges like climate change, urban pressure, and tourism, digital tools help document, conserve, and promote traditional architecture for future generations.

Historic Environment Scotland (HES) is a national leader in digital heritage documentation; their Rae Project ("Rapid Archaeological Engagement") digitally scans and records vulnerable buildings using photogrammetry, 3D laser scanning, and BIM (Building Information Modeling) for historic structures.

Examples are 3D laser scanning of Edinburgh Castle to create detailed, navigable models and digital surveys of the Royal Mile buildings, capturing details of facades, materials, and structural condition (Reynolds, 1975).

Table 5-1: Table showing the Technology Used
(Source: Reynolds, 1975)

Technology	Purpose	Examples
LiDAR (Light Detection and Ranging)	Capturing high-detail topography and buildings	Edinburgh Castle Scanning
Photogrammetry	Creating 3D models from Photographs	Royal Mile facades documentation
Building Information Modelling	Managing conservation projects digitally	Restoration planning for historic tenements
VR and AR	Virtual Tours and Educational Apps	Virtual tours app for Edinburgh's old town
Geographic Information Systems (GIS)	Managing heritage resources and tracking changes over time	Edinburgh's heritage Asset database

Challenges in Digital Preservation

- **Data Volume:** Massive datasets from scans need extensive storage and management.
- **Cost:** High initial cost of scanning, modeling, and maintaining digital records.
- **Skill Gap:** Need for specialized knowledge in 3D modeling, data management, and heritage conservation.
- **Authenticity vs Interpretation:** Virtual reconstructions can sometimes unintentionally alter the perception of history.

Conclusion

Edinburgh is at the forefront of digitally preserving traditional architecture, blending ancient masonry with cutting-edge technology. These efforts not only protect the city's heritage physically but also make its historic character accessible, interpretable, and resilient for future generations. Edinburgh stands as a vivid testimony to the complex layering of history, culture, architecture, and modernity. Its ability to conserve the past while innovating for the future makes it a unique urban landscape and a model for cities that balance heritage and growth.

5.6. REGIONAL CASE STUDIES: SHAHJAHANABAD, DELHI

Introduction

Shahjahanabad, today known as Old Delhi, is in India. The greater part of Old Delhi is still confined within the space of Shah Jahan's walls, and several gates built during his rule, the Kashmiri Gate, the Delhi Gate, the Turkman Gate, and the Ajmeri Gate, still stand (India, 1908). In 1639 CE, the Mughal emperor Shah Jahan laid the foundation of the city, and it covers an area of approximately 6.1 sq km (around the Red Fort). It is the last gem in the crown of Mughal Empire, representing Indo-Islamic urban culture (Koch, 2008).

Historical Background

Shahjahanabad, the capital city of the Mughal Empire, occupied a prominent spot in the Delhi triangle. Within the watersheds of both the Jamuna and Indus rivers, the Delhi triangle had been the prominent site for the capitals of North India's empires for over six hundred years. It was an area steeped in the glorious traditions of the past, and Shahjahanabad was the last in a long line of premodern capital cities. In the early Shah Jahan reign, we have a couple of pieces of evidence showing the crowding of the gateway of the fort during public performances. Shah Jahan decided to build new cities to account the Mughal sovereign and power. Blake further

explains that from the micro-perspective, the sovereign city was an enormously extended patriarchal household, and the center of power lay in the imperial palace fortress. The city was an extension of the imperial mansion as the layout of the buildings and gardens, and the shops in the city copied the layout of the buildings within the palace complex. Similarly, the organization of production and exchange in the city, by and large, followed the same system as was prevalent in the palace-fortress. In terms of social interaction among the city's inhabitants, the imperial palace also set the standard. From the macro-perspective, the sovereign city was the kingdom in miniature. The emperor intended that his command of the city in respect of power, obedience, resources, and influence should be 'symbolic' of the influence that he and his subordinates exercised over the Empire (Goel et al., 2024).

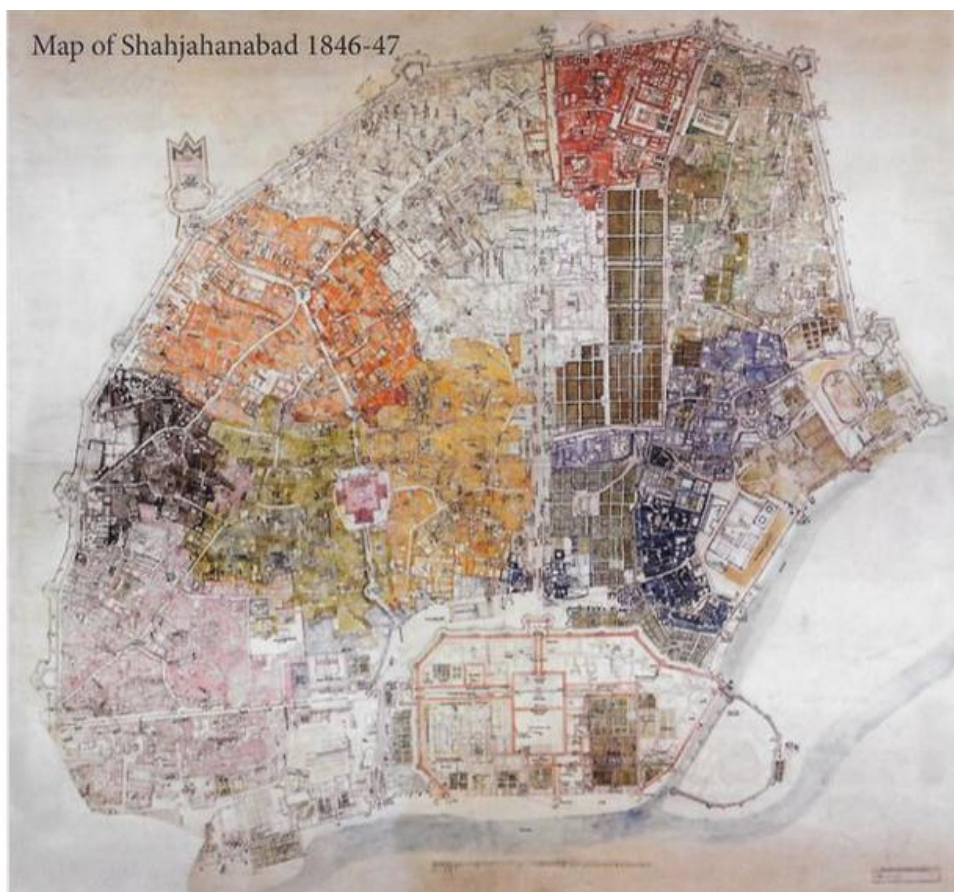


Figure 5-4: Map of Shahjahanabad, 1846-47

Source: (Liddle, 2023, Roli Books) cited by Das, 2024

Shahjahan wanted a new capital closer to the center of his empire and away from the old capital, Agra. The city was designed to showcase the grandeur, wealth, and power of the Mughal Empire, drawing on Persian-Islamic concepts of urbanism, including symmetry, order, gardens (Charbagh), and monumental architecture.

Urban Planning and Morphology

Shahjahan imposed his vision on the new capital. Its cityscape centered on the structures of the ruler and his nobles. The Mughal emperors were consummate masters of town planning, especially Shah Jahan, who had a highly cultivated aesthetic sense. He planned everything on a large and noble scale. The entire city was enclosed within a walled area. Stephen Blake points out that the shape of the city closely follows a favored and auspicious design in Hindu Vastu Shastra, specifically in the bow shape. Jama masjid was built on the highest point of the city and Akbari gate was built to give way to Khass Baazar (chandi chowk). The planning of Shahjahanabad also reflects the traditional Islamic city plan. According to it, the concept of the city lies between the two poles, man and universe, and that incorporates the symbolic principles of both. The city drew on the images of men and universe in a symbolic form. The plan of the city was also seen to emulate the anatomy of men which 'contained all the possibilities of the universe within him'. Elements of cosmological concept of the city found vogue in the working of the Iranian architects of Shahjahan's court. As Blake opines the Walled City 'symbolized the cosmos and the eight gates the four cardinal directions plus the four gates of heaven'. The city was fortified on three sides by a strong wall and the fourth - on the eastern side partly by the Fort and partly by the wall. The northern wall of the city extended just three quarters of a mile from the Water Bastion in the east to the Mori Bastion in the west. It was encircled by a massive wall more than 8 meters high and 3.5 meters wide. The total length of the walls exceeded 9 kilometers.



Figure 5-5: Chandni Chowk or the Moonlight Square
Source; British Library, X724(10) cited by Das, 2024

The wall was surmounted by twenty-seven towers and interspersed with a number of big gates and entryways at regular intervals. The major gateways pointed to the direction of the important places such as Lahori Gate, Kashmiri Gate, Ajmeri Gate, Akbarabadi Gate, etc. Towards the river, where Rajghat and Nigambodh ghat are located, smaller gates were provided for the Hindu inhabitants of the city to visit their places of worship and perform ceremonial functions. Overlooking these gates were chaukis (posts) and quarters for the security personnel. There were two hillocks within the area enclosed by the citadel. On one of these, known as Bhujalal Pahari, the Jami' Masjid was constructed. It is about 500 meters southwest of the fortress (Singh et al., 2002).

The city was enclosed by a wall with 14 gates (like Delhi Gate, Kashmiri Gate, and Lahori Gate) and a moat. The principal axes are Chandni Chowk, which is the main ceremonial avenue leading directly from the Lahori Gate of the Red Fort. Streets were wide, straight, and intersected with narrower lanes (gullies). Mohallas (neighborhood clusters) are based on profession, religion, or ethnic groups. Bazaars (markets) are organized in a hierarchical structure. Serais (inns for travelers and merchants) are along important streets. Public Spaces are open squares, water bodies, caravanserais, mosques, and gardens, while private spaces (houses and havelis) are centered around courtyards.

Architectural Character

Shahjahan commenced the building of his new capital in 1639. It took almost nine years for its completion, and the city was finally inaugurated in 1648, probably in April, coinciding with Nauroz—the new year of the Persians. By the time Shahjahan had come to the throne, the Mughals, at Delhi, Agra, Lahore etc. had shifted almost exclusively to the use of marble and sandstone for monumental structures. At times, fascia with buff, brown and (rarely) yellow sedimentary stones were used as elements of novelty.

But this was as far as monumental structures went. Other structures such as shops, houses, smaller havelis continued to be built with Delhi quartz rubble and were given a thick coating of limestone and crushed brick plaster. So, in the main, before the arrival of the Europeans and the introduction of steel in construction, the city of Shahjahanabad was a mixture of monumental structures and larger havelis built with red sandstone and marble, while markets, houses and smaller havelis continued to be built with Delhi quartz. The base was gradually undergoing a change from the Sultanate and early Mughal period to the time of Shahjahan and later (Das, 2024). The inner material that supported the façade during the

Sultanate and early Mughal period used to be rubble masonry, held together with crushed brick and limestone mortar. This rubble masonry was now replaced with bricks. These were the tiny narrow bricks known as the Lakhori or Kakaiya bricks that became increasingly popular during the reign of Shahjahan and held sway well into the very late 19th century and continued to be used till the early decades of the 20th century. They were gradually replaced by the large (approx. 9"x4"x3") bricks, popularly known as the 'ghummaeent' introduced during the colonial period, which are in almost universal use in India now (Lindsay, 2002).

- **Axial Planning:** The Red Fort and Chandni Chowk boulevard formed the ceremonial axis. Streets radiated outward in a planned yet organically adapting manner to the terrain.
- **Red Fort (Lal Qila):** A massive red sandstone fortress with palatial marble interiors. Combination of Persian, Timurid, and Indian architectural elements. Symbolized imperial power, protected by high walls and bastions. Jama Masjid,
- One of India's largest mosques. Built in red sandstone and white marble. Features wide courtyards, grand domes, and towering minarets.
- **Residential Havelis:** Wealthy merchants and courtiers constructed large havelis featuring a central, open courtyard. Features: intricate jharokhas (balconies), latticed screens (jali), carved stone/marble work. Typically inward-looking for privacy and climate control.
- **Gardens and Waterworks:** Charbagh gardens reflecting the Persian concept of paradise. Advanced systems of water channels (nahr) for irrigation and cooling.



Figure 5-6: Bird's Eyeview of Shahjahanabad
http://www.kamit.jp/02_unesco/20_delhi/xdra_eng.htm

Socio-Cultural Context

- **Cultural Hub:** A melting pot of languages, art, literature, and cuisine, and home to poets like Mirza Ghalib and Mir Taqi Mir.
- **Religious Diversity:** Though predominantly Muslim, the city accommodated Hindus, Jains, and Sikhs. Various religious institutions co-existed nearby.
- **Economic Vibrancy:** Famous bazaars (Chandni Chowk, Dariba Kalan) were international trading hubs. The goods included spices, textiles, jewelry, and books.

Decline and Transformation

- **British Conquest:** After the 1857 Revolt, the British captured Delhi. Parts of Shahjahanabad were destroyed (e.g., areas around Red Fort). New colonial administrative buildings were introduced, disrupting the original fabric.
- **Modern Challenges:** Overcrowding and commercialization have degraded many historic havelis and streets. Illegal construction and lack of maintenance are major threats.

Current Efforts in Digital Preservation

3D Scanning and Mapping: Organizations like INTACH (Indian National Trust for Art and Cultural Heritage) and Archaeological Survey of India (ASI) are using 3D laser scanning to create accurate models of key structures like the Red Fort and Jama Masjid. Photogrammetry techniques for detailed facade mapping of historic havelis and bazaars.

These digital models help in restoration planning and virtual archiving.

- **GIS-Based Urban Documentation:** Heritage GIS (Geographic Information System) mapping projects are underway to: Digitally map the traditional street patterns (galis), public spaces, water systems (baolis), and historic landmarks. Track the conditions of various historic havelis and identify endangered sites.
- **Virtual Tours and Augmented Reality (AR):** Pilot projects have created virtual reality (VR) experiences of sites like Red Fort's interiors. Augmented Reality mobile apps being developed to provide on-site digital storytelling for tourists visiting Chandni Chowk and Jama Masjid.
- **Digital Archives:** Historic maps, paintings, architectural drawings, and oral histories are being digitized and made accessible through portals like: National

Digital Library of India (NDLI). Sahapedia (Indian cultural knowledge platform). Google Arts & Culture — Old Delhi projects

Challenges in Digital Preservation

- **Data Fragmentation:** Different agencies using different formats with limited standardization.
- **Lack of Funding:** Comprehensive 3D scanning and data maintenance is costly.
- **Low Public Access:** Much of the digitized data is not yet fully open to public researchers or communities.
- **Urban Pressure:** Rapid commercialization makes physical conservation difficult even when digital data exists.

Importance and Impact

- **Risk Mitigation:** Digital records protect against permanent loss due to decay or demolition.
- **Restoration Support:** 3D models and scanned data guide architects in authentic restoration work.
- **Public Education:** Virtual platforms increase awareness about Shahjahanabad's heritage among younger generations.
- **Cultural Continuity:** Documentation preserves not just buildings but also associated intangible traditions (markets, festivals, crafts).

Conclusion

Shahjahanabad remains a priceless jewel of Indo-Islamic architecture and urbanism. Though its physical structure has suffered due to modern pressures, conservation efforts are ongoing to restore its historic grandeur. Reviving Shahjahanabad not only preserves Delhi's cultural heritage but also sustains the memory of the Mughal era's artistic and urban achievements.

5.7. NATIONAL CASE STUDIES WITHIN PAKISTAN

In the context of Pakistan, the study of national case studies focuses on emergent practices that seek to bridge traditional heritage conservation with contemporary digital tools. These initiatives are particularly significant in a postcolonial setting where historical narratives, preservation priorities, and spatial politics remain contested. The selected cases are

representative of two interrelated domains: (1) digital documentation of historic cities and built heritage, and (2) community engagement facilitated by digital platforms.

5.7.1. Digital Documentation Initiatives in other Historic Cities

Over the past decade, a series of digital documentation projects has been undertaken in key historic urban centers, including Lahore, Peshawar, Multan, Thatta, and Rawalpindi. These cities represent rich palimpsests of Mughal, Sikh, colonial, and vernacular architectural traditions, yet many of their built assets face critical threats due to infrastructural neglect, unregulated development, and environmental degradation.

Digital documentation initiatives in these areas aim to create accurate, high-resolution records of architectural heritage using tools such as:

- **3D laser scanning** for structural mapping,
- **Photogrammetry** and **drone-based aerial imaging** for facade and urban morphology studies,
- **Spatial databases** for contextualizing heritage within broader urban systems.

These efforts often operate within hybrid institutional frameworks, such as collaborations between local heritage authorities (e.g., *Walled City of Lahore Authority*), international heritage bodies (e.g., *UNESCO*, *Aga Khan Trust for Culture*), and university research labs. They serve dual purposes: providing a scientific basis for conservation planning and producing archival resources for research, education, and public dissemination.

Moreover, these projects have brought visibility to the need for capacity building in digital heritage technologies within Pakistan. The uneven distribution of technical expertise, lack of localized data standards, and challenges in long-term data stewardship highlight the infrastructural and policy gaps that persist in implementing digital heritage frameworks at scale.

Importantly, digital documentation in Pakistan also engages with the politics of representation. In many cases, the selection of sites for documentation reflects broader narratives of national identity, religious symbolism, or economic utility, often sidelining marginalized or vernacular histories. Therefore, the critical analysis of these initiatives must also interrogate whose heritage is being documented, preserved, and valorized through these digital processes.

5.7.2. Digital inventories in Pakistan

Digital inventories are indispensable tools in the documentation, management, and preservation of cultural and architectural heritage. In the context of Pakistan—a country endowed with a rich and diverse heritage that spans the Indus Valley Civilization to Islamic, colonial, and vernacular architecture, the development of comprehensive digital inventories has emerged as a crucial component of contemporary heritage management strategies.

Digital inventories involve the systematic recording of cultural assets using digital technologies, including Building Information Modelling (BIM), photogrammetry, 3D laser scanning, and high-resolution imaging. These inventories serve as dynamic databases that store critical information about historic sites, architectural features, materiality, construction techniques, historical narratives, and conservation status. They facilitate not only the monitoring and maintenance of heritage structures but also support academic research, urban planning, disaster risk management, and policy development.

5.7.3. Community Engagement through Digital Platforms

While digital documentation focuses on the technical and archival dimensions of preservation, parallel efforts have emerged that utilize digital platforms to democratize heritage discourse and amplify community participation. These initiatives are crucial in countering the historically top-down, expert-driven approach to conservation in Pakistan. Community engagement projects—often spearheaded by NGOs, cultural collectives, or academic networks, use digital media to collect, curate, and share local narratives. Notable examples include:

- **Crowdsourced heritage mapping** using mobile applications and interactive GIS platforms,
- **Digital storytelling** initiatives capturing oral histories, personal archives, and everyday spatial practices,
- **Social media campaigns** advocating for the preservation of threatened heritage sites, often mobilizing public pressure on authorities.

Such projects aim to shift the perception of heritage from being a static, monumental past to a living, participatory construct rooted in collective memory and identity. They provide a platform for underrepresented groups—such as women, religious minorities, and informal settlement residents—to contribute to the heritage discourse.

In cities like Karachi, digital campaigns around neighborhoods such as Saddar or Baloch Colony have highlighted the tension between modernization agendas and grassroots heritage claims. Similarly, in smaller towns, digital tools have enabled diasporic communities to reconnect with their ancestral spaces, fostering transnational networks of memory and belonging.

These practices also resonate with global decolonial discourses that challenge Eurocentric, materialist definitions of heritage. By emphasizing narrative, affect, and local epistemologies, digital platforms in Pakistan open up new possibilities for what counts as heritage and who has the authority to define and protect it.

Analytical Significance

Together, these national case studies underscore a critical transition in heritage practice in Pakistan—from preservation as a state-centric, technocratic endeavor to a more inclusive, digitally mediated field of cultural negotiation. They highlight how digital tools can serve not merely as instruments of documentation but as catalysts for dialogue, agency, and transformation.

Furthermore, these cases contribute to broader theoretical conversations on postcolonial digitality, participatory heritage, and the politics of memory. They suggest that in contexts like Pakistan, the digital turn in heritage is not only technological but also epistemological, raising fundamental questions about how heritage is conceived, whose knowledge is privileged, and how power is mediated through platforms and data.

5.8. CASE STUDIES (FIELD WORK) WITHIN THE WALLED CITY OF LAHORE

5.8.1. Case Study - Digital Conservation of Barood Khana, Lahore Fort

The research is an attempt to develop a three-dimensional scaled wire-frame model using Total Station as an integrated approach towards digital preservation of historic monuments and heritage sites, with a particular focus on a significant historic monument, Barood Khana, located in the Lahore Fort. In the historical context of Lahore, there is a dire need for the application of digital technologies for the safeguarding of architectural and urban built heritage in terms of documentation, data archiving and preparation of conservation plans. The research focuses on the documentation and recording of Barood Khana, using total station with electronic distance measurement (EDM) technique for the development of scaled wire-frame three dimensional model. With the application of advanced techniques in 3D modeling and digital reconstruction, this study aims to capture architectural details of Barood Khana with

high level of precision and accuracy. The development of wire-frame model involves site surveys including pictorial and visual surveys and documentation using total station for identifying structure's dimensions, architectural details and spatial relationship within its context. The digital documentation using total station presents a detailed understanding about damages and deteriorations leading to the conservation efforts. The equipment is a gateway towards application of digital technologies for the conservation and restoration of built heritage.

Introduction

At present, it has become a challenge to save the cultural heritage of Lahore due to ever increasing urbanization and modernization. These monuments and heritage sites are on threat and being deteriorated due to multiple agents including human activities. The current status of these urban built heritage needs holistic approaches for preservation (Liang et al., 2023). The historic cores are of prime importance as they are index of various cultures, witness of human activities of the past (Mughal, 2011). The study aims at the digital documentation of Barood Khana, a legacy of British period, to develop 3D model with the application of modern tools and software. On-site digital in the form of a scaled wire-frame model of Barood Khana provided accurate details in terms of horizontal and vertical angles and distances (Tania Qureshi, 2023).

Historic core of Lahore has a wealth of historic monuments, open urban spaces and traditional bazaars, representing tangible and intangible cultural values. Lahore Fort is also part of old Lahore and was used by the royal family members. Mughals laid the foundation of Lahore Fort and Sikh rulers made interventions to satisfy their desires and needs. Few significant structures were added to the fort and few were added with additional floors (Ali, 1990a).

British occupied Lahore through East India Company and added few structures to meet the requirements of his artillery. The royal fort was declared as a center for British army and Barood Khana was constructed as store to place gunpowder. The structure is at the central place in the close vicinity of Almgiri gate and Mussaman derwaza. With the application of digital technologies to make a record, Aga Khan Cultural Services of Pakistan (AKCSP) took the initiative to use Total Station with laptop to develop 3D model (Sulman, 2009). As total station is based on electric distance measurements, therefore, model is wire-frame, rather solid faces. But it helped to record intricate details of the monument.

The 3D model of the Barood Khana gives a comprehensive detail of the monument dimensions, angles, cracks, damages in pilaster, damages in the walls and vault. It also explores the

potentials of the digital technologies among the various stakeholders such as architects, engineers, policy makers, and conservation experts. Being part of the cultural heritage of old Lahore, Barood khana contributes to the significance of the heritage site (Tania Qureshi, 2018a).

The visual and pictorial surveys of the site, collection of archival data and preparation of 3D modeling can help to maintain a record based on the multilayer information. These 3D models can support to reconstruct the monument in digital environment for the conservation projects. The sharing of data among various stakeholders is another benefit of digital technologies. The study can provide a base for the future generations to identify the damages and deteriorations, to record historical evidences, to manage and monitor heritage sites. Barood Khana presents British legacy and dignity.

The monument was ignored for ages and vegetation destroyed the structure, until Walled City Lahore Authority (WCLA) took the notice of its bareness & destruction and decided to safeguard it. The documentation was done in 2019 and conservation plan was prepared. After conservation, the monument is being used as a meeting place for officials and delegations. The effort shows the interest of authorities towards conservation efforts to make the heritage sites alive and dynamic, contributing to the enhanced tourist value.

Aims and Objectives

The Lahore Fort is comprised of 21 monuments of significant historic value and needs appropriate documentation. Similar to the other monuments, Barood Khana possesses significant historic value due to its function and location in the historic environment. The application of digital technologies provide us, comprehensive details in terms of architectural and ornamental details. Traditional techniques have constraints in terms of time span, accuracy and precision. In comparison, digital technologies can provide more accurate and precise details in shorter time span (Bullock & Richard E. Warren, 1998). During the preparation of Master Conservation Plan 2016 by the Walled City Lahore Authority, Fort and Badshahi Mosque has been assigned a number 1B in the proposed list of zones of special value (WCLA, 2016)

The primary objective of the study is to address the issues and challenges of conventional methods of documentation and the potential and limitations of a wire-frame 3D model prepared by advanced surveying tools.

- To review existing literature on historic recording and documentation, 3D modeling techniques and historical value of Barood Khana.
- To conduct visual and pictorial survey of the site to develop walk through details.
- On-site digital mapping and survey of the site using total station to obtain precise measurement of the monument's dimension, details of architectural elements and spatial relationship with its context.
- To develop 3D model based on wire-frame data for the preparation of conservation plan.

Through these achievements, the study targets to contribute the goals for sustainable development of historic cores with the help of conservation projects. It will help to understand the historical significance and architectural legacy.

Significance of the Study

The application of digital surveying and mapping tools encompasses multiple dimensions such as digital mapping, archiving, managing and monitoring of historic monuments and archaeological sites. It also involves public involvements and sharing of data among stakeholders. Historic monuments including Barood Khana are facing various issues such as botanical, environmental, climatic changes. If they are not protected, a great loss can damage national identity and source of education for the future generations. These monuments are record of our past and they must be protected with integrity and authenticity.

The digital technologies have revolutionized the conservation industry and enlighten the path towards sustainable development goals saving human and financial resources. A systematic approach to develop 3D models of heritage sites for the protection of urban built heritage can serve as a digital platform, facilitating preservation projects.

Digital Technologies Used

Historic city of Lahore including Lahore Fort is witnessed various ruling dynasties and has been influenced by intruders. The indigenous architecture absorbed the cultural and architectural character of the invaders and developed new styles. There are three main historic periods which laid the foundation of the present day modern Lahore. The Mughal, Sikh and British periods are the most influential time spans which can never be removed from the story of the historic Lahore. It is mandatory to save the memories and remains of the past for the future generations (Iftikhar, 2019). Lahore Fort is also a place of cultural evidence of these

three periods, and it was declared a UNESCO World Heritage Site in 1981, and Barood Khana is also Part of this World Heritage Site. UNESCO has prepared a five year Master Plan for the conservation of Lahore Fort in 2006, with the collaboration of international organizations (UNESCO, 2011).

This literature review describes and evaluate the data, regarding the historical background and architectural significance of Barood Khana. This data has been collected for the digital documentation using total station, for the restoration and adaptive reuse of the monument.

Barood Khana is an addition, in the heart of Lahore Fort, presenting the British identity and attitudes towards the urban built heritage. There are multiple structures in the historic Fort which are symbol of art and architecture of the Mughal and Sikh rulers. Among those highly detailed ornamented monuments, Barood Khana is a repository of British artillery architecture with its simplicity and dignity. It is very challenging to save all historic evidences of the human activities of the past (Hassani et al., 2015).

With the annexation of British, Lahore experienced rapid urbanization and modernization, damaging the character of the old Lahore, laying the foundation of modern Lahore, at the outskirts of old Lahore. This wave of urbanization and modernization influenced the urban built heritage and threatened its existence. It has been crucial to save these historic remains and developing an archive based on the documenting and archiving these structures (Rafiq, 2010).

Conservation experts are trying to find new methodologies to document, record, developing archive, management and monitoring of the heritage sites with minimum utilization of the resources. It has been realized globally that energy resources can be saved with the restoration and adaptive reuse of the heritage, rather to construct new structures and modern technologies can complete this task more comprehensively, as compared to conventional methods. Total station is one of the digital tools which initially was adopted for the documenting of the built heritage, but it was also time consuming and in the later times, it is replaced by terrestrial laser scanner. It has its own benefits and limitations, but still being used as an innovative solution to the preservation of heritage sites (Leon et al., 2020).

In the last decades, advancements in 3D modeling software and digital imaging technology have empowered conservation experts to document heritage more precisely and accurately, saving money, time, and human resources. (Haddad, 2011).

Barood Khana is also witnessed the intangible character of the specific activities done in the British period, to maintain the control over the Indian continent through power and is responsible to influence the socio-cultural character of the city. It was selected as a royal throne by the Mughals and Sikhs, maintaining its position during colonial rule in sub-continent.

The analysis of conservation policies, methodologies and practices, it has been realized that it is need of the time to apply modern techniques as an integrated approaches for the conservation and adaptive reuse of the urban built heritage for the socio-cultural and socio-economic stability. These three dimensional scaled wire-frame model prepared by using total station with electric distance measurement technique, can solve the major challenge of conservation process, through the provision of orthographic representation of historic monuments within their context.

Scaled Wire-frame model through EDM

Scaled wire-frame 3D models of built structures can be prepared with the help of total station by applying EDM technique and these models can give a structural framework. Considering the plain structure of Barood Khana, this methodology has been selected as a tool. Because, there is ample space around the building to fix total stations and document the historic monument. This 3D model provided accurate detail in terms of architectural features, physical dimensions, horizontal & vertical angles of the walls, doors, ceiling, roof and other openings with the detailed layout of the damages. These models are based on the interconnected lines and vertices and can be processed in Autodesk AutoCAD Architecture suit in the form of layer, assigned properties with various colors. This simplified model give an understanding about overall geometrical form and architectural characteristics (Remondino & Menna, 2008).

There are few key elements of scaled wire-frame 3D model of Barood Khana which includes: The structural elements such as walls, doors, vaulted roof and ceiling and other openings form the skeleton of the building and depict a spatial relationship with its surrounding through layout of the Barood Khana in the close premises of Alamgiri gate and Musamman Darwaza.

It gives a proportion and scale of the monument in the surrounding context. It is located in a spacious area, near the metal road, constructed during British period to facilitate the British army for the transportation of gunpowder stored in barood Khana.

It is possible to share data among architects, engineers and conservation experts, through the uniform layouts, minimizing chances of human errors, providing insight to the preparation of conservation plans to safeguard valuable heritage (Barton, 2009).

Digital technologies provide multiple options for digital documentation multilayer data, combining electric theodolite with electric distance measurement tool to survey and mapping for precise and accurate measurement of plain and terrain surfaces. It is for the surveying of architectural features, land contours and documenting archaeological sites (Remondino & Menna, 2008)

Research Methodology

The digital documentation of the Barood Khana Lahore Fort needs an integrated approach to collect archival data, site surveys, digital modeling and analysis of 3D modeling techniques. The research methodology is based on advance technologies, tools and software to meet the challenges of modern world.

Archival data has been collected about historic data, architectural drawings, and photographic record of monument. Data has been collected through primary and secondary resources such as scholarly articles, newspaper reports, web pages, photographic records and oral historic data.

Site surveys has been conducted to record current status and condition of the site with the help of DSLR cameras. On-site survey has been conducted using Total station and laptop with the software TheoLT. It has supported to identify the cracks and material damages due to the dampness, of the vegetation and debris around the monument. Through this wire-frame model, architectural dimensions have been recorded. Detailed information has been recorded from this scaled wire-frame 3D model for the preparation of a conservation plan to preserve the monument.

Digital Documentation of Barood Khana by using Total Station

Location and Context

Barood Khana Lahore Fort is a single story structure with vaulted roof, located in the western side, near the Musammaen (octagonal) Darwaza and Almgiri gate and has been constructed in 1857 by the British rulers. It was built for the storing of ammunition and gunpowder, therefore, it is termed as Barood Khana. During the magnificent and monumental buildings, this monument is standing with its beauty and simplicity. The Barood Khana

signifies the early modern period of the western part of the world and shows the revolution in western society during the last centuries (Tania Qureshi, 2018).

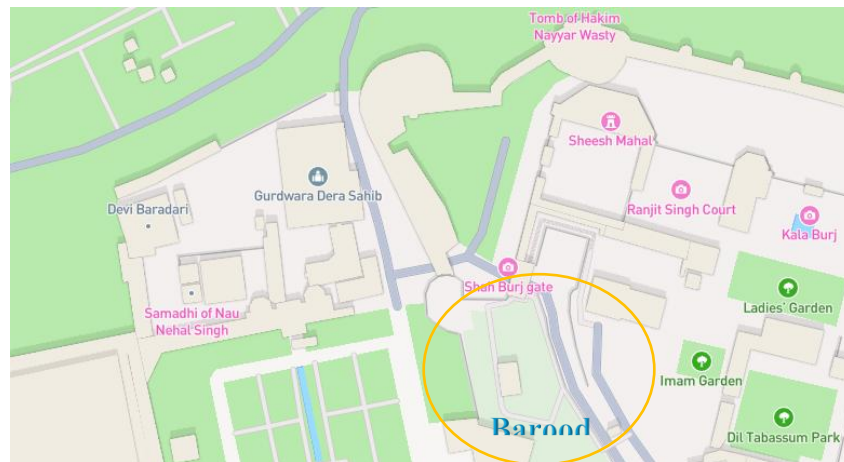


Figure 5-7: Location map of Barood Khana, Lahore Fort

source: mapbox - modified by the Authors, 2023

The main access to Barood Khana is from Shah Burj gate through Tarmac Road. A metal road was constructed during the British period, leading towards ammunition depot for the army movement in the area.

Historical Background

Barood Khana was constructed as an ammunition center for the British army to store the gun powder during the year 1887 and is part of historic environment. Being British legacy at Lahore Fort, it reflects the British period addition to the monuments of Mughal period at Lahore Fort and for all kinds of armory. Two rooms i.e. at north and south ends were constructed and made part of the building. The purpose of these rooms were to ensure the security of all the barood stored in the building.

During the British period, Lahore Fort was occupied by the East India Company and significant modifications were made to adjust the British army. The British army settled in the southern end of the Fort and constructed this structure for the safeguarding of gunpowder, making a lot of changes in the other parts of the fort complex (Khalid, 2021).

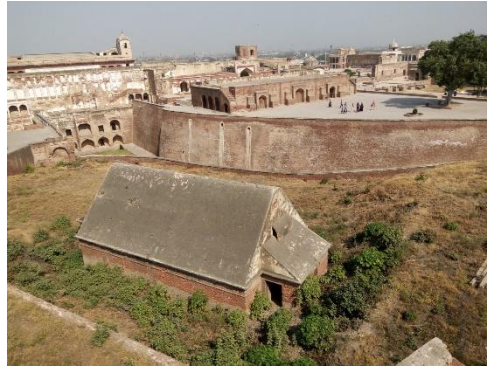


Figure 5-8: View of Barrod Khana from Alamgiri Gate

Source : WCLA, 2019

Current Function of the Monument

After the conservation, the monument is being utilized for the official meetings and academic seminars after a minimal payment by the groups of researchers, academicians and conservation experts. According to the web page of WCLA, 25 + 5 persons can attend an event inside the Barood Khana.



Figure 5-9: Image showing view of an event in Barrod Khana after conservation

Source: WCLA webpage, 2023

Architectural Details

The arsenal depot or Barood khana is a rectangular structure with a groin vault design from inside and outside and very simple in its form considering the function. The other buildings of the Victorian period, designed are presenting love of designs for art and architecture, giving respect to previous historic structures such as Aitchison college, Mayo School of art, Railway Station etc.(Bryant, 2020). This specific shape for designed for the storage of the gunpowder, to control the temperature. The other structures in the premises has been ruined and now, they are part of fort's landscape. The rooms on the north and south end

were constructed for the safety of the gunpowder as there is no entrance on the east and west walls.

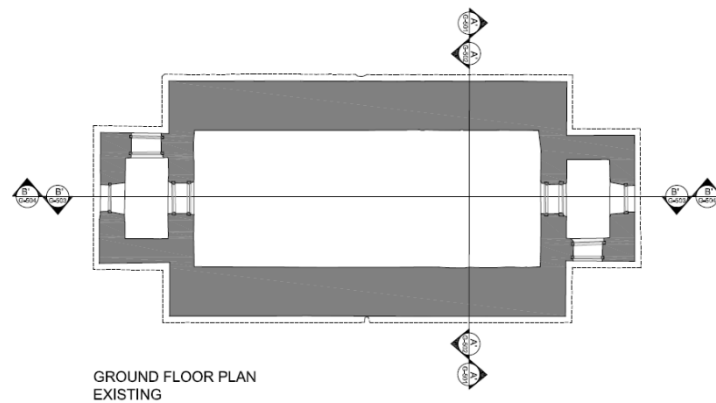


Figure 5-10: Ground Floor plan of Barood Khana

Source: WCLA, 2019

The ceiling structure is vaulted for temperature control due to the heat dissipating from the gunpowder. There were two issues related to temperature control and security.

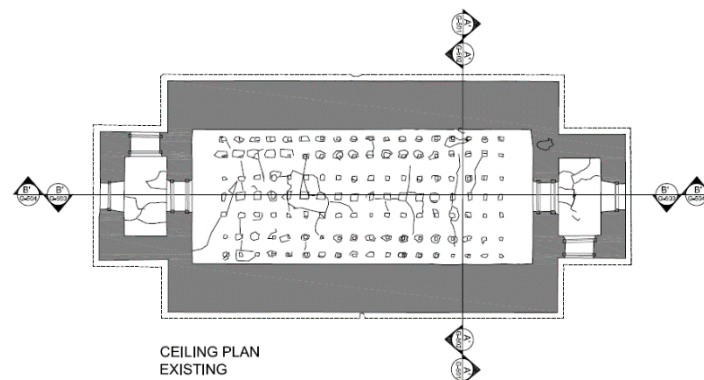


Figure 5-11: Ceiling Plan of Barood Khana

Source: WCLA, 2019

The structure is plain due to its function, but it is part of historic context and witness of human activities of the past. There is no direct entrance into the main hall, however, entrance to main hall is through the rooms adjacent to main hall. The north and south elevations are with plain structures. There are doors in the small rooms attached with the main hall.

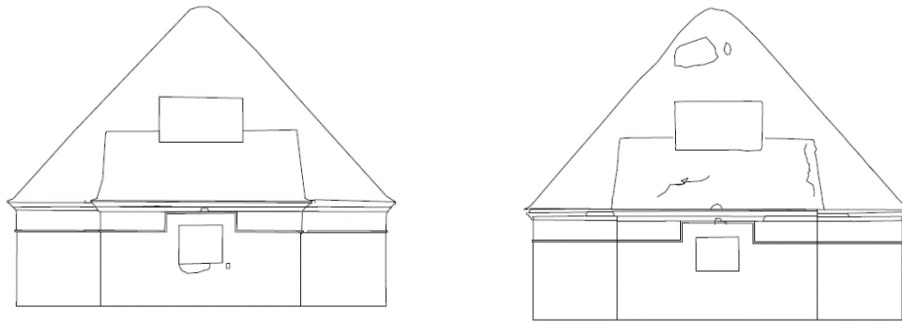


Figure 5-12 : North Side Elevation (Left) , South Side Elevation (Right)

Source: WCLA, 2019

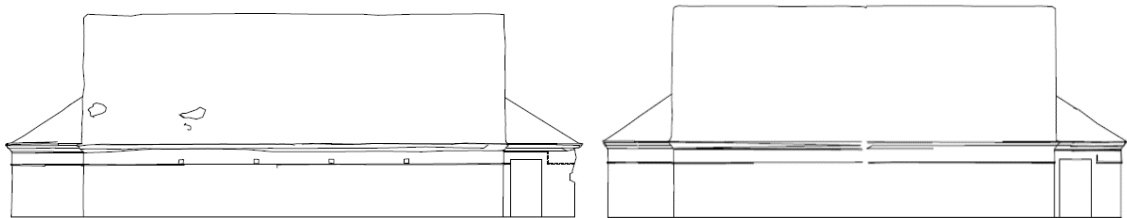


Figure 5-13: West Side Elevation (Left) , East Side Elevation (Right)

Source: WCLA, 2019

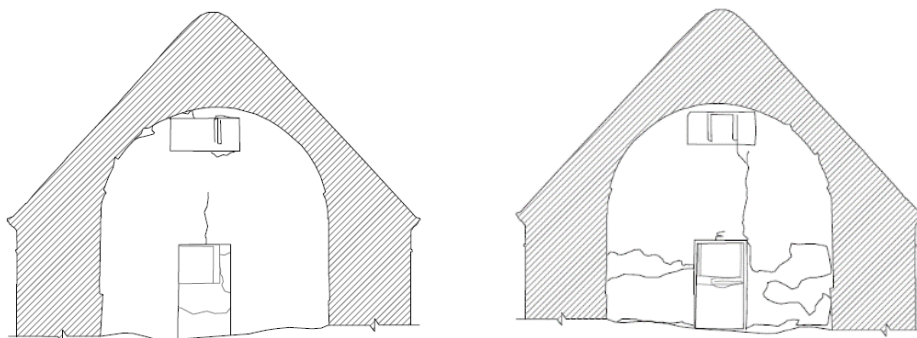


Figure 5-14: Section AA' looking North (Left), Section AA' looking South (Right)

Source: WCLA, 2019

The section AA' showing the longitudinal inner dimensions and damages in the walls of the main hall and adjacent rooms.

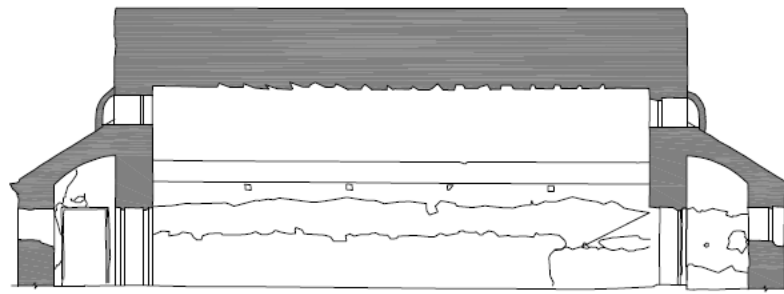


Figure 5-15: Section BB' looking East

Source: WCLA, 2019

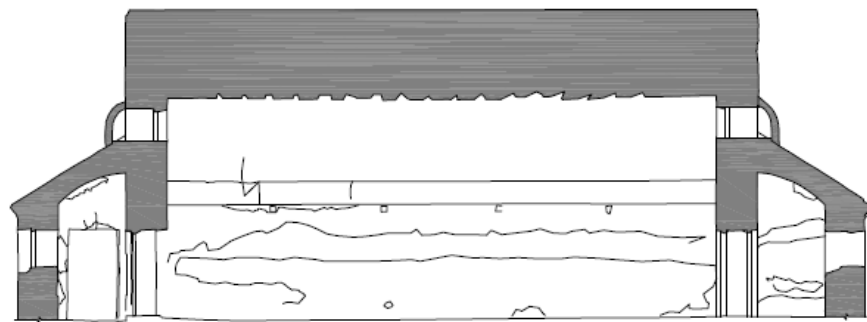


Figure 5-16: Section BB' looking West

Source: WCLA, 2019

The section BB shows the thickness of the walls and interior towards the openings, small rooms, and cracks in the walls.

Status of the Monument before Conservation

During the Colonial period, Barood Khana was constructed with Brick and lime mortar. The space around the monument has been covered by the vegetation and plants and it was the source of rain water. Accordingly, slacken the soil beneath and instigating the cracks in monument.

It has been perceived that the whole building on the Barood Khana was travail from high danger and deteriorations. During surveys, it was observed that the typical damages were in the form of in the cracks, bloated plaster, loss in brick masonry, broken cornices, destroyed wooden doors and ventilators, distressed surface and surface texture, interior side and plant growth in the immediate context.

The structural damages to the monument were a threat for the stability of the structure, all pressures and deteriorations have to be addressed and treated before converting the structure

in to worst state. The architectural elements such as openings are fully deteriorated because of aging, termite reactions, woodworms and building has been fully ignored in the past.

Rest of the building, including floors is in dilapidated condition and needs immediate rectification.



Figure 5-17: Damaged Plaster, Cracks in Building, Damaged Brick Masonry, and Decayed Wood

Source: WCLA, 2019

Threat to Exterior and Interior Renders and Finishes

The structural and architectural elements of Barood Khana are almost dilapidated due to the seepage of water from the surrounding vegetation sourced by the rain water. The rain water also caused dampness and humidity inside the building and it was on the mercy of guards without protective measures for ages. The giraffe from the walls has been vanished leaving only marks of existence. Due to the neglect, the structure captured the influences of climate change, temperature variations and rainwater. All these factors damaged the monument and deterioration of historic elements.

The water underneath the foundations destroyed the strength of the soil, weakening the structure itself. Not only vegetation, but heaps of debris were also been collected over here as there was no means of cleanliness. This debris was also a source of standing water, after rains which ultimately impact the structure stability and strength. There was a need for immediate removal of vegetation and debris as a first remedy to save the structure.



Figure 5-18: Image showing the context of Barood Khana full of debris before conservation

Source: WCLA, 2019

Damage Masonry

The brick masonry was damaged from interior and exterior sides. It was tried to save the original material from replacement, rather renovations and repairs were preferred. Cleaning was done after laboratory test of the materials to avoid further damages. Original binding materials were applied to avoid modern interventions through the application of cement mortars.



Figure 5-19: Image showing structural damages such as peeling of lime plaster and rotten bricks

Source: WCLA, 2019

Damage Plaster

The plaster was also peeled off and needs to be repaired with few measures: Same material was used during repair and renovation. The building has been documented before intervention to maintain the record of previous condition of the building. The recorded data was saved for future studies. Any material which was not part of original structure has been

avoided. The peel of parts of the plaster has not been treated by the external materials. The plaster has been protected only with a layer of plaster to maintain the record of this intervention.

Structural and hair cracks

There was structural and hair cracks in the building due to the settlement caused by rain water and they are handled according to their nature. The solution has been found depending upon the nature of the damage. Minor cracks in the interior and exterior walls were rectified, minimizing the chances of loss of original material.

Dilapidated condition of the floor

The floors has been deteriorated and damaged and the holes can be seen at very few places of the floors. The absorption of rain water through foundation, causing minimum loss from the interior which was repaired. Major portion of the floor was fine and need only cleaning and minor repair.



Figure 5-20: Image showing damage floors

Source: WCLA, 2019

Significance and State of Conservation

The Barood Khana was the structure which was constructed for a specific function and is a rare existing example of its own. Now it is part of the historic environment. It symbolizes the geometry and proportion and unparalleled use of space in terms of security and temperature control inside the structure. It is beautiful blend of historic, cultural and architectural identity.

In the conservation plan, prepared by the UNESCO team during 2006-2011, the structure was not entertained due to the lack of monumental impacts and was left undiscussed. The administration of the WCLA took the notice and decided to restore the structure with a plan for adaptive reuse. In this regard, all the steps were taken, including digital documentation.

Architectural drawings were prepared showing the damages to the structure and it was restored according to the conservation plan.

The current role of the Barood Khana is a place for meetings of the officials, tourists and delegation. At times of need, the sitting arrangements can also be done in the surrounding landscaped area of the monument.



Figure 5-21: Image working environment with Total Station

Source: WCLA, 2019

Development of a Scaled Wire-Frame Model

Barood Khana, located in the historic core of Lahore, Pakistan, is a symbol of dignity, giving tribute to the British rule, being part of historic context. This case study focuses on the development of a scaled wire-frame model of Barood Khana, employing advanced digital modeling techniques and historical research to create an accurate representation of this significant monument. The total station is a surveying tool for the measurement of distances and angles with the help of software Theo LT, installed in Laptop attached with Total station through cables.

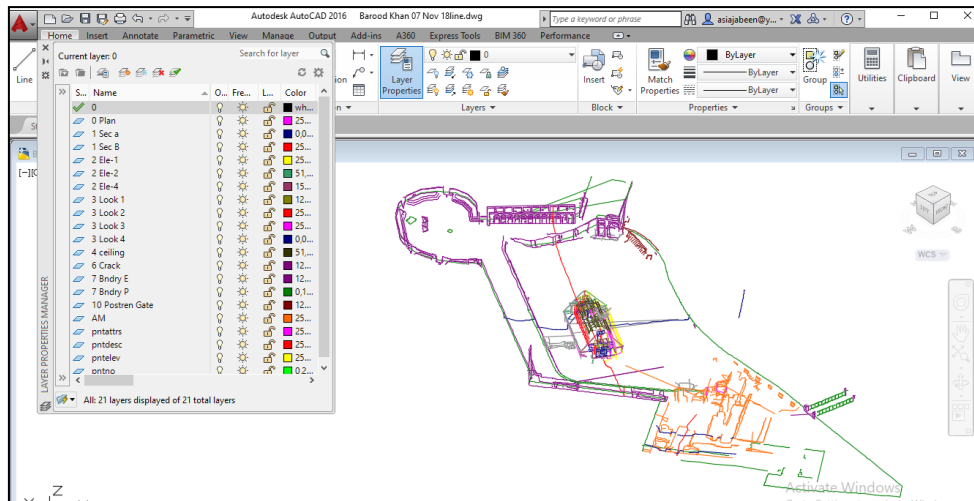


Figure 5-22: Barood Khana with its Context, the work is in the Form of Layers

Source: WCLA, 2019

There are total 21 layers, assigned different properties for various architectural and structural elements. The outcome of the whole is the digital documentation of Barood Khana using total station as a surveying tool. The 3D model is in the form of scaled wire-frame model. The layer assigned to plan and perspective with the identification of cracks in structure has been shown in the figure below. Although the methodology has been implemented decades back but continued till the introduction of terrestrial Laser scanner, accommodating the ornamentation of the heritage sites.

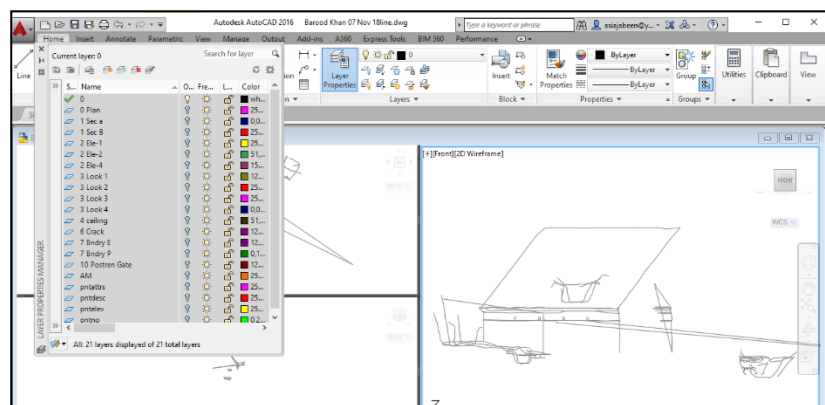


Figure 5-23: Image showing layer of roof structure

Source: WCLA, 2019 (modified by authors)

The images of the floor plan and perspective is showing various layers in terms of ceiling of vault structure and cracks, differentiated with various colors.

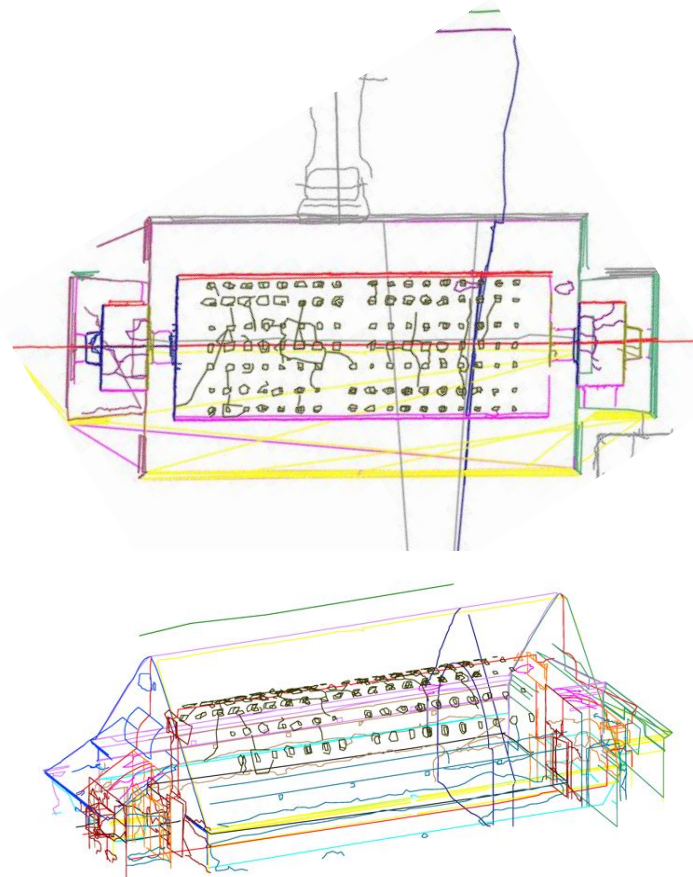


Figure 5-24: Image showing layer of floor plan and 3D model

Source: WCLA, 2019 (modified by authors)

Through this Scaled wire-frame model, accurate measurement can be drawn in terms of damages.

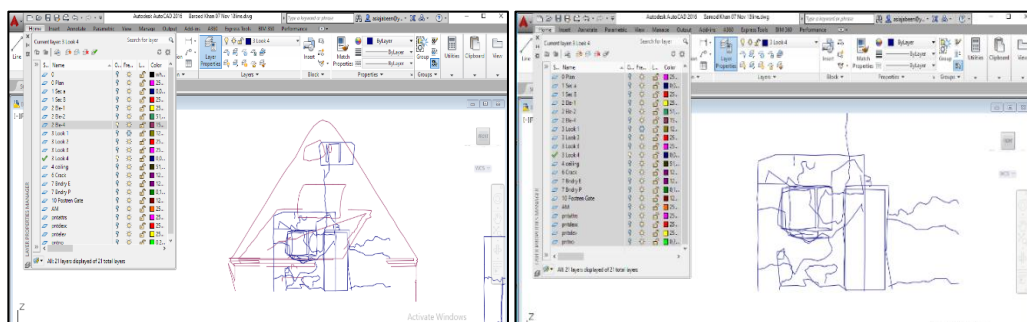


Figure 5-25: Image showing damage in north and south elevations

Source: WCLA, 2019 (modified by authors)

The development of a scaled wire-frame model of Barood Khana represents a significant contribution to the documentation and preservation of Lahore's cultural heritage. This case study demonstrates the effectiveness of combining historical research with digital modeling techniques to create accurate representations of significant monuments. The wire-frame model serves as a valuable tool for understanding, preserving, and promoting awareness of Lahore's architectural legacy for future generations.

Recommendations

The Lahore Fort came under the umbrella of Walled City Lahore Authority (WCLA) in 20023 (Naqvi, 2023). Barood Khana was built by the British. The Lahore Fort describes complete history from Mughal era to British era. Barood Khana shows the presence of British in sub-continent. However, this building was ignored for conservation works and was kept hide or importance of the building was not explored to the tourists visiting Lahore Fort. Building possess historic importance and therefore it is imperative to conserve this building and explore for the local as well as foreign tourists.

Conservationists from all parts of the world are doing their best to preserve the cultural heritage of the ancient civilizations. Same work was also applied in Pakistan to preserve our cultural heritage(Din, 2018). There are many monuments in Pakistan especially in Lahore built by the Mughals; Lahore fort, Shalimar Garden, Begum Shahi Masjid, Badshahi Mosque, Masjid Wazir Khan, Shahi Hamam, Sunehri Gold Masjid, 13 Gates, Temple etc. are the important monuments in Lahore. Many historic residential buildings are also present within Walled City of Lahore which reflects the complete history from Mughals time to British. British have also built couple of building in Lahore and in royal fort built the one of marvelous building which is known as Barood Khana and after partition as well.

It was decided to protect Barood Khana as a symbol of dignity and attention was paid for its preservation. Conservation of façade, floor, roof, window, door and other part of the Barood Khana need to be done so that the historic buildings may be retained in its original condition by using same material used in ancient time. After the completion of conservation works at Barood Khana, it will attract more tourists at Lahore Fort. The manpower to be used in such historically important monument should be experienced like ustads, craftman etc. wherever needed.

5.8.2. Digital Conservation by using Total Station and 3D Laser Scanner - Sheesh Mahal Lahore

This case study emphasizes the significance of preserving historic monuments, emphasizing their role as tangible records of human history. It highlights the necessity of conserving such heritage assets for the sustainable development of historic cities, with a particular focus on the documentation process. The case study revolves around Sheesh Mahal in Lahore, chosen for its historical importance and the application of digital tools like Total Station and Terrestrial Laser Scanner (TLS) in its preservation efforts. By evaluating the strengths and weaknesses of both documentation techniques, the Research aims to deepen our understanding of the intricate spatial dynamics within heritage sites. Sheesh Mahal, situated within the Shah Burj of Lahore Fort and commissioned by Mughal Emperor Shah Jahan in 1631-32 A.D., holds a prominent position among the 21 significant monuments constructed by the Mughal rulers within Lahore Fort. Its recognition by the Indian Department of Archaeology in 1927, subsequent protection under the Antiquities Act by the Federal Department of Archaeology, Pakistan in 1975, and in 1981, it was declared as UNESCO World Heritage site underline its cultural and historical importance. The digital documentation of Sheesh Mahal, conducted by the Aga Khan Cultural Services of Pakistan (AKCSP) in 2017 using Total Station and by the Walled City Lahore Authority (WCLA) in 2022 using Terrestrial Laser Scanning, exemplifies the application of modern technologies in heritage preservation. In conclusion, the research provides an analysis of the precision and accuracy of digital documentation techniques, shedding light on their efficacy in capturing and preserving the intricate details of historic monuments. This evaluation contributed to documenting the historic monuments, ensuring that it will be a learning source for academicians and future generations.

Introduction

The heritage of societies serves as an index, reflecting their past stories. Physical heritage reflects the living patterns of past nations, while intangible heritage showcases their norms and rituals. Globally, the importance of built heritage has been widely acknowledged, and a consensus has been established regarding its conservation. (Trillo, et al., 2020a). The conservation process includes archival research, data collection, site surveys, documentation, evaluation of the causes of decay, preparation of a conservation plan, management, and monitoring of the heritage sites (LAH, 2018). The concept of conservation has been transformed from individual buildings to historic areas, and its extended framework, new

methods, and strategies need a holistic approach to maintain a balance between conservation and urban developments in historic cities (Haddad, 2011).

The documentation of the historic monuments is a significant stage in the process of conservation, and it includes measured data in terms of architectural drawings, color, texture, and three-dimensional models. The degree of precision and level of accuracy of documentation decides the quality of conservation works, saving human and financial resources (Rafiq, 2010). The digital documentation of the historic monuments helps to develop a comprehensive conservation plan for the preservation of heritage sites, and it has changed the conservation methodologies and practices. (Džikić & Radin, 2019).

Conventional methods based on manual surveying and mapping using measuring tapes and hand-drawn drawings provide accurate measurements due to direct access to the architectural elements. Virtual methods based on digital surveying utilizing total stations and 3D laser scanners provide accurate measurements due to direct access to the architectural elements. Provides more accurate and precise data, assessing damage over time (Bastem & Cekmis, 2022).

Sheesh Mahal (Mirror Palace) is situated within Lahore Fort, and it has been selected as a case study due to its intricate architectural details. Mughal Emperor Shah Jahan built this palace for his beloved wife with rich ornamentation. When Maharaja Ranjit Singh occupied Punjab, he declared Sheesh Mahal his residence and constructed another floor on top of it for his Queen Jindan. The selected site has tangible as well as intangible heritage, as it is associated with the feelings and memories of the Mughal emperors and their family members (Din, 2018). The site has been converted into a tourist attraction and desperately needs to be protected against human vandalism. The application of digital technologies for preparing virtual tours and panoramic views can enhance the tourist value of the site.

Research Aim and Objectives

The research focuses on the documentation techniques for historic monuments to record accurate and precise data. The monument is known due to its intricate details of mirror work on the walls and ceilings of the main hall (used as an entrance lobby), and there are sleeping rooms adjacent to the main hall. The small pieces of mirrors were fixed in plaster, reflecting an image of stars. The Pietra dura, fresco paintings, and gilt work are a testament to mastery in a unique style, and are rarely found in other monuments of the Mughal period (Koch, 2008).

The monument was destroyed various times due to human vandalism during the Sikh and British times, as it was misused. The monument was conserved during the later British period, with a focus on protecting it from further decay. (AKDN, 2015). The long-term protection is made possible through the integration of digital technologies. In the case of digital documentation, there is minimal direct contact with the surface, letting work be done through laser beams. The product is presented in the form of accurate digital data, which can be shared among all stakeholders. However, budget management at the initial stage is a constraint, but it has long-term benefits. (Woodward & Heesom, 2019).

The selected case study, Sheesh Mahal, was digitally documented utilizing a Total Station and a Terrestrial Laser Scanner to develop a wire-frame and a 3D model, respectively, exploring the potential and limitations of both the digital tools (Gomes, 2023).

Literature Review - Sheesh Mahal

The Lahore Fort, a royal residence, was declared a protected monument under the Ancient Monument Preservation Act 1904, with notification 2425 dated January 27, 1920. Due to its location within the boundaries of the Lahore Fort, Sheesh Mahal is also declared a UNESCO World Heritage Site. The Federal Department of Archaeology, Pakistan, added Lahore Fort to the List of Protected Monuments according to the Antiquities Act 1975 (DOAM, 2024). The Lahore Fort and Shalimar Gardens, located in Lahore, were declared UNESCO World Heritage sites as a single entity in 1981. They were subsequently added to the list of monuments in danger in 2000. UNESCO, in collaboration with local government authorities, prepared a Master Plan for the Conservation of the Lahore Fort and Shalimar Gardens, spanning from 2006 to 2011 (UNESCO, 2011).

Historical Background & Cultural Significance

The Mughal Emperor Shah Jahan constructed the monument Sheesh Mahal for his favorite wife, Mumtaz Mahal, in 1631 -1632 AD. The princess stayed in Sheesh Mahal during her visit to Lahore, but could not live in her dream palace, as she died at a young age. The palace is the most beautiful monument and a masterpiece of architecture in the Lahore Fort (Hankey, 1999). After occupying Punjab, Ranjit Singh selected this Palace as his residence (Naeem, 2010) and the dream palace of Mughal Princess Mumtaz Mahal became the residence of Ranjit Singh and his family. Ranjit Singh added a Harem (female residence) for his Queen, Rani Jindan, on top of Sheesh Mahal. It reflects not only Mughal grandeur but also showcases the opulence of the Sikh rule (Tufail, 1962). The palace consists of Bedrooms, a central

entrance hall to bedrooms, Shahi Hammam, Naulakha Pavilion, and a courtyard with a central fountain. The palace has been decorated with extensive mirror work, semi-precious stones, gilt work, Pietra dura, and fresco paintings.

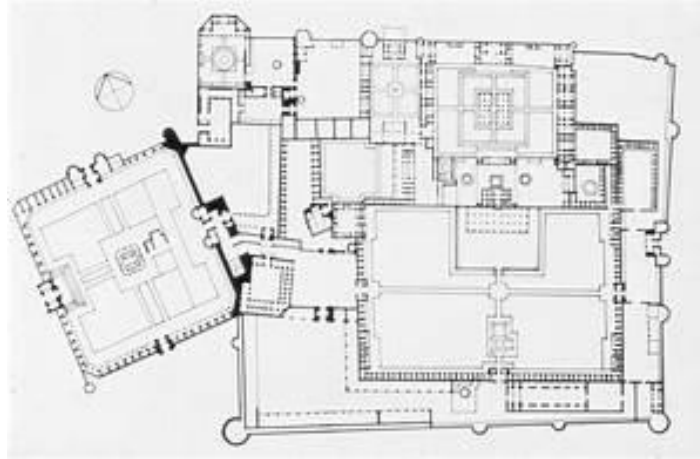


Figure 5-26: Plan of Lahore Fort
Source: Google image, 2017

Legislation for Conservation

After partition, the process of conservation was left behind, and the settlement of the migrants was the priority. It was the sole responsibility of the Government of Pakistan through the Department of Archaeology to protect national monuments. The Antiquities Act 1975 was enacted in 1975 and amended in 1990 (Qadeer, 1996). The responsibility was shared among provinces after the constitution of provincial acts and ordinances. The walled city of Lahore came under the umbrella of the Department of Archaeology, Punjab, according to the Punjab Special Premises (Preservation) Ordinance 1985 (Khan et al., 2022). The Directorate General of Archaeology, Punjab was established in 1987.

The Punjab Heritage Foundation Act was constituted in 2005 for the protection of Historic monuments. The Walled City Lahore Authority was established in 2012 and authority took the charge of Lahore Fort in 2023 (Naqvi, 2023).

Architectural Significance

The historic monument was built by the Mughal Emperor Shah Jahan, as double story structure for his beloved wife, Mumtaz Mahal. There is a summer palace in the basement for the stay of royal family members during the hot days of summer. The main hall is double height ceiling structure with door and window openings of the sleeping chambers. The structure was constructed with white marble which is a characteristic architectural element of the buildings

built by Emperor Shah Jahan. The palace was ornamented with colorful glasswork, extensive mirror work and delicate fresco paintings. The most significant decorative element of Sheesh Mahal is its mirror work, which was done on the ceilings and walls of the bedrooms and main hall. The intricate geometrical patterns have been developed by the number of small pieces of mirrors, embedded into the plaster (Kamran, 2017).

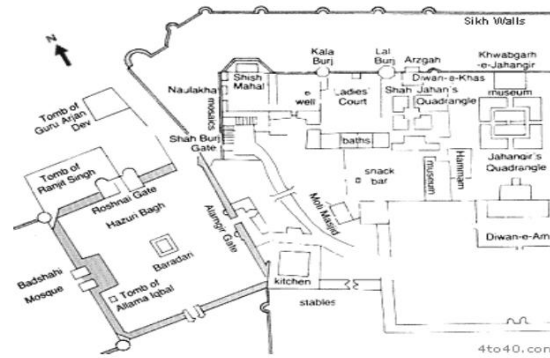


Figure 5-27: Plan of Lahore Fort showing Shah Burj

Source: Kamran, 2017)

Another feature of the Sheesh Mahal is its fresco paintings elaborating scenes from the natural royal life. The art work is matchless in terms of craftsmanship of the artists.

Function of Sheesh Mahal in different periods of time

The Sheesh Mahal was constructed by Emperor Shah Jahan for his beloved wife. However, she died in 1631 A.D. at Burhanpur, Deccan (present-day Madhya Pradesh), and she was unable to revisit the palace that had been built for her residence. The Mughal emperor Shah Jahan transformed Lahore Fort into a pleasure place and added remarkable structures to it, especially in Shah Burj (Chaudhry, 1998).

Maharaja Ranjit Singh established his Harem on top of Sheesh Mahal, pushing the monument to the brink due to the additional construction of rooms on the first floor. After that, the roof was cracked due to additional loads and these rooms had to be removed in the year 1905-1906 during the British period, (DOAM, 2024). Ranjit Singh constructed his court, termed as Athdara, at the place of the main entrance to Sheesh Mahal, and also added Kangra-style fresco paintings to the Sheesh Mahal (Vandal & Vandal, 2006).



Figure 5-28: Elevation of Sheesh Mahal, showing Sikh period Additions

Source: Kamran, 2017

During the British Period, the fort was used by the military and closed to the General Public. It was handed over to the Department of Archaeology, India, in 1927. The summer palace of Sheesh Mahal was used as a store during the British period. After gaining independence, it was placed under the umbrella of the Federal Department of Archaeology, Pakistan. Currently, it functions as a tourist site and has been maintained by the Walled City Lahore Authority (WCLA) since 2023.

History of Preservation of Sheesh Mahal

Pre-partition conservation (1905-1906)

The Sheesh Mahal, located within the Lahore Fort, underwent repairs and conservation at various times. The most significant and intricate details pertain to the mirror work and the ceiling details of the main hall (Kamran, 2017). Sheesh Mahal damaged the wooden ceiling of the Main Hall and sleeping rooms due to the construction of a floor on top of it, and it lost its aesthetic value due to the robbery of precious stones and metals during the Sikh and British period (Mumtaz, 1985b).

According to the 1905 archaeological survey of India, published in 1908, the false ceiling of the Sheesh Mahal was structurally damaged due to the load of the floor added to its top. The condition of the ceiling became worse due to the cracks, and the structure was threatened with collapse if not conserved. The ceiling of the main hall was protected by adding a protective layer of metal and mirror work was also tried to be saved (India, 1908).

Ceiling of Main Hall

The wooden ceiling of the monument was preserved and covered with a concrete layer that also increased the dead load on the false ceiling. When the conservation work began, the exposed surfaces appeared more damaged than they were assessed during the survey. On starting the operation for the protection of the damaged false ceiling, a few facts were observed: two wooden beams were rotten at an advanced stage, and they had to be replaced. The concrete above the wooden beams were carefully removed and rotten beams were supported by iron and it has to be supported from underneath. It was the first repair for strengthening the false ceiling of main hall, done by the Department of Archaeology of India in 1905-1906 (India, 1908).

Mirror Work

Mirror work of the palace is unique of its kind. There are chances to damage the mirror work on the false ceiling, but it was saved carefully. There was a difference in quality between the mirrorwork on the ceiling and the walls.

Post Partition (1947 – 2024) - Conservation in 1973

After partition, the Department of Archaeology prepared its first conservation plan for the protection of the Sheesh Mahal in 1973, and it was added to the list of protected monuments in 1975. The project continued for 10 years until 1985 but was not completed. Only 25 % of the estimated work, including the repair of the floors, could be completed (UNESCO, 2011).

Conservation in 1991-1992

The Federal Ministry constituted a committee to develop a conservation plan for the protection of the monument in 1991, as it was deteriorating and decaying badly, with serious cracks in the ceiling of the Main Hall (Kamran et al., 2016).

Conservation in 2003-2005

Sir Barnard Fielden visited the site (India) in 2000 and recommended the conservation of the ceiling of the Sheesh Mahal, which was already conserved in 1905-1906. On his recommendation, UNESCO proposed the conservation of the Sheesh Mahal, which was done in 2003-2005 (UNESCO, 2011).

Conservation in 2008

The proposed conservation plan in 1985 focused on cleaning the mirror work, maintaining the authenticity, and originality of the ornamentation. (Iftikhar, 2019). The northern chambers were also restored at that time (Ijaz & Sharif, 2011)

Research Methodology

The mixed-method approach, based on qualitative and quantitative techniques were employed to fulfill the primary objectives of the research. Archival data has been collected from secondary sources, and digital data was collected from the Walled City Lahore Authority. Conventional and virtual methodologies were used for the conservation of built heritage in the historic core of Lahore. Visual and Pictorial surveys have been conducted to document the current status of the monument and record previous interventions. The monument was documented using a Total Station in 2017 by the technical experts of the Aga Khan Cultural Services of Pakistan (AKCSP) and with a Terrestrial Laser Scanner in 2023 by the technical experts of the Walled City Lahore Authority.

The scanned data has been processed to develop three-dimensional models and automatically generated orthographic drawings. An analysis has been conducted to determine the application of digital tools for specific monuments, guiding future conservation efforts.

Location & Context

The iconic structure, Sheesh Mahal, a royal residence, is situated in the fortified walls of Lahore Fort, also known as Shahi Qila (Tufail, 1962) and it is in the list of twenty-one monuments located in the Lahore Fort that have witnessed the rise and fall of numerous dynasties. The foundation stone was laid by Mahmood Ghazni in the 11th century, and it has been extended and reconstructed by subsequent rulers. Currently, it comprehends significant structures, including palaces, mosques, gardens, pavilions, and administrative buildings. The reconstruction of various buildings, renovation, and conservation works for the protection of historic monuments were done by the Mughal, Sikh, and British rulers (Vandal & Vandal, 2006).

The immediate context of Sheesh Mahal comprises a historic environment in the north, a circular road in Lahore (which is now part of the new project, Greater Iqbal Park), and on the south, there is the historic city of Lahore. On the east, there is Kashmiri Gate and the area of Badami Bagh, Lahore. On the west, the Badshahi Mosque is located, showcasing the glory and magnificence of its time.

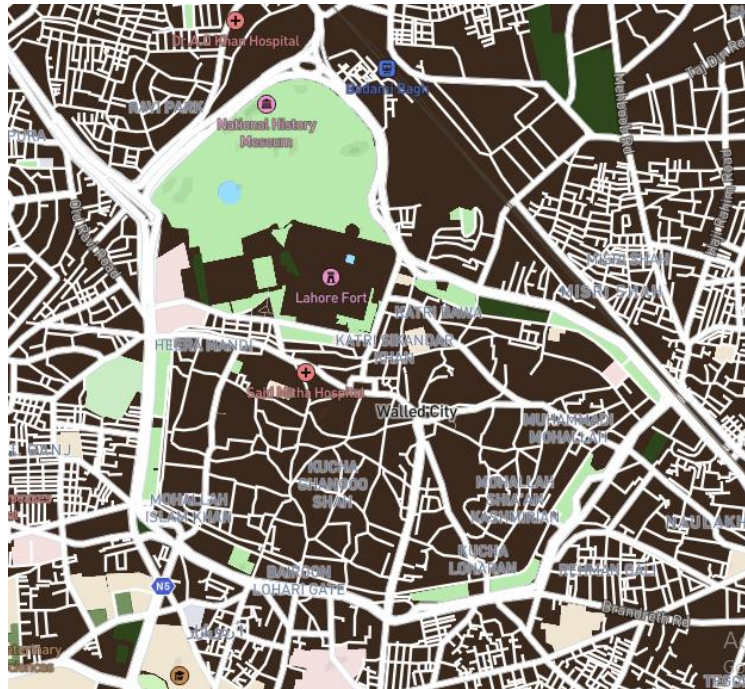


Figure 5-29: Location Plan of Lahore Fort

Source: Mapbox modified by the author, 2023

The Sheesh Mahal is located at Shah Burj, in the north-western corner of the Lahore Fort. The whole complex is comprised of Picture Wall, Shah Burj Gate, Hathi Paer, Sheesh Mahal, Noulakha Pavillion, Sheesh Mahal Courtyard, Shahi Hammam. All these structures are on the ground floor and there is a summer palace in the basement of the Sheesh Mahal. The corner functioned as Royal residence and is unique due to its construction style, materials of decoration. Sheesh Mahal is located in the south-east corner of the Shah Burj (Mumtaz, 1985b).

Digital Conservation in 2017-2021- Electronic Distance Measuring (EDM) Technique

Total station provides exceedingly precise digital three-dimensional data for topographical mapping, and it is a pioneer in 3D modeling. The key feature of the total station is its Electronic Distance Meter (EDM), a laser rangefinder that measures distances up to several hundred meters with excellent precision. (Hassani et al., 2015). The total station has a built-in theodolite to measure distances, directions, and angles, providing wireframe 3D models. The angle measurement accuracy of the total station is one arc second, and the distance measurement accuracy is up to 0.5 mm (Bullock & Richard, 1998).

Development of Scaled Wireframe Model through EDM Survey

In 2005, the Aga Khan Cultural Services of Pakistan (AKCSP) initiated the digital conservation utilizing a Total Station with TheoLT and AutoCAD for the development of wireframe 3D models and orthographic drawings in KPK, marking a shift from conventional to digital methods. (Sulman, 2009). The Sheesh Mahal was also documented by AKCSP using Leica TCR 805 ultra on the field laptop with Auto CAD and TheoLT as plugins (Total Stations) in 2017 (Arif & Essa, 2017a).

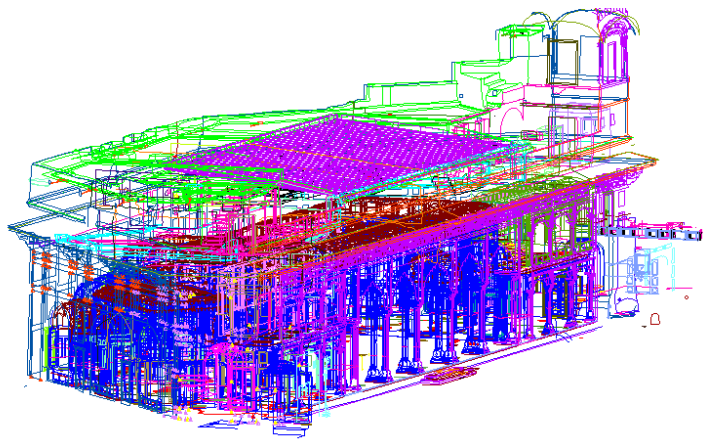


Figure 5-30: Three dimensional Wire-Frame Model with Total Station (EDM) of Sheesh Mahal

Source: WCLA, 2017 (edited by the Author,2023)

The three-dimensional model developed by the application of Total Station is in the form of polylines, and this model is constituted by the layers (a Total of 435 in number) for the documentation of the Main Hall and its adjacent Sleeping Chambers. Five Total Stations are used to complete the task.

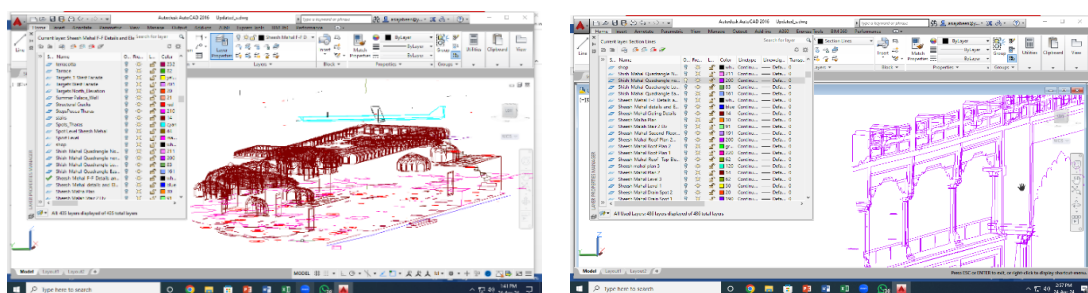


Figure 5-31: Images of the Roof Plan (Left) & Façade of Main Hall (Right) with layer properties

Source: WCLA, 2017 (edited by the Author,2023)

At that stage, more accurate and modern technology was available, in the form of Total Station which requires large number of experts. It also requires long hours, therefore, it is time consuming. The alignment of the objects to create a line is the skill of the site surveyor during the projected drawing of the building. The total station records data in the form of polyline, creating a wire-frame model, rather solid form. In AutoCAD, plans and elevations can be extracted through the control of layers.

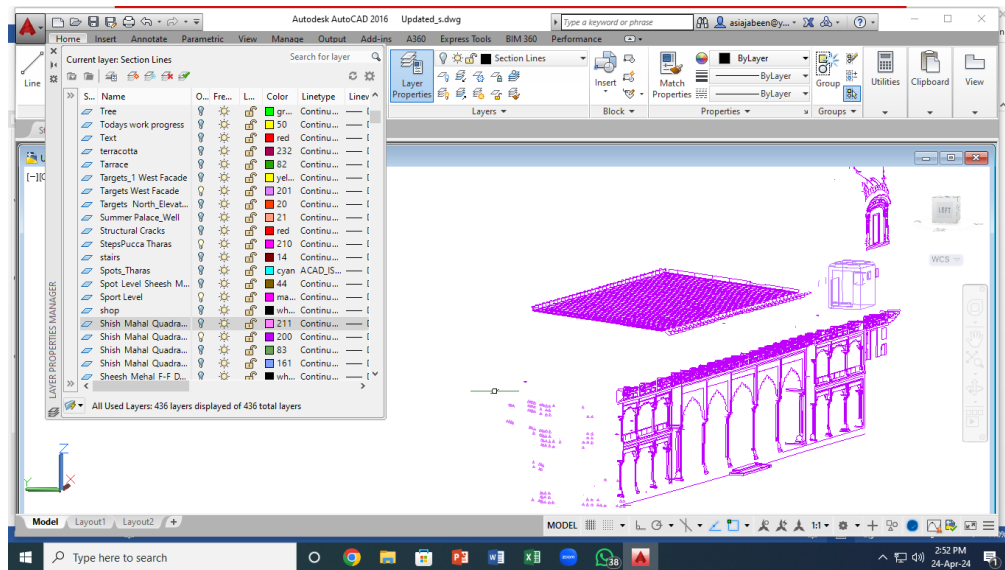


Figure 5-32: Entrance of the Main Hall and Roof Plan with layer properties, assigned different colors

Source: WCLA, 2017 (edited by the Author, 2023)

Digital Conservation-Terrestrial Laser Scanner (TLS) Technique

The Terrestrial Laser Scanner is a device used for field surveys of heritage sites, capable of capturing hundreds of thousands of points of point cloud data per second. It is also capable of acquiring large volumes of accurate multi-layer data. Conventional methods based on manual techniques, as well as virtual methods based on digital tools, provide accurate data, but the accuracy can never compete with the precision and speed of TLS, which is 9,76,000 points per second of Faro S70 (Dore & Murphy, 2015) as compared to a Total station, which is one arc per second (Sulman, 2009). Sheesh Mahal Lahore Fort was scanned with faro terrestrial Laser Scanner (a Faro Focus ^s - Owned by WCLA).



Figure 5-33: Faro Focus ^S (TLS) (Left) and Spheres (Targets) (Right)

Source: WCLA, 2022

A pre-scan survey has been conducted to collect data through visual and pictorial techniques, to plan the on-site digital survey. The location of the target points has been fixed according to the area angles. The target points are known as “spheres,” Artificial Common Reference Objects (targets). Forty-four target points were fixed to scan the interior and exterior surfaces. The target points were fixed according to the wavelength of the laser beams. Forty-four scans were conducted using TLS to capture the facades, interior, and exterior surfaces of Sheesh Mahal, including its ornamentation. Each scan spans a time cover of ten minutes.

Name	Date modified	Type	Size
Faro_scan_518	9/17/2022 8:05 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_519	9/17/2022 8:07 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_520	9/17/2022 8:10 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_521	9/17/2022 8:13 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_522	9/17/2022 8:16 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_523	9/17/2022 8:19 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_524	9/17/2022 8:21 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_525	9/17/2022 8:24 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_526	9/17/2022 8:27 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_527	9/17/2022 8:30 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_528	9/17/2022 8:33 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_529	9/17/2022 8:36 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_530	9/17/2022 8:39 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_531	9/17/2022 8:42 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_532	9/17/2022 8:45 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_533	9/17/2022 8:48 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_534	9/17/2022 8:51 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_535	9/17/2022 8:54 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_536	9/17/2022 8:57 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_537	9/17/2022 9:00 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_538	9/17/2022 9:03 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_539	9/17/2022 9:06 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_540	9/17/2022 9:09 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_541	9/17/2022 9:12 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_542	9/17/2022 9:15 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_543	9/17/2022 9:18 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_544	9/17/2022 9:21 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_545	9/17/2022 9:24 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_546	9/17/2022 9:27 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_547	9/17/2022 9:30 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_548	9/17/2022 9:33 PM	Autodesk RecCap S...	392,037 KB
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Faro_scan_556	9/17/2022 9:57 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_557	9/17/2022 10:00 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_558	9/17/2022 10:03 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_559	9/17/2022 10:06 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_560	9/17/2022 10:09 PM	Autodesk RecCap S...	392,037 KB
Faro_scan_561	9/17/2022 10:12 PM	Autodesk RecCap S...	392,037 KB

Figure 5-34: List of Scans from Scan 518 to Scan 538 (Left) and Scans from 539 to 561 (Right)

Source: WCLA, 2022 (edited by the author, 2023)

The scan data was registered in the Scan Manager of the software, Faro Scene 2019, and then all the scans were combined to create a single digital file of the entire monument. A 3D model of the scanned site can be achieved through Autodesk Recap 360. There is an option to erase unwanted data while combining the scans.

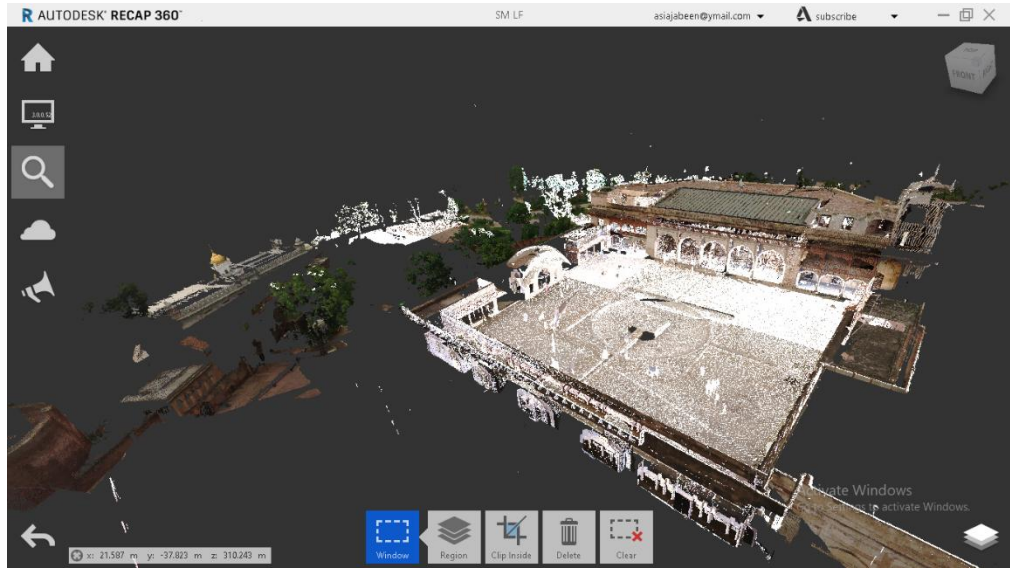


Figure 5-35: Three-Dimensional Model of Sheesh Mahal (Autodesk Recap 360)

Source: WCLA, 2022 (edited by the author, 2023)

The site has been scanned in forty-four scans, each of ten minutes duration, and almost ten minutes were required to set the targets for the following scan. There are two stages: one is on-site scanning and the second is Studio work, which starts with the registration of scans and proceeds to the preparation of 3D virtual models and panoramic views.

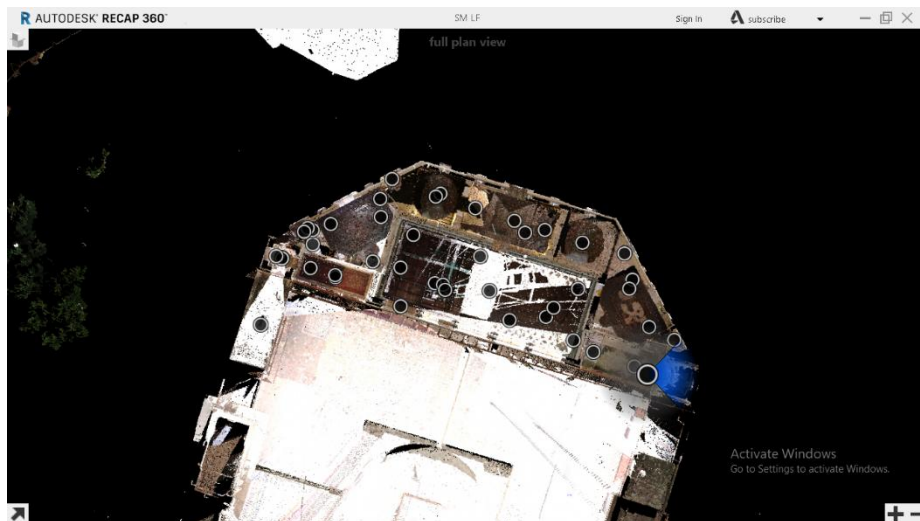


Figure 5-36: Plan of Sheesh Mahal showing target Points

Source: WCLA, 2022 (edited by the author, 2023)

All forty-four scans were combined through the Scan Manager of the “Faro Scene 2016” software. The file format is *.rcp, ready to open with the software “Autodesk Recap 360 Pro” and can be developed in HBIM models.

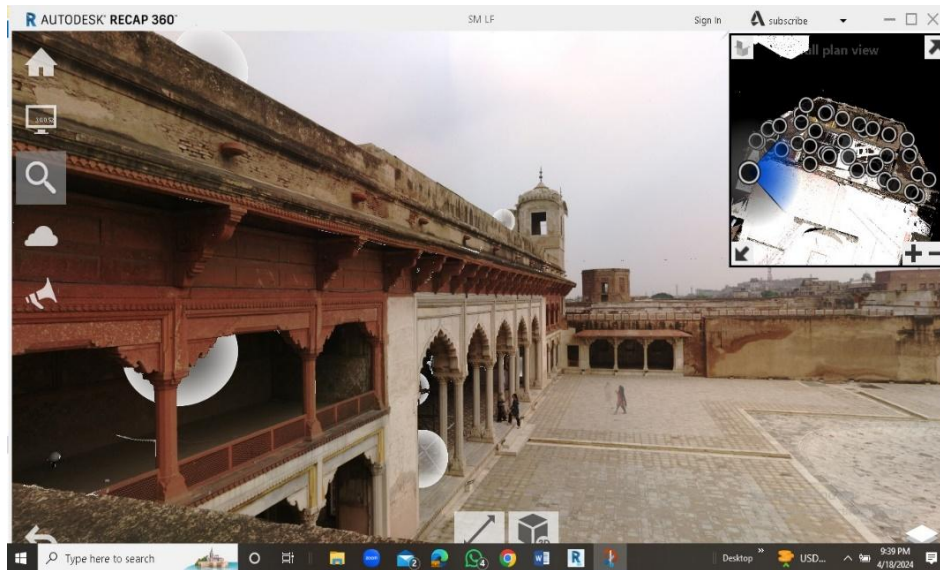


Figure 5-37: Details showing 3D Real Models in the *.rcp support files showing direction of targets

Source: WCLA, 2022 (edited by the author, 2023)

From Scan data to Building Information Modeling

Files edited in “Scenes” in *.rcp format have been transferred to “Autodesk Recap 360 Pro” to develop 3D models with multilayer information in RGB colors. In the upper right corner, the placement and orientation of targets can be traced to view the desired model with geometrical designs.



Figure 5-38: RGB 3D Model of Ornamentation in Autodesk Recap 360 Pro

Source: WCLA, 2022 (edited by the author, 2023)

Autodesk Recap can help to develop HBIM models to provide details, beyond the limits of conventional methods. Key feature is the use of “Field of View” to visualize the details of the HBIM model.

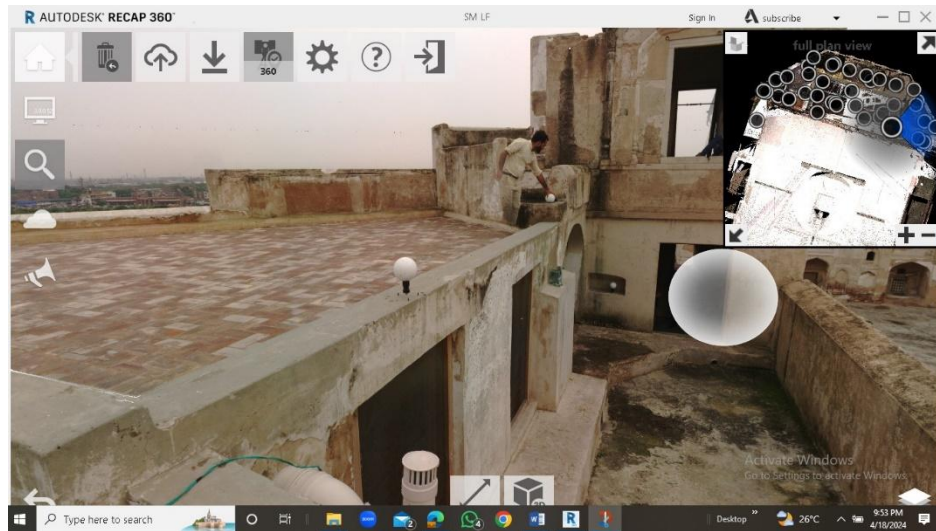


Figure 5-39: HBIM of Roof of Sheesh Mahal Lahore Fort

Source: WCLA, 2022 (edited by the author, 2023)

Measurements can also be taken from these HBIM model, saving time and energy. The manual drawings will consume number of days to develop measured plans but HBIM models can be developed saving time and money both. The highly technical details of the roof can be drawn in Autodesk to prepare orthographic drawings.

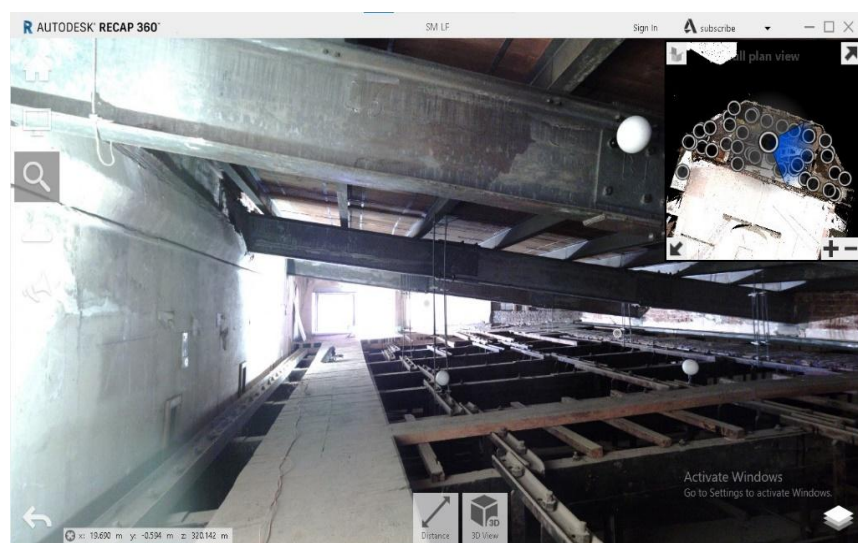


Figure 5-40: HBIM Model showing ceiling details after adding new roof structure

Source: WCLA, 2022 (edited by the author, 2023)

In depth details can be extracted from the HBIM model and can be measured and present condition of the deteriorated elements can be recorded, unmatched with any other conventional technique for the development of digital models.

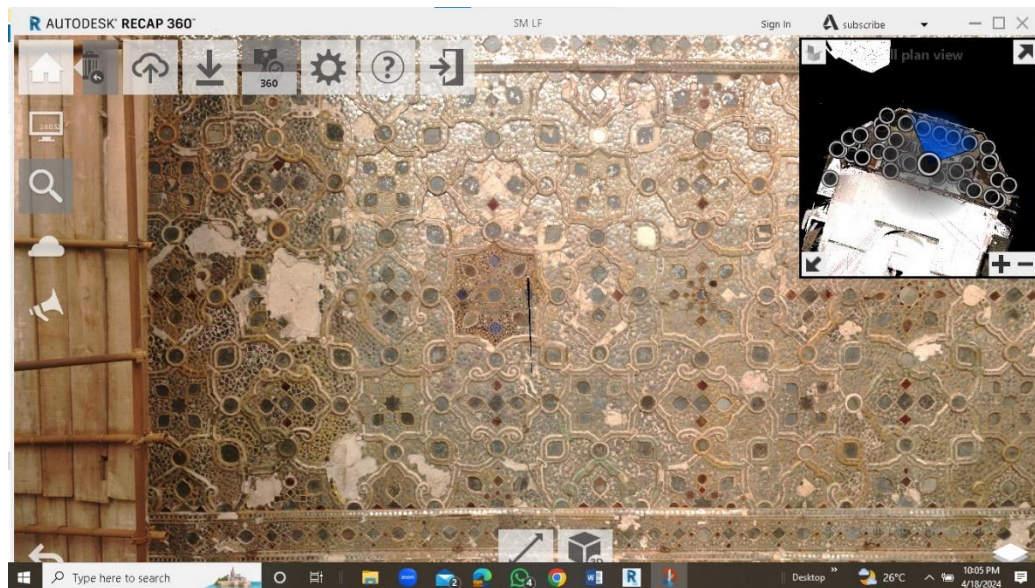


Figure 5-41: HBIM model with geometrical details of mirror work on the ceiling

Source: WCLA, 2022 (edited by the author, 2023)

Building heights is also measured through expression of colors. Autodesk Recap has the option to get the heights of buildings. This image is showing the heights at 288 -314 meters at focal length of 50mm. The software can also support to “crop” unwanted objects from the model.

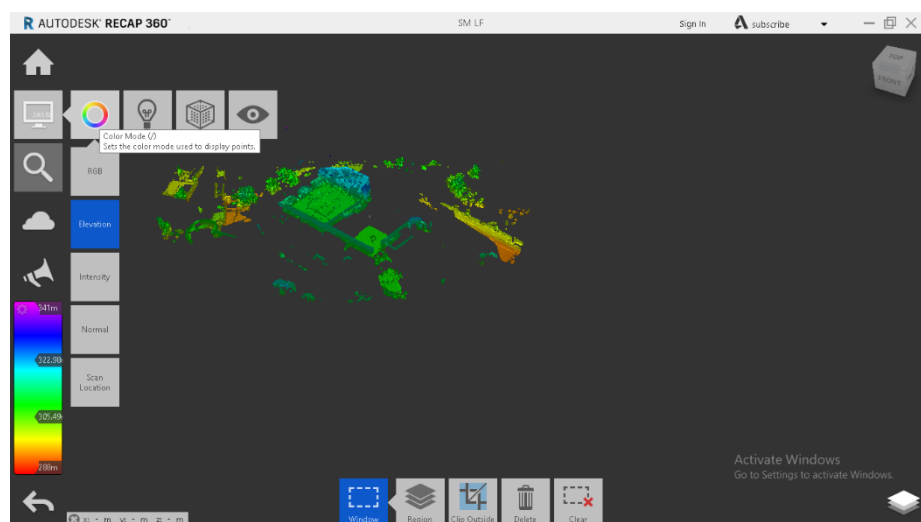


Figure 5-42: HBIM Model showing structure heights in colors

Source: WCLA, 2022 (edited by the author, 2023)

HBIM Models in AutoCAD

The files of Autodesk Recap can be transferred through a key feature” import point cloud” to AutoCAD & Revit to develop 3D models for the execution of the projects such as as-built drawings and digital documentation of heritage sites.

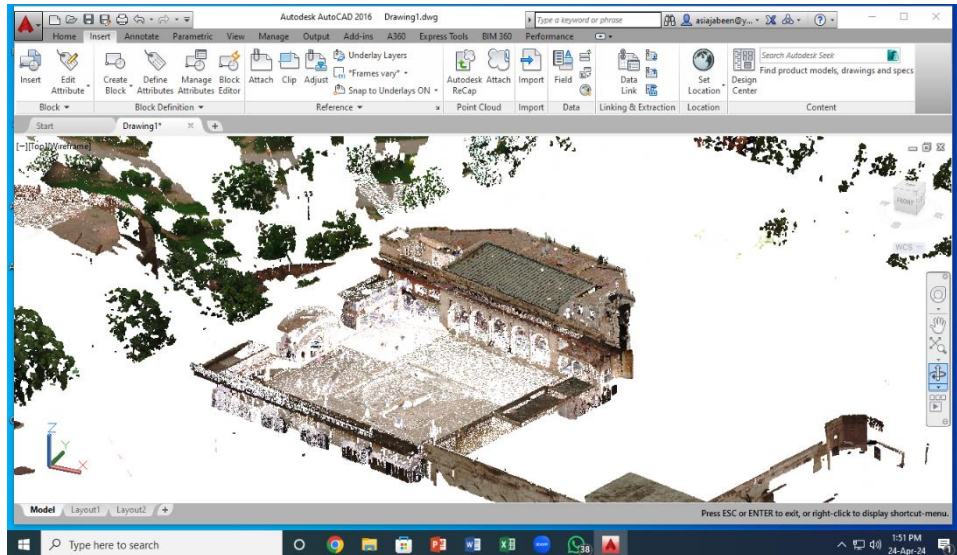


Figure 5-43: Point Cloud Model attached in Autodesk AutoCAD Suite.

Source: WCLA, 2022 (edited by the author, 2023)

Results and Discussions

Digital technologies have transformed the conservation industry by optimizing resource utilization in terms of precision, accuracy, time, and cost, shifting from conventional to virtual approaches. Conservation experts are exploring authentic methods to document built heritage using digital technologies. These digital technologies have enabled the preservation of intricate architectural details, assessment of damage, and monitoring of surface deterioration and structural damage. Scan data offers precise information in minimal time. For instance, capturing a courtyard, which could take weeks manually, now takes only three hours, reducing the likelihood of human error. Moreover, measuring the facades of multistory structures requires additional equipment; however, digital tools streamline this process.

While orthographic projections and intricate decorations like kashi kari, mosaic, and engravings are challenging to measure manually, high-resolution point cloud data enables their scanning and conversion into 3D CAD and Revit models. These measured drawings aid in project planning and execution on-site.

Furthermore, digital technologies facilitate the development of digital archives by conservation agencies. This research explores the integrated use of digital tools and software to convert scan data into AutoCAD files, highlighting the potential of Terrestrial Laser Scanning and HBIM approaches for preserving architectural and urban heritage in Pakistan.

5.8.3. Digital Conservation Practices - Jogi Mohallah, Walled City Lahore

The research focuses on documentation techniques for the conservation of Jogi Mohallah, a part of the Walled City of Lahore. The case study has been selected because it involves the application of digital tools across various phases of the documentation process. The selected site is about Bazaar-e-Hakeeman. The virtual and conventional methodologies for documentation have been evaluated for the multifaceted three-dimensional relationship between diversified features of the built heritage. The core objective of the research is to assess the authenticated methods to collect and manage multilayer information through HBIM models. The focus of the study is the application of HBIM workflows for the conservation of heritage sites and the evaluation of the potential of these technologies. The research involves the analysis of the three main stages of modeling with BIM that includes data acquisition, pre-processing of digital survey data, and 3D modeling with HBIM. In conclusion, analysis will be done to assess the authenticity and accuracy of the documented work based on the application of digital technologies.

Introduction

Despite the extensive application of Building Information Modeling in the construction industry for new buildings, less attention has been paid to investigating the importance of digital technologies for the protection of existing structures. However, an initiative has been taken to explore quantitative as well as qualitative values of the historic elements through HBIM models. HBIM is an emerging technology that has introduced reliable, digital three-dimensional models of intervening heritage sites, carrying multi-layer smart information to plan and manage projects for conservation, restoration, and rehabilitation. The HBIM with different methodologies has become a necessity of the cultural heritage sector due to its progress in qualities and capabilities. (López et al., 2018).

During the last few decades, Historic Building Information Modeling (HBIM) played a vital role to explore comprehensive knowledge of historic buildings, monuments, and archaeological sites concerning their original concept, historic context, the timeline of interventions, present condition, and causes of deterioration (Chee Wei *et al.*, 2010). The

innovative techniques and methodologies have introduced smart data and perceptions in the field of historic preservation due to their advantages as they are innovative, user-friendly, simplified, and challenging for academicians and researchers. These innovative techniques are being applied for surveying, documenting, mapping, and multi-scale viewing of heritage sites (Caroti et al., 2021).

Selected case study “Choara Khoo, Jogi Mohallah” is located in the Walled City Lahore and it is one of the communal spaces, surveyed and documented by the Aga Khan Cultural Services of Pakistan (AKCSP) under the umbrella of Walled City Lahore Authority (WCLA) by using hybrid methodologies, both manually and digitally (Total Station & 3D Faro Terrestrial Laser Scanner) from May-December 2016 Site comprises of a group of buildings categorized on account of architectural and historical values (WCLA, 2016).

Emperor Akbar divided Lahore into 36 districts and nine of them are within the Walled City of Lahore. The districts within the old city have been named after the name of their administrators and professionals termed as Guzars (WCLA, 2009). The Selected site is located in Guzar Talwara (One of the nine forgotten Guzars). Jogi Mohallah is accessible from Bhatti gate and Taxali gate through Bazaar-e-Hakeema and Bazaar Samian. Bhatti Gate was famous due to literary and cultural activities and was titled as “Lahore Ka Chelsea ” by Hakeem Ahmad Shuja because of the similarities with an area of London "Chelsea". It is also famous for its connectivity being the oldest gate of the Walled City linking the southern area to the Royal fort through Bazaar-e-Hakeema (Shuja, 1988).



Figure 5-44: Map showing Boundaries of Choara Khoo, Jogi Mohallah inside Bhatti Gate

Source: Google Maps (edited by authors, 2023)

After the development of new sensors, data capture techniques, and multi-resolution three-dimensional tools, a lot has changed in the research area for heritage protection and it has also been well recognized globally with all limitations and potentialities (Remondino, 2011). Many of our historic monuments and archaeological sites are in dilapidated condition and couldn't be saved due to the poor methods of surveying and documenting. Rapid and reliable methods are the need of the hour for planning, management, and monitoring of heritage assets (Arif & Essa, 2017).

The Walled City of Lahore comprises historical buildings, monuments, and significant archaeological sites. It contains both types of cultural heritage (tangible and intangible) and they are decaying due to various constraints, one of which is related to the application of digital technologies during the conservation procedures and practices in the current environment. There is a necessity to evaluate workflows and potential of the Historic Building Information Modeling with an integrated approach for Data acquisition, Pre-processing of digital Survey Data, and 3D modeling with HBIM for the sustainable development of historic cities.

Literature Review

Globally, it has been accepted as a universal truth that our heritage is a record of human activities of the past, and it has to be protected for future generations. Technology is playing a key role in promoting the conservation, restoration, and preservation of built heritage. It has been realized that we are facing various issues in terms of consumption of our energy resources and we must adopt measures for saving our energy resources. The construction industry is consuming a high ratio of energy consumption, and we can save these resources by protecting and reusing the existing structure through adaptive reuse, enabling them for future needs, rather than building new structures. Following the concept of adaptive reuse of existing buildings, the concept of conservation has been transformed into the Rehabilitation and Redevelopment of heritage sites and historic cities. Considering the need of the hour, conservation techniques, procedures, and practices should be integrated for accurate and authentic workflows. The application of digital methodologies has supported the "Conservation Sector" to achieve reliable and accessible data to develop conservation plans (LAH, 2018).

Pakistan is blessed with a wealth of historic assets and comprises various categories of historic buildings, groups of buildings, and urban areas. Walled cities of Pakistan, possess remarkable historic, cultural and architectural value. These cities can be a source of economic growth by upgrading their "Tourist value". Walled City Lahore is famous for its gates, bazaars,

winding streets, Chowks / Urban squares, galies, Mohallahs, Koochas. There are buildings of various categories such as Havelies, mosques, temples, Gurdawars, residential houses, etc. WCL has a specific urban hierarchy and it is one the best examples of pre-colonial urbanism in the Northwestern part of the sub-continent. (Hindi, 1882). Due to its architectural and historic values, it should be protected saving its cultural assets and after conservation, its tourist value will also increase.

Heritage comprehends historical records and showcases the index of society and the historic elements are learning sources of the present, for future generations. Cultural heritage is in the process of continuous decay due to various agents of nature and human neglect (Bruno and Roncella, 2019). Nothing is eternal and every object on the surface of the earth has to be diminished, however, their life can be extended and they can be protected for a longer span with the help of authentic conservation techniques, procedures, and practices. Historic Building Information Modeling is an integrated approach toward more reliable conservation methods and procedures for the sustainable development of historic cities (Escarcena *et al.*, 2011).

Historic Building Information Modeling as an integrated approach

There are noteworthy inadequacies in the planning of projects for the conservation and rehabilitation of built heritage. These inadequacies led to compromises in the legitimacy, authenticity, and accuracy of work done, with the increase in budget and long time span. While using traditional methods, various disciplines such as conservation experts, architects, civil engineers, etc. work separately and produce dispersed data. There is an increasing trend to adopt new methodologies to reduce these inefficiencies (Jordan-Palomar *et al.*, 2018).

In Pakistan, the progress started with the use of a total station with Archi CAD software to document heritage in three dimensions rather than producing two dimension manual drawings. This technique provided the opportunity to visualize architectural heritage in three-dimension but it has its own constraints and was not proven successful to document facades with rich architectural and decorative details. In 2016, a new phase came when Dr. Murtaza documented six sites in the four provinces of Pakistan with a 3D terrestrial laser scanner (Leica). The scanned data provided smart information and a hybrid technique started to apply for the surveying, scanning, mapping, and 3D viewing of sites in the Walled City of Lahore by AKCSP with the team members of WCLA since 2016.

HBIM is the most suitable tool for the restoration and refurbishment of large-scale historic sites due to its capabilities of archieving and managing all the information about the

cultural asset, reference data on the 3D HBIM model, and its support for renovation and redevelopment. Planned conservation is considered as a workflow to manage cultural heritage and it can be done through accurate evaluation of potentials and limitations of HBIM with reference to possible risks/damages and weather conditions. Tracking all the interventions and damages can protect heritage property from the worst situations (Bruno and Roncella, 2019).

According to Murphy, the historic building information modeling is a system to generate two and three dimensional models, including the details of surfaces of the objects, construction methods and material specifications. Murphy and Dore also elaborated the working areas of HBIM:

The present condition of the art for the creation of geometry of Building Information Modeling.

- Standards of the documentation of heritage.
- Techniques of Data collection
- The concepts of three dimensional model
- As-Built drawings
- Technical Modeling

They described documentation of heritage which provides accurate information to empower precise conservation, management and monitoring for the existence of an artifact (Dore and Murphy, 2017).

Digital documentation of existing structures involves a hybrid approach to visualize survey data, computer-aided drawings, photographs, and data collected by the use of a 3D laser scanner. Now the concept of HBIM has been changed and it has been accepted as a technology to collect intelligent data and it also has been accepted BIM as a source to explore the complex relationships between tangible and intangible heritage (Fai *et al.*, 2011).

Choara Khoo Jogi Mohallah – Historical Background

When Mahmood Ghaznavi invaded, Lahore was divided into two parts, one is comprised of Guzar Talwara (area between Bhatti gate and Taxali gate) and Guzar Rara (Area near Delhi gate). Guzar Talwara has significant historical structures such as Unchi Mosque near Bhatti gate, Faqir Khana Museum, Haveli Wajid Ali Shah, Haveli Mian Afzal Javed, Naqsh, and Art Academy. Bhati Gate is linked with the Royal Fort through a long spine named Bazaar Hakeema. The other parallel roads are Samian Bazaar/Judge Street and androon-e-Taxali Road.

The area was famous as it was a hub of art and culture. It was inhabited by writers, poets, doctors, lawyers, and artists (Hindi, 1882).

The area on the premises of Bhati Gate was a favorite place of renowned personalities for the cultural activities and the area in the premises of Taxali Gate was captured by the people engaged in performing arts. Guzars (administrative zones) are Mohallahs and koochas named after administrators or professionals. Bazaar-e-Hakeema is one of the examples which is named after the name of Hakeem Abdullah Ansari who was an expert in medicine and he also constructed a mosque near Unchi Mosque. Jogi Mohallah is situated in the locality of Bazaar-e-Hakeema. Syed Faqiruddin, a member of a rich family, migrated to Lahore at the invitation of the emperor, gave a new cultural value to the area and now, their residence has been transferred into a museum, named after the family name, Fakir Khana Museum (Talbot and Tahir, 2017).

Jogi Mohallah is famous for the literary giants, Syed Muhammad Latif, writer of a number of valuable books on history and he also composed a book with the title “Lahore: Its History, Architectural Remains, and Antiquities. He was also the founder of a famous Magazine “Naqoosh” (Tufail, 1962). The other one belonging to this mohallah is Munshi Tahiruddin who was an intellectual and developed a medicine “Dil Roz” and another one was Mir Miran Bux, Barrister at law. The area was a residential place of renowned intellectual personalities who inhabited this area in the 19th & early 20th centuries (Shuja, 1988).

Conservation of Jogi Mohallah

Jogi Mohallah Walled City Lahore was famous for its cultural and literary values. This cultural heritage has lost its significant characteristics due to weather conditions and human neglect. The area has been encroached on by the residents vertically as well as horizontally to increase accommodation in their houses. The city was pedestrian but now two-wheel and four-wheel transport are the basic needs of life. Open spaces have been occupied illegally and narrow streets have lost their breathing spaces as the narrow streets are occupied by residents for motorbike parking. The area taken is a vast area and bears architectural value which needs to be saved.

The area is too large and congested to document manually. In July 2016, Walled City Lahore Authority decided to document this area with the collaboration of AKCSP by using technical tools such as Total Station and a 3D laser scanner as a pilot project. Wherever use of this equipment was not possible, manual documentation was done. Streets were too narrow and

the scanner documented the facades of the buildings very successfully screening the encroachments as well as damages. Architectural plans were drawn manually. The project was done to conserve a zone of special value (Inner Zone West, 5D). Under this project, 182 properties have been documented and Choara Khoo is a small part of it (WCLA, 2016). Conservation and Rehabilitation have been planned on a project basis rather than an integrated approach. Appropriate conservation can enhance the cultural and tourist value of the area upgrading the socio-spatial management of the heritage site. Tourists can be invited to visit the residential and burial places of literary icons of the past (V. Kumar et al., 2020).

Research Methodology

Desk-based research has been implemented for the collection of data from the concerned departments such as Walled City Lahore Authority (WCLA) and Aga Khan Cultural Services of Pakistan (AKCSP). A visual and Pictorial Survey has been conducted to document the present condition, current interventions, and continued cultural activities. The selected site has been digitally documented and conserved in 2016 and it is now part of the digital archive. Previous records and current data have helped to visualize the rate and types of encroachments, changes in cultural values, and identification of the decaying process.

The main objective of the research is to develop an understanding of the application of Historic Building Information Modeling to document historic monuments and urban areas. Focusing on the core objective, Simulation methodology has been adopted as it is much more efficient in the case of dynamic representation of historical studies. Dynamic representations can be derived through virtual representations such as photographs, videos, and digital images (Groat and Wang, 2013).

A 3D model of an urban space named “Choara Khoo” has been prepared with BIM technologies for the representation current status of the area by the author. The buildings around this urban space with communal activities are of high, medium, and low architectural value. Residents of the area have increased the number of stories, closed balconies, changed the original material of door frames, and provided support to decaying members of the buildings. It has been tried to document all the interventions from 2016 to 2023 in the 3D Model for a better understanding of the historic environment and to record and assess changes during the last decade.

Finally, an analysis has been done to evaluate the accuracy and authenticity of the collected data socio-spatial organization of architectural and urban heritage for data acquisition, pre-processing of survey data, and 3D modeling with HBIM.

Case Study: Choara Khoo Jogi Mohallah

The area in the close vicinity of Bhatti gate is named after the Rajput Bhati migrants by the approval of Mughal Emperor. This gate was used as an entrance from the south end and is linked with Royal Throne through Bazaar-e-Hakeema. The intellectuals from different parts of India migrated and settled here, transforming it into a cultural hub. Many intellectual giants such as Allama Iqbal who wrote his famous book “Bang e Dara” during his stay in a house near Unchi Mosque. Jogi Mohallah is also been a residential place of Syed Mohammad Latif who was a famous writer and he also issued a Journal with the name “Naqoosh”. Walled City Lahore Authority has selected this site as a zone of Historic value and documented facades of buildings with the “Faro Terrestrial Laser Scanner” in 2016.

Location & Context

Jogi Mohallah is located on an adjacent road of Bazaar-e-Hakeema on the east side and it can be accessed by both of the gates Bhatti and Taxali gate, however, the route through Taxali gate is a bit longer. The other side of this Mohallah is adjacent to Bazaar Samia on the west. Khghzan is in the North and Noor Mohallah is in the South. The selected site is a part of Jogi Mohallah and comprehends significant value due to its cultural, architectural, and historical importance. There are small open spaces, serving as breathtaking vistas in the narrow streets of Jogi Mohallah. Choara Khoo is a small open area, being used for cultural activities around a well (Khoo) in the middle of this open space serving just as a courtyard of a house. This is a junction of streets diverging in four directions linking the main spine to the neighborhood. The open space is at a height compared to the rest of the area and a well was constructed in the middle which was permanently closed on the availability of the Drinking water through the pipeline. Even after closing this “Khoo”, the space is still being utilized for communal as well as commercial (Neighborhood Shops) activities.

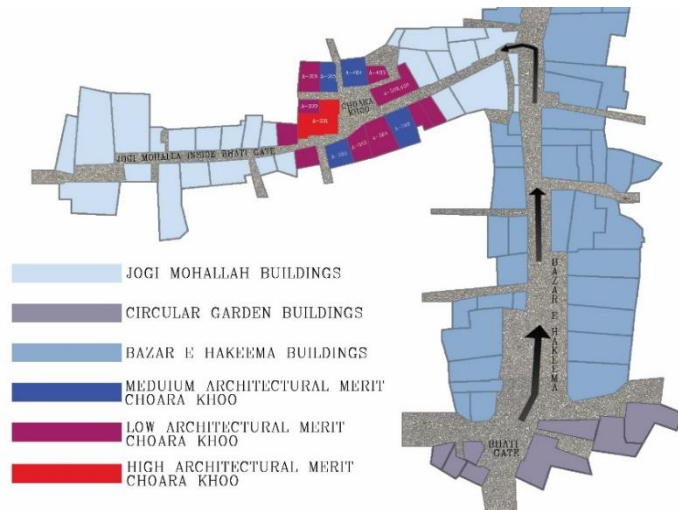


Figure 5-45 : Location Map

Source: Basemap WCLA, 2016 (edited by author, 2023)

Cultural, Architectural & Historical Significance

The properties documented under the Project of “Master Conservation and Redevelopment Plan (MCRP)” by the Architectural team of WCLA with AKCSP for the conservation of Inner West Zone (Bazaar-e-Hakeema), 182 properties have been documented. Out of these, there are 07 properties of High, 17 properties are of medium and 158 properties are of low architectural value. Choara Khoo located in the Jogi Mohallah inside Bhati Gate comprises of 01 properties out of 07 of High, and 04 properties out of 17 are of medium architectural value.

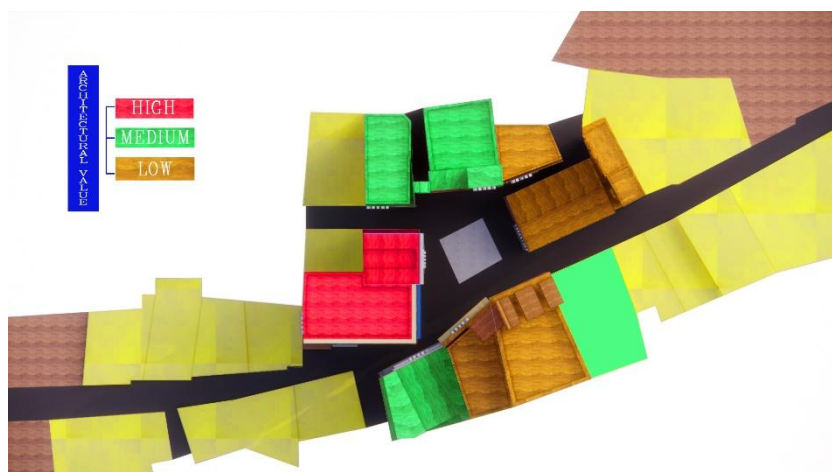


Figure 5-46 : Choara Khoo Showing buildings of different architectural value

Source: Basemap WCLA, 2016 (edited by author, 2023)

The area is significant with reference to cultural, architectural, and historical value. The place remained the center for writers and poets. Doctors, lawyers, and barristers. It was the land of issuance of newspapers and magazines such as “Pesa Akhbar” Makhzen and Naqoosh. It was also honored with the presence of Dr. Muhammad Allama Iqbal who wrote many books during his stay in this area.

The area is also famous due to the Havelies, the most significant was Haveli Wajid Ali Shah and Haveli Mian Afzal Javed, Unchi Mosque, Shrine of Pir Bhole Shah, Fakir Khana Museum and so many other buildings of architectural value of different categories such as High, medium and low value depending upon the period of construction such as 19th century, early 20th century and built after 1947 respectively. The buildings constructed during the 18th century have been declared as monuments and there are few monuments in this area (Shuja, 1988).

The area is also significant as the gate was constructed by the Emperor Akbar and named after the Bhati clan who were invited by the Emperor to come and settle in the area. Due to its significance, it has been documented and protected by the WCLA as a pilot project in 2016 by hybrid methodology e.g. manually, by total station and 3D terrestrial laser scanner of Faro technologies.

Digital Documentation of Choara Khoo

The area is composed of narrow and winding streets and few of them are covered partially. The Jogi Mohallah with 182 properties has been digitally documented. The architectural drawings such as plans were drawn manually, open spaces were measured by total station, and the facades of the buildings were scanned by the 3D Terrestrial Laser Scanner by the WCLA in 2016.

Being part of Digital Achieve, the properties around the Choara Khoo are of different categories with reference to Architectural values. House no. A-133 is of high house no. A-315, 404, and 382,389 are medium, and house no. A-388,400,382,383 are of low architectural value. The area has been resurveyed to prepare a record of interventions. It will be helpful to check that these interventions are approved by the *Heritage Board* constituted by WCLA for the renovations in the historic city of Lahore.

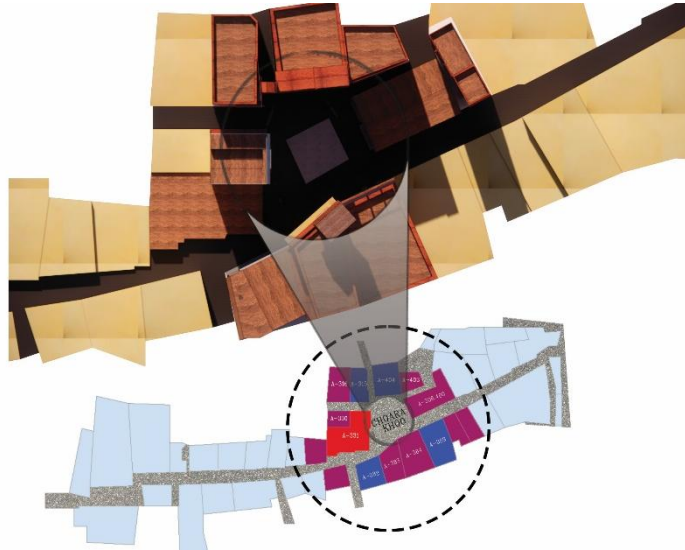


Figure 5-47 : Context of Choara Khoo, Jogi Mohallah inside Bhati Gate

Source: Basemap WCLA, 2016 (edited by author, 2023)

In 2023, Visual and Pictorial surveys were conducted by the authors and a Virtual model of the urban space was prepared to visualize the site with an integrated approach. A comparison has been done to assess the accuracy and authenticity of the smart data. The buildings around Choara Khoo are of High, medium, and low architectural value.



Figure 5-48 Visual & Pictorial Survey of Pakistan

Source: authors. 2023

Historic Building Information Modeling has been applied for the 3D models of the properties with the help of building plans prepared manually by AKCSP and data collected by Digital cameras. Historic environment has been explored through these models and a record of decays and renovations has been prepared.

Previous records also update the period of construction. As an example House No. A-331 is a structure with high architectural value and possesses a number of significant elements and has been constructed during the 18th century, House no.A-315, 400, 382, 389, are of 19th century and carry medium architectural value, and House no. A-(388,400), 382,383 have been constructed after 1947 and bear no significant features but need to be saved as part of the historic environment. (WCLA, 2016) and the function of the building has been transformed after modifications. Small shops have been developed on facades of property nos. A-(388,400), 384 facing the Choara Khoo adding the commercial activities.

Present Condition

The dust of time can easily be observed in the cultural and architectural value. The place which was once performing as a hub of intellectual activities. Now, it has been transformed into a bunch of squatters and slums and significant structures are showcasing human neglect. Local residents are modifying them to fulfill their needs. In some places, windows have been permanently closed by brick walls. A platform has been constructed in the front of each building to repel rainwater from the doorsteps. More than one floor has been added to increase more accommodation for the family members disturbing the skyline of the area. All of these encroachments destroyed the historic character and reduced air circulation. The open space has lost its cultural value as now it is presenting an enclosure without fresh air. But still, women are doing their leisure activities with their kids in this open place area. There is a law for the protection of built heritage within Walled City Lahore but there is a need for strict compliance to safeguard the historic environment.

3D Models of the Urban Space

Data collected from the WCLA in the form of Architectural Plans drawn manually and with Total Station and elevations scanned with the help of a Terrestrial Laser Scanner. These elevations have been rendered on Adobe Photoshop with the help of images taken during the visual and pictorial surveys. A 3D model of the area has been prepared on Sketchup to visualize the historic environment and to make a record of damages and encroachments.



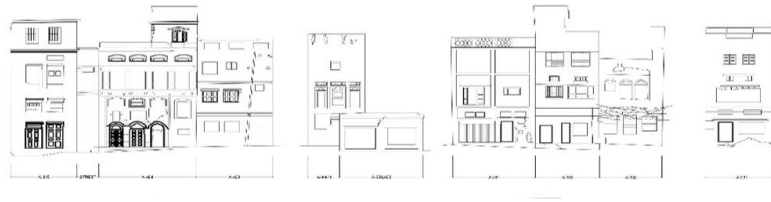
Figure 5-49: 3D Modeling of Choara Khoo, Jogi Mohallah inside Bhati Gate

Source ; Authors, 2023

Results & Discussions

Historic Building Information Modeling has provided a platform to achieve more authentic and accurate data with the help of digital tools such as 360 Digital Cameras, Total Station, and 3D Terrestrial Laser Scanner. Digital technologies have minimized chances of error on one hand and they also have saved time consumed for different phases of conservation procedure on the other hand. Digital technologies reduce the constraints of traditional methods and open new doors to the world of heritage (Alshawabkeh and Haala, 2004).

Choara Khoo has been documented under a project “Master Conservation & Redevelopment Plan (MCRP) in May 2016 and completed in December 2016. 36 properties of Jogi Mohallah were documented manually and with a total Station and 3D Terrestrial Laser Scanner of Faro Technology. In 2023, the site was again surveyed and documented by the author, and 3D models of the urban space were developed to assess the interventions and changes in architectural and cultural values by the residents and local authorities. The change in color of the doors (From blue to brown) of house no. A-404 has destroyed the historic environment and it can be visualized by the 3D model of the space. The most significant role of this scanning technology for the heritage field to document historic buildings and heritage sites is the capability to express time-based inter-relationship between both kinds of cultural values (tangible & Intangible). It also has reduced hazards for heritage documentation.



Elevations of Buildings around Choara Khoo with 3D Faro Laser Terrestrial Scanner (By WCLAI in 2016)



Rendered Elevations of Buildings around Choara Khoo with 3D Faro Laser Terrestrial Scanner (By WCLAI in 2016)

Figure 5-50: Elevations of houses around Choara Khoo

Source: WCLA, 2016

The cultural values of the urban space can be evaluated from the record of the “Digital Archive” in the form of architectural drawings (manual), urban plans (with Total Station), and 3D models (with terrestrial laser scanner) of the life pattern of the residents couldn’t be upgraded due to the financial constraints and they haven’t tried to protect their historic environment as they haven’t enough money. But a comparison of the previous record and current documentation and 3D models reveals that they are trying to facilitate their families through minor changes such as the closing the openings, changing the color of paint, increasing floors to the existing structures, adding platforms (Tharas) at the outer basis of the houses and transforming their drawing rooms in the squatted shop. Within the pedestrian city, vehicles are running and a mesh of electricity and cable wires has obstructed the views.



Figure 5-51: Elevations of the Houses around Choara Khoo

Source: Authors, 2023

The HBIM models can give a perception to plan an environment, free of all above stated issues, adding the tourist value to the city. Which will ultimately help the people to upgrade their standard of living.

Conclusions & Recommendations

In conclusion, our research has guided us about the future potentials of HBIM for the documentation of built heritage. It is serving as a simulation tool as an integrated approach for historical, architectural, and cultural aspects to manage heritage buildings into a single object. BIM has been proven as a tool for the management of the life cycle process showing all the interventions at multiple scales. Collection of BIM data related to methods of construction for heritage documentation. Accuracy and authenticity of the documented work can be assessed at various timelines. An integrated HBIM framework can be generated for better documentation of built heritage to address challenges at heritage sites. Historic sites like the Walled City of Lahore, possess a number of historic monuments and buildings, urban spaces with significant structures around, and breathtaking vistas that need an integrated approach rather than project-based conservation works. The city has been planned on a specific hierarchy such as Guzars (main spines) was designed for vehicular activities and the basic requirement was that it should be able to run two carts parallel. No vehicle was allowed in streets (Secondary) and galies (Tertiary). There well wells and baolies for water provision. Chowks (Junction of Guzars) was the hub of commercial and cultural activities. Similarly, open spaces in the cluster of buildings (Significant & non-significant) were just like the courtyard of the houses as the residents were used to performing their daily routine work mutually while increasing interaction with other neighbors. These historic cities bear not only tangible values but also intangible values.

It is not an easy task to survey, scan, plan, manage, and monitor such a mega-scale historic city with traditional methodologies which have discrepancies and constraints. It is a challenging task as the answer can be a 3D HBIM approach but these approaches also curtail limitations in terms of operability and functionality with reference to narrow streets and congested overpopulated areas. The future potentials will have to be identified and will have to embark on rules and regulations to get the best outcomes.

5.8.4. Case Study - Revitalization of Urban Squares (Chowk Wazir Khan)

The case-study is an effort to understand the process of revitalization of the open urban spaces of the historic cores of Lahore, with a focus on the historic context. There is a close relationship between communal and cultural activities in the open urban spaces of the historic cities in terms of urban morphology. Wazir Khan Chowk, Walled City Lahore signifies the Mughal architectural styles and open urban spaces in terms of cultural activities. The rapid urban sprawl and commercialization within the historic cores have fashioned modern trends around the historic cities. The study signifies the preferences of the transformations in the urban areas during the regeneration, revitalization, restorations and refurbishments leading towards the socio-cultural and socio-economic sustainability of the historic cities. The modern transformations changing the traditional roles and characteristics effect the historic environment. The core objective is to explore the variables within central core and the impact of these variables on the heritage sites and to investigate the indicators creating outer pressures. The research enhances the investigation of complex process pf social, economic and technical transformations, in addition to future activities. In the conclusion, urban interventions in the historic cores can be planned and positioned for the development of the historic cities, with the focus on the needs of the residents.

Introduction

Urban renovations, substantial context and planned location plays vital role to define the historic landscape of the historic cities and there is a close association between the urban morphology and cultural accomplishments in the open urban spaces of the heritage sites (Sajjad et al., 2020). The “Physical Fabric” of the Walled City Lahore includes gates, bazaars, gali-koochas and chowks/Urban Squares. It also includes facades of the historic monuments. Modern interventions influenced traditional activities and social character of the urban open spaces of the historic cities globally. Walled City Lahore was greatly affected by the different conquests of the invaders who came to sub-continent to conquer the land and left their remains

in the form of buildings, norms and values resulting changes in the socio-economic patterns of the historic site. Mughals ruled in sub-continent from 1526 to 1752 A.D. and Historic city of Lahore gained its majestic period when Mughal Emperor Akbar made Lahore his headquarter from 1584 A.D. to 1598 A.D. Mughal city of Lahore was occupied by Sikh from 1799 to 1849) A.D. and followed by British from 1857 to 1947 A.D. The two periods are sandwiched by Sikh rule who contributed a lot in the development of the historic core of Lahore. In order to study the socio-economic, traditional and historic values of the present day Walled City Lahore, we have to analyze three significant periods such as Muslim, Sikh and British. The growth of the city after independence can also be taken in consideration while deciding the future of the city (WCLA, 2021).

During the Emperor Akbar's period, Walled City was not confined inside walls but has been extended its boundaries beyond the walls with the neighborhoods such as Chah Miran, kot Khawaja Saeed, Mughalpura etc. Emperor Akbar has divided Lahore into thirty six administrative districts and there were only nine districts inside the Walled City. These Districts were divided by Guzars which are the main spines and hub of commercial activities. The junction of these Guzars is termed as urban squares and in local terminology as Chowks. These chowks were center of cultural and communal activities (Yamane et al., 1998)

Chowk Wazir Khan is the courtyard of Wazir Khan's Mosque and significant component of the Wazir Khan Complex. It is situated on the thorough fare from Delhi gate to Taxali gate. The urban square is enclosed in the religious environment and was center of traditional activities and religious ceremonials such as Hujras for devotes and shops for illustrators, book binders and calligraphers on the eastern and Northern sides of the principle mosque. Wazir Khan Chowk is a hub of cultural activities, including bethak (social gatherings on small scale) systems, portable stalls for food and other products, Melas based on religious themes. Qawalies on the religious ceremonial days such as Meraj Sharif, shab-e-barat etc.(Campos, 2015)

Modern interventions changed the socio-economic patterns of the historic cities, resulting the change in traditional activities within these urban squares as per contemporary functions. Due to these interventions, the social, economic and environmental character of the Chowk Wazir Khan also transformed and a chaos was created by the shopkeepers and residents of neighborhoods and situation becomes most awful. The major cause of this deteriorated environment is lack of any effective control safeguarding public rights over public spaces and historic buildings. Diagonal path from Chita gate to north-western corner, was a constant

problem for the shopkeepers of the southern side. Semi-permanent constructions adjacent to Tomb of Hazrat Syed Said Souf and Dina Nath well were appeared in the form of physical encroachments. The western façade of the court has sunk 2.5 meter into the ground and was filled with debris. Structure of the Chita gate was on extreme disrepair. The court was captured by the physical erections, extended shop fronts, debris, and squatted shops.(AKCSP, 2012b)

Looking at the dilapidated condition of the Wazir Khan Mosque and its forecourt, Walled City Lahore Authority decided to protect the heritage site. Chowk Wazir Khan rehabilitated on priority basis due to its historic and architectural character as it is one of the squares which was surrounded in the religious environment and serving as forecourt of the Mosque Wazir Khan which is principal mosque of the historic city. The core objective of the project was to revive the original use of the squares maintaining the current function of the site.

Historic Core of Lahore

Walled City Lahore remained center of the trade route between Delhi, Kabul and Kashmir and attacked by various invaders for multiple times and absorbed their rituals and traditions generating a new social life. The cultural and social values were greatly affected by the political invasions. The dominant role was played by the Mughals to upgrade the social and political values of the historic city. Then Sikh contribution is remarkable to define the city skyline and finally, city developed a new pattern of life during the British annexation. British introduced a new colonial city on the South-western part of the city, maintaining new life standards. The local residents of the Walled City moved towards colonial city of Lahore and city life moved towards decline. In order to understand the historic character of the heritage site, we have to study the significant characteristics of the Muslim, Sikh and British periods. However, we have to deeply study the interventions done after independence.

Evolution of Walled City of Lahore is connected with the Royal Throne in Lahore due to the muslim conquests starting from Mehmood Ghaznavi in 998 AD who appointed Malik Ayyazas as Governor, founder of Present day Lahore. Walled City Lahore was named as “Little Ghazna” on the name of Ghazni which was royal throne of Afghanistan. After Mehmood Ghaznvi, various muslim rules take over the seat of Lahore and the last one of those were Mughals who came from Persia and built a lot of historical structures. It is true that Walled City was not confined inside the city wall constructed by the Emperor Akbar but has been extended its boundaries beyond the walls with the neighborhoods such as Chah Miran, Kot

Khawaja Saeed, Mughalpura, etc. There are a lot of structures remaining in their original condition after the establishment of Muslim rule in Lahore.

Research Methodology

Primary and secondary data methodology is adopted considering the core objectives of the research. At first, site has been visited to record current condition and function of the site. Visual survey has been conducted regarding historic, cultural and socio-economic character of the area. Data has been collected from the Walled City Lahore authority and Aga Khan Cultural services of Pakistan regarding conservation of Chowk Wazir Khan. Current contemporary function of the area has been captured through digital images and compared with the dilapidated condition of the site due to the contemporary interventions and commercial activities of the area. The approach towards regeneration of the urban spaces within Walled City Lahore has been evaluated reviving historic character and traditional activities in the context of the monument. Data was also collected from relevant departments. The analysis is based on the study of the issues in the historic urban square such as physical encroachments and visual barriers due to the unplanned commercial activities. Vehicular and pedestrian movement created hustle and bustle due to the various type of traffic movement. The conservation plan has been analyzed based on the morning and evening activities in the area at present linking them with the past. The policy to resolve the issues has been studied deeply to develop a platform for the conservation of the urban open spaces in the historic city.

Case Study - Chowk Wazir Khan

Chowk Wazir Khan is the forecourt termed as Jilaukhana of Wazir Khan's Mosque and an important Wazir Khan Complex. It is situated on the thorough fare from Delhi gate to Taxali gate. The chowk is surrounded by buildings on three sides and façade of the mosque is on the forth side. North South Dimension is 53 meters and East west Dimension is 47 meters. There are five entrances into the square. After crossing monumental gateway named as Delhi gate to old city of Lahore, there is a significant historic monument, Shahi Hamam. walking on the road towards Taxali gate, there is a muddle of commercial spaces, muddle of narrow streets, portable food stalls, and historic Mughal jharokas, interwoven rooftops. After crossing chitta gate, we enter into a forecourt of Masjid Wazir Khan which is splendor of Lahore. The Wazir Khan Mosque is the jewel in the crown of Mughal monuments and was constructed during the period of Mughal Emperor Shah Jahan in 1634 A.D.

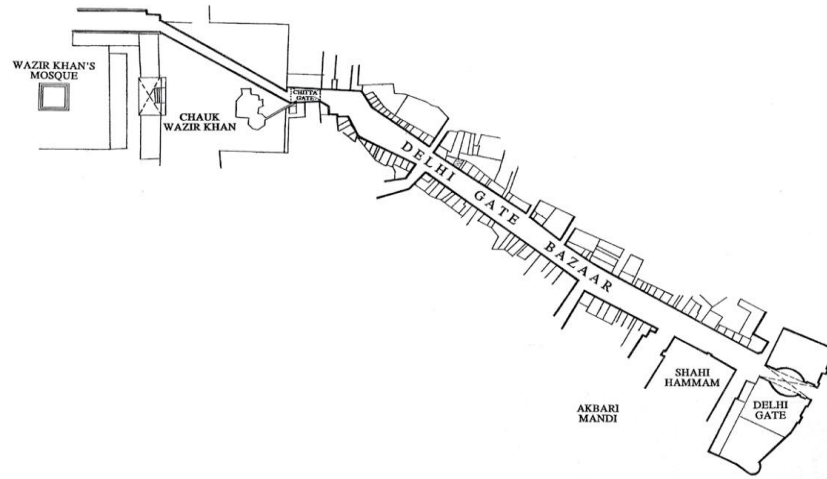


Figure 5-52 Location of Chowk Wazir Khan

Source: WCLA, 2021

There is an important feature of the mosque, Hujras and shops on the northern and eastern side which were financial resource to meet the expenditures. Shrine of a saint Syed Said Souf is located on the south-eastern corner of the chowk and Dina Nath well is located on the north-eastern corner, just opposite the shrine. The well was named after the name of Dina Nath who performed as a finance minister of Ranjit Singh. There are four entrances on the four corners to link the chowk with its adjacent neighborhood. The fifth entrance is in the north-western corner linking the square with the Azam Cloth Market and Pakistan Cloth Market through Chowk Purana Kotwali.

Landmarks at Chowk Wazir Khan

The most significant landmarks of the Chowk Wazir Khan is the tomb of Syed Said Sauf and Dina Nath Well.

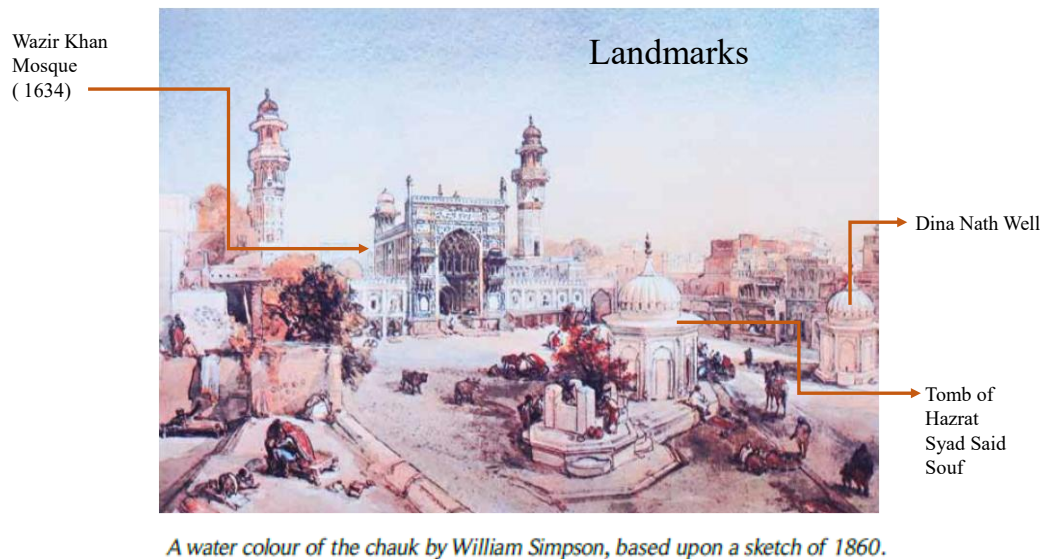


Figure 5-53 : View of Wazir Khan Chowk (Tomb of Hazrat Syed Said Sauf)

Source: WCLA, 2009

Approaching towards from Delhi gate to chitta gate, we experience commercial activities in chaos in the form of venders, static shop fronts, physical intrusions in the result of current interventions and modern needs. From chitta gate, we enter to the Chowk Wazir Khan from the east. Shrine of Hazrat Syed said Souf is located on the Left side of the square. The garve is housed in an octagonal structure with an enclosure. The enclosure has been decorated with panels of terracotta fretwork. The parapet walls are in merlin design and there is a low dome with a metallic finial. The interior of the burial chamber and its adjacent enclosure is decorated with intricate mirror work and embellished by the use of chandelier.

The saint Hazrat Syed Said Sauf (786 / 1284) was a contemporary of the saint Syed Ishaq Gazruni whose grave is in the basement of the courtyard inside the mosque. The saint arrived in Lahore during the reign of Feroze Shah Tughlaq and was martyred in battle. The tomb is located in the area which was once named as Mohalla Rra and Haveli of Nadir Khan is also located in the area. Governor of Lahore, Shaikh Ilm-ud-din Ansari whose royal title was Nawab Wazir Khan bought the place for the Grand Mosque to be used as principal mosque before the construction of Badshahi mosque. During British period, Major Macgregor (Deputy Commissioner) ordered to demolish all the buildings in the close vicinity of mosque to create an open space in front of the mosque, the tomb of Hazrat Syed Said Sauf which was very famous during the Sikh rule among the residents, rebuilt by the contractor Mian Muhammad Sultan. On the aspiration of Major George Macgregor, a marble plaque was placed depicting “

Mazar of Hazrat Syed Said sauf, built by Sheikh Sultan Contactor Sarkar Faiz Asar company angrez behadurdam iqbalahu (May their dignity last forever), in the year 1852, corresponding to 1908 Samvat and 1268.”

The tomb is still functional as the enclosure adjacent to the mosque is being used by devotees to say prayer five times a day. (WCLA, 2021).

Dina Nath Well

Well of Dina Nath is located on the right side of the eastern entrance of the Chowk Wazir khan, opposite to Tomb of the saint. It is the only well in the Walled City which is walled. Diwan Dina Nath , a member of Pandit family was living in Delhi invited by Maharaja Ranjit Singh to visit Lahore in 1815 and offered the post of mutsaddi or writer to work in the military department as head of military finance department. Dina Nath was awarded the title of Diwan which means custodian of finance. During his service, he ordered the construction of Haveli with the construction of a well. He died in 1857 near Kot Khawaja Saeed Lahore.

The well was captured by the intrusions as of squatted shops adjacent to the wall of the well, static shop fronts, hoardings, portable inclusions, parking purposes and infrastructure. All these interventions destroyed the historic character of the area. At the time of conservation, all the encroachments were removed to clear the visibility of the monument. (WCLA, 2021)

Major issues at Chowk Wazir Khan

Urban interventions and encroachments adjacent to Mosque, Tomb of Syed Said Sauf and Dina Nath well and in the surrounding of the mosque deteriorated the historic character of the Chowk Wazir Khan. The court has been raised its level due to the debris and hujras on the eastern façade of the mosque was buried under these debris. The chowk has lost its original character and traditional activities became the story of the past and courtyard was a place to be utilized by the shopkeepers of the squatted shops, sitting space for beggars and a corner was filled with the transformers for electricity supply to the neighborhoods. The diagonal path from chitta gate to north-western corner was a critical issue for the shopkeepers of the southern side. Fountain in the center of the court was in dilapidated condition. The pedestrian area has been transformed into a passage for the vehicular movement creating a chaos. No segregation between pedestrian and vehicular movement can be seen there in the chowk.

Due to the intrusions made by the locals in the form of temporary shops and outlets, rusted by humidity, the road from Delhi gate to Wazir Khan Chowk has lost its identity by the retail shops and seized open spaces. The open spaces were illegally occupied by the

neighborhood residents. During the age of urbanization and commercialization, the mosque and its courtyard was also occupied by the squatted shopkeepers and two transformers, baggers, motor mechanics etc.

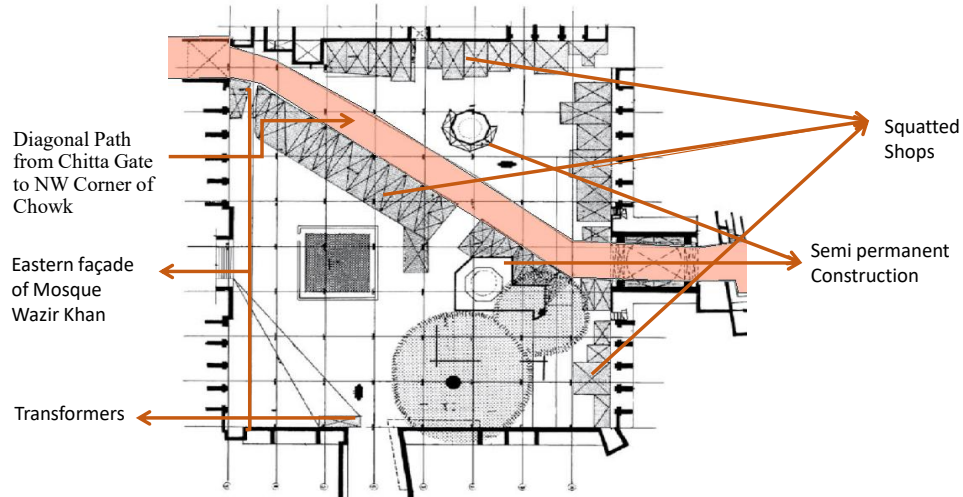


Figure 5-54 Plan of the square showing encroachments

Source: Basemap WCLA,2009 (edited by author, 2023)

The open spaces in front of the mosque was illegally occupied and was being utilized by the residents living in the close vicinity as a parking of carts and resting place of visitors. The entire environment was damaged due to these illegal occupants. This spaces is the only open area in the context of royal trail which is serving as a hub of cultural activities and due to these encroachments, the forecourt of the mosque, not only lost its identity, but the people also were been deprived of their facility. Due to all these issues, the space character has been changed and visitors are also reluctant to visit such historical spaces. There is a need to enhance tourist value of the city center to raise the socio-cultural values (WCLA, 2021).

Rehabilitation of Chowk Wazir Khan

As per PEPAC, There are three level policy framework for the Walled City of Lahore. Re-Channelization of External Pressure, Conservation of the City Fabric, Refurbishment & Reintegration of the Historic spaces with high number of historic buildings.

Walled City Lahore Authority has taken the responsibility of Management & Operation of Historic Urban square, Chowk wazir Khan. Considering the historical significance and dilapidated condition of the courtyard, Walled City Lahore Authority (WCLA) with the

collaboration of Aga Khan Cultural Services of Pakistan planned to rehabilitate, revitalize and redevelop Chowk wazir Khan. The project was co-funded by United States Ambassadors Fund for Cultural Preservation (AFCP) with an amount of \$ 1.2 million. The project started in 2015 and completed in 2017. The square surrounded by saturated urban context was selected for adaptive re-use. The square serves as a breathing space and provide a spatial experience embedded within rich cultural backdrop in the historical inner city (AKCSP, 2012a).

Proposed Use & Adaptations

The refurbishment projects including revival of the traditional activities and reintegration of the original form through digging of courtyard at the depth of 2.5 meters to segregate the original level of the courtyard and present level of the adjacent road under the activity of archaeological excavations. Due to the difference of the levels of the courtyard and road, a retaining wall has to be built to protect the areas from the intruders and to support the structure of the hujras, facing to the courtyard.

Dina Nath well is located in the northeast section of the urban square and was part of the project. It was also conserved as a source of knowledge for the future generations and the 06 meters around the well was also excavated to provide a space for the visitors to identify and study the significance of the well during the Mughal and Sikh rule, in the absence of municipalities.

The Council General Fidkew described the future functions of the square such as community functions, cultural activities, meet & greet space of visitors, hujras can serve as commercial spaces to deal with traditional crafts, religious activities.

In April 2012, the WCLA removed all the encroachments from Chowk Wazir Khan and Shahi Hammam, and completed the rehabilitation of the courtyard, with the collaboration of Aga Khan Cultural Services of Pakistan, to retain the identity of the Mosque and a space to visualize the beauty of the façade of the Mosque. Besides the excavation of the forecourt, the repair and restoration of Hujras and bazaar of the Mosque, was also conserved to regenerate the original historic and religious environment.

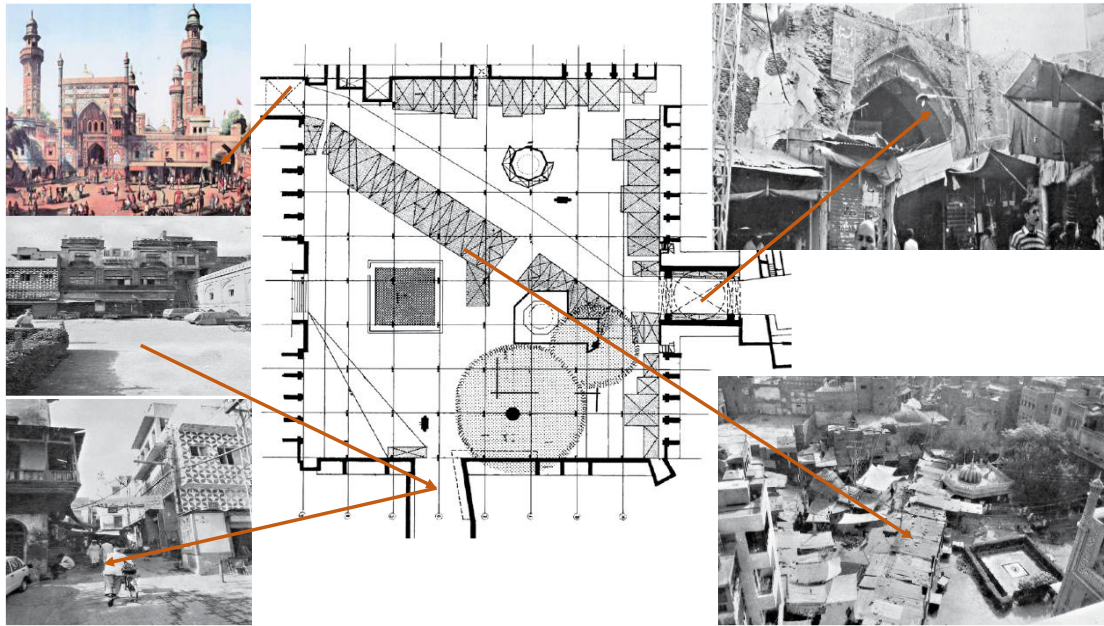


Figure 5-55 Spatial analysis of Chowk Wazir Khan

Source: Basemap WCLA,2009 (edited by author, 2023)

The removal of debris and squatted shops from the area, in addition to the restoration works, created a feeling in terms of revival of traditional character of the space, providing a vista for the visitors and residents, busy in commercial activities. The project upgraded the cultural identity of the courtyards with reference to its context. The forecourt has resumed its tourist and communal value through its performance as a space for socio-cultural interactions. The project supported the conservation of Royal trail and proved a milestone, in a wider context of the historic core of Lahore. It became the focus of the visitors, national and international. The frequent visits of foreign delegations and tourists enhanced the historical significance of the religious place and courtyard is serving as a place of relaxation, in the middle of shops around the courtyard.

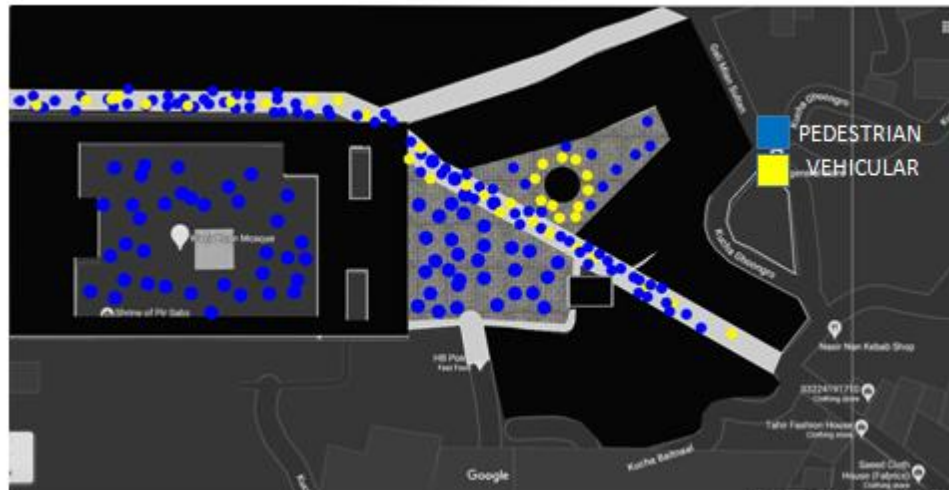


Figure 5-56 Pedestrian and vehicular movement in Wazir Khan Mosque and in Chowk Wazir Khan

Source: Basemap WCLA,2009 (edited by author, 2023)

The courtyard is serving as a tourist hub and all of these activities make the space alive and dynamic and helped to increase tourist value of the site with its commercial context.

- Revival of its functions as a pedestrian forecourt to the Wazir Khan Mosque.
- Re-organization of Vehicular traffic from Delhi gate to connected streets and Bazaars
- Restoration of Façade of Wazir Khan's Mosque
- Improvement of buildings facing the chowk
- Removal of Encroachments within and along the chowk.
- Removal of shops squatting along the diagonal path.
- Removal of rampant encroachments within Chita gate.
- Relocation of transformers from the center of the court to behind the southern entrance of the court in the concealed form.



Figure 5-57 Day v/s Night Activities at Chowk Wazir Khan

Source: WCLA, 2021

Results & Discussions

Wazir Khan Chowk was not only serving as forecourt of the Mosque Wazir Khan which was grand mosque of the Walled City before the construction of the Badshahi mosque. The route from Lahore Fort to Mosque Wazir Khan is significant as Emperor and his courtiers have to travel from Fort to the mosque to say prayer from Masti gate through Chowk Kotwali. The people coming from Delhi have to come to the mosque through Chitta gate and people coming from Kabul have to come to the mosque through Masti gate and Delhi gate. The area surrounding the mosque was hub of Havelis of Muslim nawabs and Sikh administrators. The main spines were commercial hub providing eating and clothing facilities to the visitors. With the passage of time, there was a remarkable change in the social patterns of the local residents after the British annexation. There is a shift from Old city to colonial city creating a potential for commercial activities. The vacant properties were occupied by the venders, shopkeepers and whole sale merchants. This changing socio-economical change destroyed the historic character of the area. The Chowk wazir khan becomes the center of the activities for the shopkeepers and residents living in the close vicinity of the courtyard. The activities transformed from cultural and communal to commercial for portable venders, squatted shopkeepers, parking place, debris, sitting space for beggars and even for provision of infrastructure by the local authorities. The eastern wall of the mosque was buried in the debris and level of the courtyard had been raised up to 2.5 meters. The area was in dilapidated condition and needs attention of the stake holders. Walled City Lahore Authority took the initiative to regenerate the urban space as pilot project to be implemented on rest of the urban

spaces of the Walled City Lahore. The surveys were conducted and issues were documented with the help of digital technologies. A plan was proposed to revive the historic character of the urban space fulfilling the contemporary needs of the neighborhoods. The pedestrian city has now been owed too much to vehicular movement. The segregation was the priority. Squatted shops were the critical factor to deal. Extraction to expose the eastern façade is another important part of the redevelopment plan. With all these, encroachments in the form of static shop fronts and semi-permanent shops adjacent to the walls of the mosque, tomb of the saint and well of Dina Nath were the core reason to damage the traditional function of the courtyard. This project is co-funded by United States Ambassadors Fund for Cultural Preservation (AFCP) with an amount of \$ 1.2 Million. A house in front of the northern wall of the square manually documented by the Pakistan Environmental Planning and Architectural Consultants Limited (PEPAC) with the help of Building Information Modeling tool to maintain the accuracy. The manual data is digitized by the conservation experts and house was restored to be as part of the historic environment. (AKCSP, 2012a). The project was completed during the period of 2015 – 2017 proving technical expertise of the relevant departments. But yet, there is a need to develop awareness among the people to change their attitudes towards the protection of heritage sites.



Figure 5-58 Chowk Wazir Khan after regeneration

Source: WCLA, 2021

Conclusions & Recommendations

The original function of the chowk has been revived through re-organization of pedestrian and vehicular activities from Chita gate to the north western corner of the forecourt.

Façade of the Wazir Khan Mosque has been restored. A trial has been done to improve facades of the buildings facing chowk but still needs to remove shops squatting along the Tomb of Hazrat Syed Said Souf and Dina Nath Well. Commercial activities in the surrounding should be shifted to an appropriate space. Currently, the forecourt is being utilized for multiple purposes, including camps for free medical check-ups and cricket games organized by the children of neighboring communities.

5.9. COMPARATIVE ANALYSIS AND LESSONS LEARNED

The comparative analysis of the case studies, spanning from the International to the local, reveals a complex interplay of technological innovations, cultural politics, and institutional frameworks in the development of contemporary conservation procedures and practices. At the same time, each case study operates in a distinct context with unique socio-political, economic, and historical values.

5.9.1. Digital Infrastructure and Technological Capacity

A clear distinction emerges in the level of technological maturity and infrastructure across the case studies. European examples, particularly in countries such as Germany, the Netherlands, and the United Kingdom, demonstrate advanced applications of digital twin technologies, which integrate real-time data, structural monitoring, and predictive analytics into heritage management. These systems are supported by robust institutional backing, interdisciplinary research ecosystems, and long-term funding models.

By contrast, initiatives in As-Salt and Dubai reflect the application of digital tools within more constrained or selectively curated contexts. As-Salt's efforts focus on digital documentation of traditional architecture to support UNESCO nomination processes and local heritage education. These are characterized by a culturally embedded, community-sensitive approach, albeit with limited technological depth. Dubai's strategy, on the other hand, is characterized by state-led restoration of historic districts (such as Al Fahidi), integrating digital tools into broader urban branding and tourism narratives rather than into long-term preservation systems.

In Pakistan, digital documentation remains largely project-based, often dependent on international collaborations. Technological adoption is uneven and frequently concentrated in urban centers. While there is growing awareness of the potential of digital tools, a systemic digital heritage infrastructure is yet to be developed. This gap underscores the need for

institutional investment in capacity building, training, and locally adapted technological solutions.

5.9.2. Institutional and Policy Frameworks

European cases benefit from well-established heritage policies, integration of digital tools into national conservation standards, and a strong culture of heritage research. Their policy environments support experimentation, cross-sector collaboration, and the institutionalization of digital methods in routine conservation practice.

In contrast, Dubai's heritage initiatives operate within a top-down governance model where heritage is closely tied to economic development and nation-branding. While well-resourced, these projects often lack transparency and community involvement. As-Salt presents a more balanced model where heritage policy intersects with community memory and international heritage frameworks (e.g., UNESCO), fostering a more sustainable and locally grounded conservation ethos.

Pakistan's heritage sector is marked by fragmented institutional coordination, limited funding, and inconsistent policy implementation. However, emerging partnerships between provincial governments, universities, and international organizations have begun to create pockets of innovation. The absence of a unified national digital heritage strategy remains a significant limitation, though it also presents an opportunity for more contextually sensitive, decentralized models of practice to take root.

5.9.3. Community Engagement and the Politics of Representation

The comparative lens reveals substantial divergence in approaches to community participation and heritage democratization. In As-Salt, community narratives and participation are central to heritage documentation, reinforcing the social and intangible dimensions of architectural heritage. Similarly, several national initiatives in Pakistan—particularly those using digital storytelling and crowdsourced mapping—attempt to re-center marginalized voices and local knowledge systems.

In contrast, Dubai's heritage spaces often present a sanitized and commodified version of the past, curated primarily for tourists and external audiences. Community involvement is minimal, and heritage is often divorced from everyday urban life.

European models vary in their engagement practices, with some projects using digital platforms to crowdsource historical data, engage local communities in decision-making, or

visualize heritage futures through participatory design. These models highlight the potential of digital tools to foster inclusive conservation when embedded within transparent and reflexive institutional cultures.

5.9.4. Lessons Learned and Implications for Pakistan

Drawing from the comparative analysis, several key lessons emerge that can inform the evolution of digital heritage practices in Pakistan:

- **Invest in Capacity and Infrastructure:** Pakistan must prioritize the development of local technological capacity through academic curricula, professional training, and investment in digital infrastructure tailored to heritage contexts.
- **Localize Digital Tools:** The adoption of European-style digital twins must be critically adapted to local contexts. Lightweight, open-source tools and scalable documentation methods may be more suitable and sustainable in the short term.
- **Institutional Coordination:** A national policy framework for digital heritage, with clear inter-agency coordination, funding mechanisms, and data governance protocols, is crucial for long-term impact.
- **Community-Centered Models:** Lessons from As-Salt and Pakistani grassroots initiatives affirm the value of participatory approaches. Future projects should prioritize community co-authorship, especially in contexts where heritage intersects with contested histories and socio-political marginalization.
- **Decolonial and Reflexive Practice:** Finally, digital heritage in Pakistan must move beyond technical replication of global models to critically engage with **postcolonial heritage politics**, challenging dominant narratives and incorporating vernacular knowledge, memory, and spatial justice into conservation efforts.

This comparative framework thus not only informs context-sensitive recommendations for heritage practitioners in Pakistan but also contributes to broader debates

5.9.5. Best Practices and their Applicability to Lahore's Context

The comparative study of diverse heritage conservation initiatives—ranging from the digital preservation of traditional architecture in As-Salt (Jordan), the state-led restoration of historical districts in Dubai (UAE), European digital twin applications, and national heritage documentation efforts in Pakistan, offers critical insights into the evolving paradigms of architectural heritage management (Trillo, et al., 2020c). While these case studies vary in their

technological sophistication, institutional arrangements, and sociopolitical settings, they present valuable best practices that may inform more contextually grounded and future-oriented conservation strategies for Lahore, one of Pakistan's most historically and architecturally significant cities.

As-Salt, Jordan

- Integration of digital documentation with community-based knowledge and oral histories.
- Emphasis on vernacular architecture and urban fabric, beyond monumental or iconic heritage.
- Use of digital tools to support UNESCO World Heritage nomination, combining international standards with local identity.

Applicability to Lahore: Lahore, with its layered urban history and active citizenry, stands to benefit from As-Salt's community-inclusive, narrative-rich approach. While several documentation efforts in Lahore (e.g., Shahi Hammam, Walled City Trail) have focused on architectural features, incorporating local storytelling, spatial memory, and everyday urban practices into digital heritage tools can deepen the significance of heritage and encourage civic stewardship. This is especially relevant in areas like Bhati Gate or Taxali, where the socio-cultural fabric is as valuable as the built form.

Dubai, UAE

Government-led investment in restoration, urban regeneration, and adaptive reuse of heritage assets (e.g., Al Fahidi Historical District).

- Integration of heritage conservation into urban development strategies and cultural tourism.
- Deployment of digital documentation tools for architectural conservation and public engagement.

Applicability to Lahore: Dubai's model demonstrates how restoration and digital heritage can be aligned with economic and cultural goals. While Lahore's heritage sector is less resourced, selective projects—such as the Shahi Guzargah Project—have demonstrated the potential of linking conservation with tourism, economic revitalization, and public space enhancement. However, Lahore must be cautious of replicating top-down narratives and instead ensure that

restoration efforts preserve authenticity, cultural diversity, and community access rather than erasing them for marketable aesthetics.

Edinburgh (European Example)

Implementation of digital twin technologies for real-time monitoring, simulation, and predictive conservation (e.g., in Amsterdam, Vienna, and historic centers in the UK).

- Use of interoperable data models (e.g., HBIM) to integrate architectural, environmental, and social data for heritage planning.
- Strong institutional frameworks and academic partnerships supporting innovation and sustainability.

Applicability to Lahore: While the full implementation of digital twin models may exceed Lahore's current technical and financial capacity, scaled-down, context-sensitive adaptations can be piloted. For example, heritage sites such as the Lahore Fort, Badshahi Mosque, or **the** Walled City could benefit from Digital inventory systems, 3D scanning, and environmental monitoring tools to inform maintenance and disaster preparedness. The development of a centralized digital heritage platform could serve as a precursor to more complex data integration in the future.

National Case Studies in Pakistan

Use of photogrammetry, drone mapping, and GIS in documenting historic sites in Multan, Peshawar, and Rawalpindi.

- Emerging community engagement models leveraging social media, oral histories, and participatory mapping.
- Collaborations between provincial heritage authorities, academic institutions, and international donors (e.g., UNESCO, AKTC).

Applicability to Lahore: These national examples reveal contextually appropriate, low-cost digital tools that can be scaled or replicated in Lahore's heritage districts. Moreover, they emphasize the importance of multi-stakeholder collaboration, an approach that Lahore has already begun to institutionalize through the Walled City of Lahore Authority (WCLA). Future projects in Lahore could incorporate youth engagement, women-led oral history archives, and citizen-based mapping to enrich official narratives and expand the heritage discourse beyond formal institutions.

Toward an Integrated Heritage Strategy for Lahore

Synthesizing the best practices across these case studies points to a series of strategic directions for Lahore's heritage sector:

Hybrid Approaches

Combine high-tech methods (e.g., digital scanning, Photogrammetry, Drones) with community-led documentation to create layered, inclusive heritage archives.

Capacity Building

Invest in training for heritage professionals, architects, and urban planners in digital tools, data management, and participatory design.

Policy Integration

Develop a municipal or provincial digital heritage policy, with clear frameworks for data governance, inter-agency collaboration, and public engagement.

Inclusive Heritage Narratives

Expand the definition of heritage to include vernacular spaces, intangible practices, and contested histories, particularly those excluded in colonial or elite narratives.

Scalable Innovation

Pilot modular digital heritage systems that can be incrementally expanded, rather than relying on one-size-fits-all or externally imposed models.

Conclusion

The comparative analysis demonstrates that while technological capacity and institutional structures vary significantly across global and national contexts, the core principles of sustainability, inclusivity, and cultural specificity remain central to effective heritage conservation. For a city like Lahore, rich in material and intangible heritage, yet facing intense urban pressures, the adoption of best practices must be critically filtered through local needs, historical consciousness, and community aspirations. Digital heritage, when grounded in context, offers not only tools for preservation but also platforms for dialogue, identity, and urban justice.

5.10. IMPLICATIONS FOR LAHORE'S DIGITAL CONSERVATION FRAMEWORK

The city of Lahore, with its centuries-old architectural legacy, layered urban histories, and vibrant cultural life, presents a compelling yet complex context for developing a digitally enhanced heritage conservation framework. While recent initiatives, such as those spearheaded by the Walled City of Lahore Authority (WCLA), have introduced elements of digital documentation, a comprehensive and sustainable digital conservation strategy remains in its formative stages.

Drawing from global and national precedents, this section outlines a forward-looking framework that integrates appropriate technologies, policy interventions, and participatory strategies tailored to Lahore's socio-technical landscape.

Table 5-2: Data Showing the Selection of Case-Studies within the Walled City of Lahore
Source: Author

Case -Study	Typology			Digital Tool			Goal		
	UNESCO World Heritage Site	Historic Monument	Open Space / Group of Building	Total Station	TLS	None	On-site Surveying/Documentation	Management /Monitoring	Rehabilitation /Regeneration
Barood Khana									
Sheesh Mehal									
Jogi Mohallah									
Wazir Khan Chowk									

5.10.1. Potential Technologies and Methodologies to Adopt

Developing a robust digital conservation framework for Lahore necessitates the adoption of a hybrid technological model—balancing cutting-edge tools with context-sensitive, resource-efficient methodologies.

Digital Survey and Documentation Tools

3D Laser Scanning and Photogrammetry can be used to create high-resolution, geometrically accurate models of historic structures, particularly vulnerable monuments such as the Shahi

Hammam, Wazir Khan Mosque, and Lahore Fort. These digital replicas aid in condition assessment, structural analysis, and restoration planning. UAVs and Drone Imaging can be deployed for urban-scale mapping of heritage precincts (e.g., Taxali Gate, Mochi Gate) to document roofscapes, circulation networks, and spatial density patterns. While GIS and Spatial Data Infrastructure (SDI) can support heritage zoning, spatial analytics, and integration with urban planning databases.

Data Integration and Modeling

Heritage Building Information Modeling (HBIM) platforms facilitate the integration of architectural data with material, historical, and environmental information, supporting informed conservation decisions. Digital Twins (Scaled) environments may not be immediately feasible, but pilot models could be developed for select heritage clusters to simulate environmental impacts, crowd movement, and structural behavior.

Archival and Narrative Technologies

Digital Repositories and Online Archives can house historical maps, architectural drawings, oral histories, and visual documentation, accessible to researchers, students, and the public. Interactive Story Maps and AR/VR Applications offer immersive experiences of lost or inaccessible heritage, enhancing both education and public engagement.

5.10.2. Considerations for Policy Development

The absence of a coherent, city-wide digital heritage policy is a significant gap in Lahore's conservation ecosystem. A strategic policy framework must address legal, institutional, infrastructural, and ethical considerations.

Regulatory Integration

Digital heritage practices should be formally embedded within existing heritage laws and urban planning regulations (e.g., Punjab Special Premises Act, Master Plan 2050). Create provisions for mandatory digital documentation prior to any alteration, demolition, or adaptive reuse of registered heritage assets.

Data Governance and Standards

Establish protocols for data collection, storage, interoperability, and access across institutions (e.g., WCLA, LDA, academia). Develop standardized metadata schemas, documentation templates, and quality assurance benchmarks for digital heritage records.

Institutional Coordination

Mandate inter-agency collaboration between municipal authorities, heritage departments, research institutions, and civil society. Encourage the creation of a centralized digital heritage coordination unit under the City District Government or Provincial Culture Department.

Legal and Ethical Frameworks

Ensure compliance with intellectual property rights, especially for community-contributed materials. Develop ethics guidelines for representing contested histories, minority heritage, and sensitive spatial narratives in digital formats.

5.10.3. Strategies for Stakeholder Engagement and Capacity Building

For digital conservation in Lahore to be effective and sustainable, it must transcend technocratic approaches and invest in inclusive governance, institutional learning, and community participation.

Stakeholder Mapping and Engagement

Identify and involve a broad spectrum of stakeholders, including residents, historians, architects, IT professionals, municipal planners, artisans, and youth groups. Establish multi-stakeholder heritage councils at the neighborhood level, ensuring community voices are integral to digital conservation decisions.

Capacity Building and Training

Partner with local universities (e.g., NCA, UET, LUMS) to create training programs in digital heritage technologies, including GIS, HBIM, and archival practices. Support vocational training for artisans, technicians, and conservation staff in using digital tools for restoration, maintenance, and documentation.

Knowledge Sharing and Innovation Ecosystems

Facilitate inter-city exchanges and knowledge-sharing platforms between Lahore and other South Asian or Middle Eastern cities engaged in digital heritage: Incubate startups and tech collectives that develop low-cost, open-source heritage tools tailored to local needs.

Public Awareness and Cultural Literacy

Launch digital storytelling initiatives, community mapping workshops, and school outreach programs to build public ownership of heritage. Use social media and mobile apps to promote participatory documentation and crowdsourced reporting of heritage degradation.

5.10.4. Conclusion

The future of heritage conservation in Lahore lies at the intersection of technological innovation, inclusive governance, and cultural sensitivity. While global models offer useful templates, Lahore's digital conservation framework must emerge from its historical trajectories, urban challenges, and socio-cultural dynamics.

Adopting fit-for-context technologies, formulating enabling policies, and investing in participatory infrastructures can transform Lahore's approach to conservation from a reactive and elite-centered model to a proactive, inclusive, and digitally empowered practice. Such a shift not only enhances the resilience of heritage sites but also repositions them as living, evolving elements of the urban fabric, central to questions of identity, justice, and urban sustainability in the 21st century.

Chapter 6: Conservation Techniques in the Historic Core of Lahore

6.1. CONCEPTUAL FRAMEWORK

6.1.1. Principles and Objectives

6.1.2. Integration of Digital Technology

6.2. DIGITAL DOCUMENTATION AND DATA ACQUISITION

6.2.1. Total Station

6.2.2. 3D Laser Scanning

6.2.3. Photogrammetry

6.3. DATA MANAGEMENT AND ANALYSIS 256

6.3.1. Digital Heritage Inventory

6.3.2. BIM for Historic Buildings

6.3.3. Data Integration and Interoperability

6.4. DIGITAL TOOLS FOR CONSERVATION PLANNING

6.4.1. Rationale for Digitalization in Heritage Contexts

6.4.2. Key Digital Tools and Applications

6.4.3. Condition Assessment and Monitoring

6.4.4. Risk Analysis and Mitigation Strategies

6.4.5. Intervention Planning and Simulation

6.5. PUBLIC ENGAGEMENT AND DISSEMINATION

6.5.1. Virtual and Augmented Reality Applications

6.5.2. Web-based platforms for Heritage Interpretation

6.5.3. Citizen Science and Crowdsourcing Initiatives

6. CONSERVATION TECHNIQUES IN THE HISTORIC CORE OF LAHORE

The historic core of Lahore represents one of the most significant urban heritage sites in South Asia. This densely urban quarter is enclosed within the remnants of the wall with its 13 gates and showcases the architectural, cultural, and social significance that has spanned over a millennium. Its grandeur spans from the Wazir Khan Mosque, Shahi Hammam, and Lahore Fort to the intricate vernacular residential typologies, along with Sikh and colonial era interventions. The historic core of Lahore is a testament to its identity and is increasingly threatened by unregulated developments and environmental degradation, socio-economic pressures, and neglect of cultural heritage.

In response to these threats and challenges, conservation techniques have gained prominence in policy and practice, tailored for the unique condition of the historic core of Lahore. These techniques range from traditional restoration and material restoration to digital technologies, community-led strategies, and integrated urban regeneration (Geng et al., 2023). The conservation of the historic core of Lahore remained a complex and complicated phenomenon due to its living urban character, where heritage buildings remain inhabited, commercialized, or repurposed, necessitating a dynamic approach that balances cultural continuity, socio-economic vitality, and architectural integrity.

This chapter explores the spectrum of conservation techniques employed in the historic core of Lahore, critically investigating their theoretical underpinnings, methodological adaptations, and practical implications. It underscores the intersection of international charters and local practices, the role of institutions such as WCLA, and the evolving discourse on context-sensitive conservation in post-colonial, urban South Asia. This study aims to contribute to a more nuanced, locally informed understanding of heritage conservation that will preserve the past while actively engaging with the present and future through discussions on specific materials and cultural contexts.

6.1. CONCEPTUAL FRAMEWORK

In developing countries like Pakistan, conventional preservation techniques are still used with cutting-edge technology. The most significant includes preventing the fundamental causes of degeneration, including light, dust, heat, and humidity. Indigenous techniques, such as protection from insects and human error, sunshine to prevent dampness and unnecessary plant growth, made it feasible to maintain heritage (Pocobelli et al., 2018).

Appropriate methods and work with rules and regulations are done by several organizations, such as PEPAC, AKDN, USAID, etc., under the observation of WCLA. The manual documentation practice is applied to some AKCSP projects in the Northern Areas of Pakistan. (Sulman, 2009). Fixing points or scars on the surviving fabric may frequently be used to identify missing structures and finishes, providing hints as to the shape of the older building. It is crucial to identify the layers of the previous building, which calls for close inspection. How readily and in what form adaptations and services can be built to enable suitable usage in the future will depend on the building and its finishing (Hankey, 1999). .

The consultant team must use effective survey methods, which are crucial before and after selecting the building for the conservation process. It is frequently impossible to scaffold a massive structure or to thoroughly inspect all potential flaws on just one façade. Before crucial decisions about price and reuse can be made, the owner must commit to completing the project and purchasing the necessary scaffolding.

6.1.1. Principles and Objectives

The conservation of the historic core of Lahore is based upon a holistic framework of internationally recognized heritage theories, adapted to the socio-cultural and urban conditions of Pakistan. The international charters, such as The Athens Charter International (1931), The Venice Charter (1964), The Washington Charter (1987), and The Burra Charter (2013), emphasize the importance of authenticity, integrity, community engagement, and sustainable development in heritage preservation (ICOMOS, 1987b). In the context of the Historic city of Lahore, these are further reinforced by National and provincial legislation such as the Antiquities Act 1975 and the Punjab Special Premises (Preservation) Ordinance 1985, and the regulatory mechanisms established by the Walled City Lahore Authority.

a. Principles

The core principles are as follows.

Authenticity and Integrity

Conservation efforts in the Walled City of Lahore seek to retain the authenticity and integrity of the historic monuments. In terms of design, materials, artisanship, and setting. The unique character of the Mughal. The Sikh and the colonial era are treated as a narrative rather than isolated aesthetic moments. The conservation of Shahi Hammam and Wazir Khan Mosque is the finest example, saved by the LDA, AKTC, WCLA, and other funding agencies. Here,

meticulous documentation, material analysis, and artisanal restoration were prioritized to save the original features.

Minimal Intervention and Reversibility

Minimal interventions are designed with reversible methodologies employed to preserve historic fabric. The approach aligns with Article 9 of the Venice Charter, advocating that additions must be distinguished from the original and avoid falsifying the historical narrative.

Contextual Sensitivity and Urban Continuity

Conservation efforts are not limited to individual structures but are extended to the urban morphology, street networks, and socio-economic practices. This approach reflects the principle in Historic Urban Landscape (HUL) recommendations (2011), which integrates heritage conservation into broader urban planning and development. The Royal Trail (Shahi Guzargah), for instance, balances pedestrianization, facade rehabilitation, and infrastructural upgrades while preserving traditional activities and spatial organizations.

Community-Centered Conservation

The role of local communities is central to the sustainability of conservation initiatives, as emphasized by UNESCO and ICOMOS. In the historic core of Lahore, local artisans and residents have been trained in craft revival programs, awareness campaigns, and capacity-building activities, ensuring that conservation is not a top-down imposition but a participatory and socially entrenched process.

Sustainability and Adaptive Reuse

The Walled City of Lahore is facing various challenges and pressures, resulting in an increasing embrace of sustainability and adaptive reuse. This includes the retrofitting of historic structures for compatible contemporary functions, such as converting Havelis to academic institutes, Studio activities for performing arts, and boutique accommodations, ensuring continued relevance and economic viability.

b. Objectives

The core objectives of conservation in the historic core of Lahore can be summarized as follows.

- To safeguard the unique and multi-layered urban heritage, ensuring fidelity to historical narratives across different periods of the city's evolution.

- To rehabilitate and regenerate the urban fabric of the historic city through grounded and ethically responsible techniques.
- To promote the revival of traditional craftsmanship, including fresco work, lime plaster, calligraphy, and wood carving, through training programs and active engagement of local artisans.
- To foster inclusive heritage governance, enabling local communities to contribute and benefit from conservation-led development.
- To institutionalize heritage management by strengthening legal, administrative, and financial frameworks.
- To position the heritage of the historic core of Lahore within national and global narratives, encouraging cultural tourism, academic research, and cross-cultural dialogue.

The conservation in the historic core of Lahore is envisioned as a technical exercise and multidimensional strategy that combines urban heritage, community empowerment, and sustainable development. The evolving collaborations between governmental authorities, international organizations, and civil societies testify to this integrated, future-oriented vision of heritage management.

6.1.2. Integration of Digital Technology

The development of digital technology has improved architectural heritage documentation, conservation, and preservation methods. According to several writers (Henchoz & Crank, 2018). Digital heritage is using digital media to preserve natural or cultural heritage. The UNESCO Charter on the Preservation of the Digital Heritage in 2003 also explains it further as: “The digital heritage consists of unique resources of human knowledge and expression. It embraces cultural, educational, scientific, and administrative resources, as well as technical, legal, medical and other kinds of information created digitally, or converted into digital form from existing analogue resources.”

The preservation of cultural heritage via the use of digital technology preserves the integrity and beauty of the built environment (Bertolin, 2019). Technology development has also made it possible to save and preserve both national and international cultural heritage. These new technologies have provided fresh perspective on the evolution and advancement of techniques for the conservation and preservation of cultural treasures. Modern technology has

a critical role to play in the protection, conservation, and conservation of intangible cultural property (Zachar et al., 2018).

6.2. DIGITAL DOCUMENTATION AND DATA ACQUISITION

It is necessary to find adequate alternative methods for recording monument data, scaled drawings, and restoration schedules on the fabrics. For the kinds of issues present in Lahore, photogrammetry is unaffordable costly. Only a select few structures would be worth the cost of photogrammetry, the North Picture Wall to the Fort is one such structure.

However, it is frequently possible to use rectified photography, particularly for interior elevations of buildings' courtyards or rooms. But taking effective photos of external elevations is sometimes exceedingly challenging due to tight streets, like in the Walled City (Khan, 2017).

If employing high-quality architectural lenses, a mix of photographic and manual survey approaches could be acceptable. This can offer enough drawing accuracy and long-lasting photographic imaging for historical records, repair schedule estimations, budgeting, and contractual paperwork. However, any mistake in the information from the pre-contract survey is likely to result in inaccurate budgets and insufficient post-contract control over the work's substance. This will ultimately have an impact on project costs and programming (LAH, 2018).

6.2.1. Total Station

Digital documentation and data acquisition are foundational steps in the conservation and management of heritage sites, ensuring accurate records of architectural and spatial attributes. The use of a Total Station—a high-precision electronic/optical instrument—is a widely adopted method in this process. Total Stations integrate electronic distance measurement (EDM) with angular measurements and data logging capabilities, enabling the collection of highly accurate spatial data, including three-dimensional coordinates of structural elements. In heritage documentation, this technology is particularly valuable for capturing detailed measurements of historic buildings, site topography, and complex architectural features, often in challenging environments where other instruments may be limited. The data acquired can be processed to generate detailed plans, elevations, and 3D models, forming a critical part of the digital archive used for analysis, monitoring, and virtual reconstruction.

6.2.2. 3D Laser Scanning

With the help of a connected digital camera, three-dimensional laser scanning technology produces a quick, accurate three-dimensional model of the scanned piece in

addition to providing texture data. Applications for laser scanners in cultural heritage documentation range from little artifacts to huge complex buildings. The output data from the scanner is provided in a variety of forms, making it simpler to manipulate it with multiple programs (Badenko et al., 2017).

3D scanners quickly and precisely digitize physical items. As a result of supporting a variety of computer software formats, the final model is simple to alter. It is a useful tool for inspecting intricate components and forms. The drawbacks of this method include the fact that it is more expensive than manual surveying. The generated data includes so many points that a large memory card is required.

Terrestrial Laser Scanner

Since the 1980s, 3D scanning has been a popular technique in cultural heritage documentation. Laser scanners are robotic total stations that can acquire data from targets at high speeds and in short time, based on distance and angle measurements. They have a field of view like human eyes and can be controlled by computers and integrated with GPS. Laser scanners have a wide range of applications, from small objects to large complex buildings (Patias, 2006).

They offer real-time data acquisition, high accuracy, and high speed, producing large amounts of points. The documentation process involves three steps: field survey and data acquisition, editing and data processing, integrating point clouds, and producing final outputs like measurements, sections, texture, 2D drawings, and solid 3D models. The application and capabilities of laser scanners are continuously developing (Patias et al., 1996).

Laser scanning is a highly efficient technique compared to theodolites, offering high speed in data acquisition and better results for detailed irregular objects. It can be used independently or in combination with other techniques according to project needs (Rüther et al., 2003). However, laser scanners have limitations in documenting surfaces with sharp edges, color and texture data, and areas with obstacles or hidden points. Integrating scanning results with image data can complicate the process. Reflective surfaces, such as those with water absorption near the IR spectrum, can also affect data accuracy.

LIDAR, introduced by NASA in 1970, is a developing technology for producing digital surface models (DSM) at a high speed. It can scan a region in a stripe pattern, integrating scanned stripes to provide a point cloud model of the region. This data acquisition system functions based on measuring distance with a laser beam (Duca & Machado, 2023).

Despite its advantages, laser scanners have limitations in documenting surfaces with sharp edges, color and texture data, obstacles, and reflective surfaces. Additionally, their large size and minimum laser beam range limit their application in small interior spaces. High costs, skilled operators, and time-consuming post-processing are also limitations of laser scanners.

Modelling Combination

The tools described in this area utilize both image-based approaches with a photogrammetry foundation and non-image-based techniques that scan the target by beaming a signal to the surface. They share the structure and features of both prior categories. In order to do this, these technologies attempt to address the shortcomings and issues of two other groups (Hassani, 2015).

6.2.3. Photogrammetry

Techniques for analyzing, measuring, and modeling things based on their captured photographs make up photogrammetry. A multi-image photogrammetric technique is called a panorama. The model of this technique addresses the issues with 3D modeling by using image-based rendering as opposed to model-based rendering. By maintaining a calibrated and continuous camera adjustment, panorama photos may show dimensions. The issues with picture stitching and overlapping were solved by using this technique (Bruno et al., 2017).

Uses for panoramic photography include documentation, instruction, tourism, and showcasing historic structures and locations. The capacity of this technology to store data for a vast object with the use of few photographs is by far its most significant benefit. Other benefits of this approach include low costs, short implementation times, ease of use in GIS, ability to show data on web sites, and high user appeal. On the other hand, this technology has some drawbacks, including enormous image sizes that need a lot of memory, the requirement for viewer software, restrictions on mobility in interior places, and limitations on the camera angle (Younus et al., 2023b).

Advantages of panoramic photogrammetry

It includes It may record information about items that are inaccessible. It is reasonably priced. It is timely and effective. Geographic information systems are offered. It may be displayed on web pages and draw visitors.

Panoramic photogrammetry's challenges

The pictures are big, requiring a lot of memory. Software for viewers is required. The camera's field of view is constrained

Close-range Photogrammetry

Photogrammetry is an independent method used in documentation, based on at least two images with overlapped data, which ensures the triangulation process. It aims to simplify and speed up the recording and processing of data by providing color, texture, and metric data of objects of different sizes and complexity in a short time. This technique can be used when access to the object is limited or direct measurements would threaten it.

Using high-accuracy cameras has made the close-range photogrammetric process easier and more cost-effective. Close-range photogrammetry can generate 3D models of targeted objects, which can be used to create a 3D archive and answer various documentation goals. Applications of photogrammetry in archeology and heritage conservation include documenting historic buildings and small artifacts, measuring facades, providing color and texture data, measuring deformation of buildings, analyzing changes, and predicting future changes (Baik et al., 2013b).

Photogrammetry offers advantages such as ease in creating archives for future needs, large amounts of data, high accuracy, 3D models, metric and vector data of object texture, geographical data, and low-cost and portable equipment. However, disadvantages include being sophisticated for non-expert users, influenced by camera accuracy and resolution, and limited applicability due to lack of proper points for photography or hindrance. In these cases, photogrammetry should be combined with other techniques (Dore & Murphy, 2017).

6.3. DATA MANAGEMENT AND ANALYSIS

Effective data management and rigorous methodologies are elements of conservation initiatives in the historic core of Lahore. The architectural heritage, socio-economic dynamics, and evolving urban structures, collaborating with the collection, organizing, and interpretation of diverse data sets, are essential for decision-making and sustainable heritage.

Data Collection and Sources

The information pertaining to this particular case study was collected from both primary and secondary sources. Primary data collection involved conducting comprehensive field surveys, preparing architectural plans, taking photographs, conducting material evaluations,

and holding stakeholder interviews. All of these were performed in the various neighborhoods of the Walled City and in sections of the Royal Trail, as well as Chowk Wazir Khan and near Delhi Gate. Particular attention was paid to documenting the accompanying construction techniques, alterations of historic structures, the use patterns, and community interaction with heritage assets.

The secondary data was collected from archival documents, published conservation reports like the Walled City of Lahore Authority reports or UNESCO assessments, academic publications, municipal documents, and their plans, as well as cadastral books. Spatial information such as old maps, and modern satellite photos, alongside other spatial data were also used to monitor the modification of the town and define areas of fundamental heritage importance.

Data Management Techniques

The collected data's intricacy and diversity necessitated a systematized framework of primary data management. A geographic information system (GIS) was employed to organize spatially and visualize data concerning building types, the level of conservation work carried out, the zones marked as heritage, and the level of serviced and usage pattern.

Digital technologies such as AutoCAD, SketchUp, and photogrammetry software were employed to produce detailed architectural drawings, 3D models, and condition maps. These devices permitted accurate documentation of the façade details, structural damage condition, and intervention. The application of Building Information Modelling (BIM) was also tested for some samples to model structural response, evaluate repair and plan maintenance (Fatiguso et al., 2017).

Narrative and observational qualitative data were coded and analysed thematically in softwares such as NVivo which allowed the author to identify recurring local communities' concerns, value and resistance over conservation practices.

Analytical Framework

The theoretical framework employed in this study is multidisciplinary, integrating architectural analysis, urban studies, theory on heritage and socio-economic impact assessment. Needs for conservation were assessed according to a set of indicators derived from

international best practices (e.g., UNESCO, ICOMOS) and contextual realities of Lahore. These indicators included:

- Structural stability and material integrity
- Historical authenticity and legibility
- Social functionality and community value
- Environmental performance and resilience
- Legal and administrative protection status

Data were analysed using spatial and temporal analysis. In contrast, spatial analysis identified the heritage concentrations, risk-prone areas (sites with maximum encroachments) and potential corridors for conservation-led regeneration, and temporal analysis examined the evolution of conservation practices, building transformations, and changes in land use patterns over time.

Synthesis and Interpretation

The synthesis of quantitative and qualitative data discovered the pattern of deterioration, intervention disparities, and areas of conservation urgency. For instance, spatial analysis showed the structures with high heritage value, located along secondary streets and back lanes. Furthermore, the stakeholders' interview highlighted tension between regulatory authorities and residents, particularly displacement fears and access restrictions during the restoration process.

The findings were triangulated to develop a comprehensive conservation assessment matrix, which guided the prioritization of conservation actions and formulation of context-sensitive strategies. This analysis highlighted the importance of adopting holistic and participatory approaches for physical restoration with socio-economic revitalization and urban infrastructure improvement by including digital technologies.

6.3.1. Digital Heritage Inventory

6.3.2. BIM for Historic Buildings

Integrating Building Information Modelling (BIM) into the conservation of historic buildings within the historic core of Lahore represents a significant advancement in the documentation, analysis, and management of heritage structures. While traditionally associated with modern construction and design optimization, BIM has increasingly been adapted for

heritage applications—often called Heritage or Historic BIM (HBIM)—enabling a data-rich, multidimensional understanding of complex historic environments.

Rationale for BIM in Heritage Conservation

The historic fabric of Lahore, particularly within the Walled City, is characterized by dense urban morphology, intricate architectural details, and overlapping historical layers. These attributes present unique challenges to conservation, including limited access to documentation, ambiguity in structural integrity, and the need for context-sensitive intervention. BIM offers a solution to these challenges by facilitating digital reconstruction, simulation, and lifecycle management of heritage buildings.

Unlike traditional 2D documentation methods, BIM enables the creation of 3D parametric models embedded with metadata relating to materials, structural systems, deterioration patterns, historical phases, and intervention history. This level of detail supports more accurate condition assessments, enhances communication among stakeholders, and informs strategic decision-making throughout the conservation process.

Methodology and Application

In the context of Lahore, select case studies—including segments of the Royal Trail, Shahi Hammam, and Wazir Khan Mosque precinct—have been modelled using HBIM workflows. These models were developed through a combination of laser scanning, photogrammetry, and manual surveys, which were used to generate accurate point clouds and geometry. Software platforms such as Autodesk AutoCAD and Scan-to-BIM tools were employed to convert this data into structured digital models.

Each HBIM model was configured to incorporate:

- Architectural elements (walls, arches, columns, domes)
- Construction materials and finishes (lime plaster, sandstone, glazed tilework)
- Structural condition indicators (cracks, deflections, moisture ingress)
- Chronological data (phases of construction, historical modifications)
- Maintenance records and past interventions

This digital environment allowed for the simulation of potential conservation strategies, risk assessments, and long-term maintenance planning. Moreover, HBIM models facilitated

interdisciplinary collaboration by serving as a shared platform for architects, engineers, conservation specialists, and heritage managers.

Advantages and Limitations

The adoption of BIM for historic buildings in Lahore offers several key benefits:

- **Precision and Comprehensiveness:**

High-resolution documentation of architectural and structural features, essential for restoration planning.

- **Data Centralization:**

All information regarding a heritage asset is consolidated within a single digital model, reducing fragmentation.

- **Scenario Simulation:**

Allows for testing different conservation approaches (e.g., structural reinforcement methods) before physical implementation.

- **Lifecycle Management:**

Enables long-term tracking of interventions, condition changes, and maintenance needs.

However, several challenges also emerged during the application of HBIM in the local context:

- **Data Gaps and Uncertainty:**

Incomplete archival information and undocumented modifications often necessitate interpretive modelling.

- **Software Limitations:**

Many BIM tools are not natively designed for irregular geometries and non-standard construction typologies common in historic structures.

- **Capacity and Resources:**

The successful implementation of HBIM requires technical expertise, hardware capacity, and cross-sectoral training—resources that are often limited within public heritage bodies.

Prospects

The potential of HBIM in the historic core of Lahore is considerable. As digital infrastructure and technical capacity expand, HBIM can play a transformative role in heritage conservation, supporting not only documentation and analysis but also virtual heritage initiatives, public engagement, and educational outreach. Furthermore, its integration with GIS, IoT sensors, and environmental simulation tools may enable predictive maintenance, risk monitoring (e.g., seismic vulnerability, humidity control), and innovative heritage management.

To fully realize this potential, there is a pressing need for institutional investment in capacity-building programs, the development of local HBIM standards, and the formation of multi-disciplinary teams that can bridge the gap between digital innovation and heritage ethics. When strategically deployed, BIM has the power to modernize conservation practices in Lahore, while preserving the rich historical and cultural narrative embedded in its built environment.

6.3.3. Data Integration and Interoperability

In the context of heritage conservation within the historic core of Lahore, data integration and interoperability are critical components for achieving coherent, scalable, and sustainable conservation strategies. The multiplicity of stakeholders, data formats, and analytical tools involved in conservation projects necessitates a coordinated approach to data management that enables seamless exchange, alignment, and cross-disciplinary collaboration. This section explores the mechanisms and frameworks through which diverse data sets—ranging from architectural surveys and geospatial mapping to historical records and community inputs—are integrated and rendered interoperable within a conservation ecosystem.

Nature of Conservation Data

Conservation projects within the Walled City of Lahore generate heterogeneous data spanning multiple domains:

- Geospatial data (cadastral maps, spatial zoning)
- Architectural and structural data (measured drawings, BIM models, 3D scans)
- Historical documentation (archival records, maps, photographs)
- Material science data (composition analysis, deterioration mapping)

- Socio-economic and ethnographic data (stakeholder interviews, land use, demographics)

Each data set is often generated using different tools, stored in varied formats, and owned by different institutions or agencies. Without a robust integration framework, the fragmentation of such data hampers holistic analysis, informed decision-making, and long-term management.

Integrated Data Framework

To address this challenge, an integrated data framework was adopted in this research, incorporating interoperable digital platforms and standardized data protocols. Geographical Information Systems (GIS) was a foundational layer for spatially referencing all conservation data. GIS platforms, such as ArcGIS and QGIS, were used to consolidate architectural, infrastructural, and environmental data into a unified spatial interface.

Parallely, Building Information Modelling (BIM) tools such as Autodesk Revit and Navisworks were used to develop 3D parametric models of key historic structures. The integration of BIM and GIS, achieved through formats like IFC (Industry Foundation Classes) and City GML, allowed for spatial and structural data to coexist within a shared environment, facilitating both macro-scale urban analysis and micro-scale building diagnostics (Fondazione et al., 2009).

Metadata tagging and standard naming conventions were employed to ensure consistency across platforms. These metadata included information about data origin, acquisition method, accuracy, scale, and update frequency. Integration was further enhanced through Application Programming Interfaces (APIs) and data translation tools, which enabled interoperability between disparate systems and formats.

Inter-Institutional Collaboration and Data Sharing

One of the critical dimensions of interoperability in Lahore's conservation landscape is institutional cooperation. The involvement of multiple agencies—including the Walled City of Lahore Authority (WCLA), Punjab Archaeology Department, Lahore Development Authority (LDA), and international partners such as UNESCO and the Aga Khan Trust for Culture (AKTC), necessitated the establishment of everyday data environments (CDEs) and data-sharing protocols.

Pilot projects such as the Shahi Guzargah Corridor demonstrated the value of interoperable platforms for real-time coordination between heritage architects, engineers, planners, and policymakers. The establishment of a digital conservation repository under the WCLA facilitated centralized access to drawings, condition reports, and intervention records, fostering institutional memory and project continuity.

Benefits and Challenges

Benefits of integrated and interoperable data systems in conservation include:

- **Holistic decision-making:** Synthesizing data from multiple domains provides a comprehensive understanding of site conditions, stakeholder concerns, and historical evolution.
- **Reduced redundancy:** Avoids duplication of data collection efforts and promotes data reuse across projects.
- **Enhanced transparency and accountability:** Shared data environments increase visibility of conservation interventions, budgets, and performance metrics.
- **Improved risk management:** Integrated systems support predictive analytics and risk simulations (e.g., structural failure, water ingress, environmental degradation).

However, significant challenges persist:

- **Lack of standardization:** Absence of nationally adopted heritage data standards results in inconsistencies in format, scale, and terminology.
- **Technological disparities:** Varying levels of digital literacy and resource availability across institutions hinder seamless integration.
- **Data sensitivity and ownership:** Legal and bureaucratic restrictions on data sharing can impede collaboration, particularly for historic maps and land ownership records.

Toward a Digital Heritage Ecosystem

To overcome these limitations and move toward a fully interoperable digital heritage ecosystem, the thesis advocates for:

- **Development of national heritage data standards aligned with international frameworks** (e.g., CIDOC-CRM, ISO 19115 for metadata)

- Investment in capacity-building programs focused on digital tools, data management, and collaborative workflows
- Establishment of a centralized digital heritage portal governed by the WCLA or a multi-stakeholder consortium, facilitating secure access, visualization, and analysis of conservation data.

Ultimately, the integration and interoperability of conservation data not only enhance the technical efficiency of heritage interventions in Lahore but also strengthen institutional resilience, public transparency, and long-term cultural sustainability.

6.4. DIGITAL TOOLS FOR CONSERVATION PLANNING

The increasing complexity of the conservation threats and challenges in the historic core of Lahore has necessitated a shift from conventional methodologies to digitally enabled conservation planning. The integration of digital tools has significantly enhanced accuracy, precision, efficiency, and strategic coherence of conservation efforts. These technologies facilitate comprehensive documentation, condition assessment, monitoring, stakeholders' engagement, and simulation of conservation interventions, bridging the gap between heritage theory and modern developments (Chan, 2011).

6.4.1. Rationale for Digitalization in Heritage Contexts

The historic core of Lahore comprises a dense, multi-layered architectural typology that includes Mughal monuments, Sikh-era structures, colonial edifices, and vernacular housing. The decay of the historic assets, combined with pressures of urbanization, inadequate infrastructure, and socio-economic transformations, requires timely and informed conservation decisions. Digital tools offer multi-scalar visibility, capturing macro-level urban patterns and micro-level material vulnerabilities. The integrated conservation planning based on digital tools is sensitive to tangible and intangible heritage values.

6.4.2. Key Digital Tools and Applications

Various digital tools have been employed in the current conservation initiatives in Lahore, particularly within the historic core of Lahore under the umbrella of WCLA, AKTC, and international collaborations. These tools span across different stages of the conservation workflow.

Spatial Analysis

Visual and pictorial surveys have been conducted to analyse the spatial distribution of heritage assets, infrastructural systems, and risk factors such as encroachments, traffic congestion, and drainage issues. The spatial mapping helps us to identify historical significance, structural conditions, and vulnerability. The examples include the delineation of Special Premises Zones and the mapping of cultural routes like the Royal Trail (Shahi Guzargah).

3D Laser Scanning and Photogrammetry

High-resolution documentation using terrestrial laser scanning and photogrammetry enables accurate 3D models of monuments and streetscapes. This technology has been instrumental in digitally preserving structures such as Shahi Hammam and Wazir Khan Mosque, allowing for detailed analysis of architectural elements, structural deformations, and surface deterioration. These models serve as baseline documentation and can support virtual reconstruction and future restoration efforts.

Historic Building Information Modelling (HBIM)

Building Information Modelling has been adapted for heritage contexts to model historic monuments with embedded information on materials, structural behaviour, and conservation history. BIM enhances decision-making by enabling scenario simulations, interdisciplinary collaborations, and the lifecycle of heritage structures.

Digital Heritage Databases and Archives

Creating digital repositories, including annotated image libraries, architectural drawings, historical maps, and intervention records, has enabled better archiving, retrieving, and disseminating heritage information. WCLA has initiated steps towards digitizing its documentation and making it accessible for the researchers, planners and policy-makers.

Mobile Applications and Community Mapping

Community engagement tools such as mobile data collection apps (e.g., Survey123, KoboToolbox) have been used to involve residents in mapping traditional knowledge, recording heritage narratives, and identifying culturally significant sites (Murphy & others, 2023). This participatory approach ensures that conservation planning is inclusive and socially grounded.

Benefits of Digital Tools in Conservation Planning

Integrating digital tools has led to significant improvements in conservation planning across several dimensions:

- **Accuracy and Detail:** Enables high-fidelity documentation and analysis, essential for evidence-based interventions.
- **Time and Cost Efficiency:** Digital workflows accelerate survey, assessment, and planning processes while reducing manual redundancies.
- **Risk Mitigation:** Early detection of vulnerabilities and predictive modeling prevent future damage and loss.
- **Visualization and Communication:** 3D models and interactive maps aid in communicating conservation goals to stakeholders, funders, and the public.
- **Monitoring and Evaluation:** Tools enable continuous tracking of building conditions, project progress, and performance metrics.

Challenges and Limitations

Despite their advantages, deploying digital tools to conserve the living heritage of the Walled City of Lahore has several limitations.

- **Technical and Institutional Capacity:** Many heritage organizations lack the trained personnel, software licenses, and hardware required for sustained digital operations.
- **Data Fragmentation:** Disconnected platforms and inconsistent standards hinder data interoperability and reuse.
- **Cost and Sustainability:** High upfront technology acquisition costs and uncertain long-term maintenance plans can limit scalability.
- **Ethical Considerations:** The use of technology must be balanced with cultural sensitivity, data privacy, and respect for local knowledge systems.

Strategic Recommendations

The strategic recommendations for evaluating digital tools for conservation planning in the historic core of Lahore are.

- Institutional investment in digital infrastructure and training programs, particularly within public-sector conservation bodies.

- Development of heritage-specific digital standards and protocols, ensuring consistency and interoperability.
- Integration of digital tools into statutory conservation planning processes, supported by updated legislation and governance models.
- Public-private-academic partnerships, facilitating innovation, resource pooling, and capacity development.

In the conclusion, the strategic use of digital tools represents a paradigm shift in conservation planning, enabling data-driven collaboratives and adaptive heritage management, for cities like Lahore, where the richness of the past meets the challenges of modernity, such as tools are not merely technical assets but instruments for shaping an inclusive, resilient, and culturally rooted urban future.

6.4.3. Condition Assessment and Monitoring

Effective conservation of built heritage in the historic core of Lahore necessitates accurate and ongoing condition assessment and monitoring to detect structural vulnerabilities, material degradation, and environmental impacts. Digital tools offer non-invasive, scalable, and highly detailed methodologies that significantly enhance the reliability and repeatability of such assessments.

Techniques like 3D laser scanning and photogrammetry are routinely employed to capture high-resolution data on building geometry, surface textures, and anomalies like cracks, displacements, or moisture ingress. These tools have been applied to key heritage structures along the Shahi Guzargah, including the *Wazir Khan Mosque* and *Shahi Hammam*, to create comparative visual records over time.

Additionally, remote sensing and drone-based surveys offer a broader spatial perspective, identifying deterioration patterns not visible at ground level, especially in dense urban conditions. These are complemented by BIM-based documentation systems, where digital models can be continuously updated to reflect the evolving condition of each structural component.

Sensors and IoT-based monitoring systems, though currently limited in Lahore, have shown potential in other contexts for recording real-time data on temperature, humidity, structural movement, and vibration. Their future incorporation could significantly enhance predictive conservation strategies. Through periodic digital assessments, deterioration trends can be

visualized and quantified, creating a feedback loop that informs maintenance scheduling and risk prioritization. This shift from reactive to proactive conservation enhances the long-term sustainability of interventions.

6.4.4. Risk Analysis and Mitigation Strategies

Digital tools also play a pivotal role in conducting risk analysis for heritage assets in Lahore, allowing stakeholders to anticipate and mitigate both natural and anthropogenic threats. The complexity of the Walled City—characterized by narrow streets, aging infrastructure, and high population density, renders it vulnerable to multiple risk factors, including seismic activity, flooding, fire, illegal alterations, and infrastructural encroachments.

GIS-based multi-risk mapping enables spatial overlay of hazard zones (e.g., flood-prone areas, fire risk zones), structural vulnerabilities, and socio-economic indicators. These analyses help identify conservation priority zones and critical intervention sites. For example, integrating rainfall data with drainage infrastructure maps has helped highlight zones susceptible to waterlogging and subsequent material decay.

Structural risk modeling, supported by finite element analysis (FEA) within BIM platforms, is increasingly used to simulate stress responses of historic buildings under seismic loads or foundation settlement scenarios. These simulations provide invaluable insights into potential failure mechanisms and enable pre-emptive reinforcement planning.

Furthermore, risk analysis is enhanced by crowdsourced data and community reporting platforms, which can rapidly identify emerging issues (e.g., cracks, illicit construction, fire incidents) that may otherwise go unnoticed by formal agencies. Digital tools also support the design of risk mitigation strategies, including reinforcement proposals, zoning regulations, and urban design adjustments, thereby reducing vulnerability while maintaining the historical integrity of the urban fabric.

6.4.5. Intervention Planning and Simulation

A major strength of digital tools in conservation planning lies in their capacity to simulate potential interventions and evaluate their implications before physical implementation. This allows for evidence-based decision-making that minimizes damage to heritage fabric while optimizing structural and functional outcomes.

BIM and HBIM platforms enable virtual prototyping of conservation actions such as crack stitching, underpinning, façade consolidation, and material replacement. Each intervention can

be assessed for structural effectiveness, visual compatibility, and long-term maintenance implications. In the conservation of the *Wazir Khan Chowk*, for instance, digital simulations were used to test paving materials, drainage solutions, and lighting layouts without disturbing the physical site during the planning phase.

Digital twins, where real-time monitoring data is linked to a dynamic 3D model, further allow simulation of environmental and structural impacts over time—making it possible to compare the long-term outcomes of different intervention strategies. Such tools are particularly useful for evaluating the consequences of modern additions (e.g., HVAC systems, signage, or fire protection devices) on historic buildings.

Energy analysis tools (e.g., Autodesk Insight, DesignBuilder) are also being used to assess the environmental performance of traditional building envelopes, informing passive retrofitting strategies that enhance occupant comfort without compromising authenticity.

In addition, **augmented reality (AR)** and **virtual reality (VR)** platforms offer immersive visualization of intervention outcomes, enhancing stakeholder engagement and enabling public consultation processes. These tools can help local communities, heritage authorities, and funding bodies better understand proposed conservation actions and their impact on heritage values.

In summary, digital tools transform conservation planning from a static and reactive discipline into a dynamic, data-informed, and participatory process. Integrating condition monitoring, risk simulation, and intervention planning within digital ecosystems supports more resilient, adaptive, and context-sensitive heritage management in Lahore’s historic core.

6.5. PUBLIC ENGAGEMENT AND DISSEMINATION

Public engagement is a critical dimension of heritage conservation, particularly in historically dense and culturally rich urban environments like the Walled City of Lahore. The sustainability and legitimacy of conservation initiatives are significantly enhanced when local communities, stakeholders, and the broader public are meaningfully involved in the processes of heritage understanding, interpretation, and stewardship. Digital technologies have increasingly expanded the scope and efficacy of public engagement by offering immersive, interactive, and accessible tools for knowledge dissemination and participatory conservation.

This section explores how emerging technologies, particularly Virtual and Augmented Reality (VR/AR), web-based heritage interpretation platforms, and citizen science initiatives, have

been or can be leveraged to foster deeper public engagement in the conservation of Lahore's historic core.

6.5.1. Virtual and Augmented Reality Applications

Virtual Reality (VR) and **Augmented Reality (AR)** have emerged as powerful tools for heritage visualization, interpretation, and education. In the context of the historic core of Lahore, these technologies offer the potential to reconstruct and communicate the layered historical narratives of urban spaces and monuments, many of which have suffered physical degradation or transformation over time.

Virtual reconstructions of heritage sites—such as the *Wazir Khan Mosque*, *Delhi Gate*, and *Shahi Hammam* can be developed using data derived from 3D laser scanning, photogrammetry, and archival research. These reconstructions allow users to experience historically accurate spatial environments, either through immersive VR headsets or interactive desktop platforms. For instance, a virtual tour of the Shahi Guzargah corridor could enable users to visualize its evolution across different historical periods, enhancing public understanding of its cultural significance.

Augmented Reality applications, when deployed on mobile devices or through AR-enabled kiosks at heritage sites, allow real-time overlay of historical imagery, architectural annotations, and conservation information on the existing physical environment. Visitors can thus perceive hidden layers of architectural detail or understand changes that have occurred due to decay or interventions—bridging the gap between past and present in a highly accessible manner.

Moreover, VR and AR experiences have a significant educational impact, particularly for school and university students, tourists, and diasporic communities. They democratize access to heritage by overcoming physical, geographic, or socio-economic barriers, thereby broadening the audience for heritage appreciation and advocacy.

6.5.2. Web-based platforms for Heritage Interpretation

Web-based platforms have become essential channels for digital heritage communication, enabling continuous engagement with diverse publics through interactive, multimedia-rich experiences. In Lahore, where conservation efforts often contend with limited public awareness and institutional transparency, such platforms offer a scalable and cost-effective mechanism for knowledge dissemination and stakeholder outreach.

These platforms typically integrate:

- **Interactive maps and timelines** that trace the evolution of heritage zones.
- **Archival materials** (e.g., historic photographs, drawings, oral histories).
- **Digital storytelling modules**, showcasing narratives of buildings, artisans, and communities.
- **Access to conservation documentation**, including before-and-after comparisons, reports, and project milestones.

Institutions such as the Walled City of Lahore Authority (WCLA) have begun to establish digital archives and portals to enhance public visibility of their conservation efforts. However, there remains substantial potential to expand these into more dynamic platforms that incorporate user-generated content, feedback mechanisms, and integration with social media for wider dissemination.

Furthermore, open-access digital repositories developed in collaboration with academic institutions, NGOs, and international partners can serve both research and public education functions. These platforms can also support digital literacy in heritage by offering tutorials, toolkits, and resources for students, practitioners, and community members.

6.5.3. Citizen Science and Crowdsourcing Initiatives

Citizen participation in heritage conservation is increasingly facilitated through crowdsourcing and citizen science initiatives, which harness local knowledge and public interest to gather data, report issues, and co-create heritage value. These approaches are particularly practical in contexts like Lahore, where formal heritage documentation is often incomplete and resources are limited.

Crowdsourced mapping projects using tools such as Open Street Map or custom mobile apps can enable residents to identify heritage structures, traditional shops, crafts, or historic pathways. Such community-contributed data not only supplements official inventories but also brings attention to undervalued or threatened cultural assets.

Citizen reporting platforms allow users to document deterioration, encroachments, or illicit construction in real time, creating an informal surveillance mechanism that supports the efforts of conservation authorities. These platforms can be integrated with institutional GIS systems to update hazard maps and prioritize interventions.

Oral history and memory mapping initiatives are another form of citizen engagement, where residents contribute stories, photographs, or recollections associated with particular sites. This

participatory documentation enriches the intangible dimension of Lahore's heritage and fosters a stronger sense of ownership among local communities.

The success of such initiatives depends on trust-building, transparency, and inclusivity, ensuring that the contributions of diverse community groups—including women, artisans, youth, and minorities—are recognized and valued. Capacity-building workshops, digital training sessions, and incentive-based participation schemes can further strengthen community involvement.

Conclusion

The integration of VR/AR technologies, web-based heritage platforms, and citizen science initiatives represents a transformative approach to public engagement in conservation. These tools not only enhance access to heritage knowledge but also democratize conservation processes, positioning local communities as active stewards rather than passive observers. In the case of Lahore's historic core, where heritage is deeply embedded in everyday urban life, such engagement strategies are essential to cultivating shared responsibility, cultural continuity, and long-term resilience.

Chapter 7: Implementation and Validation of the Framework

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7. IMPLEMENTATION AND VALIDATION OF THE FRAMEWORK

The International, regional, national and local case studies have been done to develop a Digital Conservation framework (DCF) for the HCL. An urban square named Mai Eidaan Courtyard has been selected as a pilot case study to implement and validate the proposed DCF and it is situated in the Shahi Mohallah near Lahore Fort. It has been selected due to its socio-cultural significance, diverse architectural typologies, and persistent conservation challenges, particularly in terms of the historic environment and adaptive reuse of significant structures. The implementation process involved advanced digital documentation techniques, utilizing 3D laser scanning and Historic Building Information Modelling (HBIM). The techniques were integrated into unified digital platforms, enabling the creation of detailed 3D Models and facilitating a data-driven approach to heritage conservation (Lu et al., 2023).

The results of the pilot project are critically analysed, focusing on the accuracy, precision, completeness, and practical utility of the digital conservation. Focus is given to how the integrated platform supported the identification of conservation priorities and well-defined strategic decision-making. Further validation of the framework was achieved with the involvement of stakeholders, including evaluation by heritage experts, community feedback, and reviews by relevant Government and institutional bodies. Refining the proposed framework ensured the approachability to local needs, cultural contexts, and institutional capacities.

A comprehensive analysis with traditional conservation approaches is also presented, assessing the relative effectiveness, economic viability, and potential for scalability of the proposed framework. This is followed by a focus examination of the digital conservation outputs for Mai Eidaan Courtyard, including virtual simulations and structural assessments.

The implementation and validation of the proposed digital conservation framework led to the conclusion, drawn by exploring the framework's integration into urban development strategies, recommendations for large-scale implementation, and a forward-looking perspective on future technological integrations, such as virtual reality, and the concept of a city-wide digital twin. It also explored the impacts of a digitally empowered approach for enhancing heritage conservation practices, offering a replicable model for other historic urban centers.

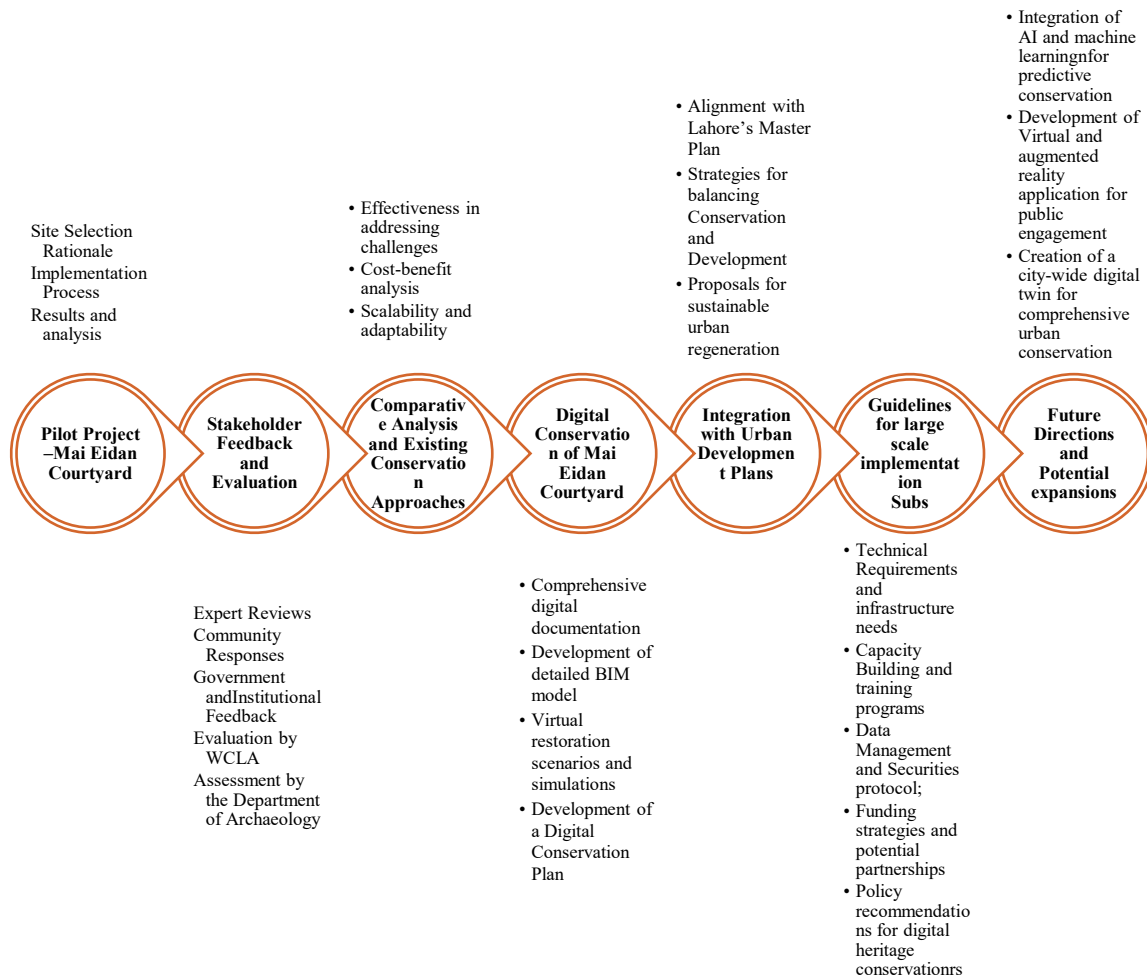


Diagram 7-1: Flowchart showing the Implementation and validation Process for Digital Conservation Framework

7.1. PILOT PROJECT: APPLICATION TO THE MAI EIDAAN COURTYARD

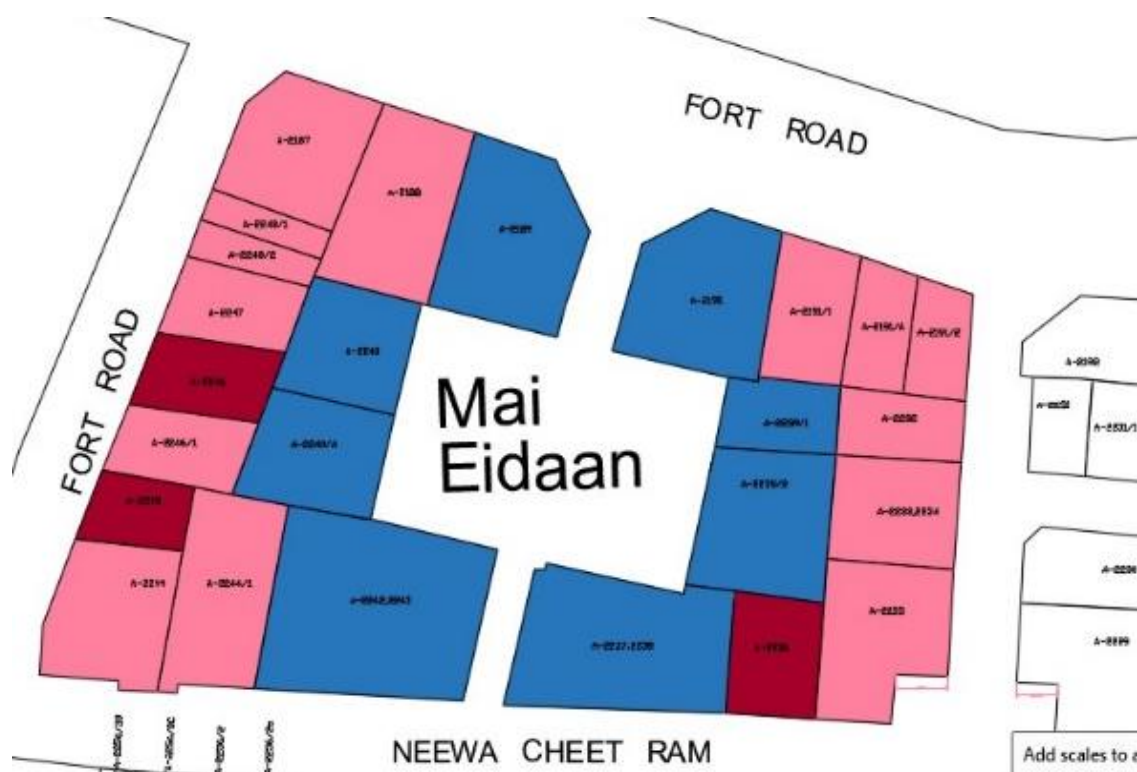
This study contributes to presenting a framework for digital documentation of the historic monuments and urban built heritage using Terrestrial Laser Scanner (TLS), with a particular focus on Mai Eidaan Courtyard. Historic cities in Pakistan are facing multiple challenges in terms of sustainability. Currently, heritage conservation is a dire need due to the energy crisis, as it secures its benefits for future generations. The selected site for the pilot project is in the historic core of Lahore, comprising a group of buildings with significant architectural, historical, commercial, and religious value. These buildings serve as a landmark of adaptive reuse within the historic context, with significant value as a destination for urban tourism.

The study examines the potential, constraints, and limitations of TLS in capturing architectural details and socio-cultural characteristics by utilizing digital technologies such as

Terrestrial Laser Scanners (TLS), thereby contributing to the broader discourse on digital preservation practices. It also enables monitoring, maintenance, and data availability to the stakeholders through heritage preservation and virtual modelling. The research will help to bridge the gap between conservation practices and the sustainable development of historic cities, with a focus on documentation techniques and underscoring the significance of the interdisciplinary collaborations among the stakeholders.

7.1.1. Site Selection Rationale

Mai Eidaan Courtyard is in the close vicinity of Lahore Fort in Shahi Mohallah and accessible from the Fort Road and Neewan / Nichean Chait Ram Road. The area has been revitalized as Food Street, and now the courtyard is part of it, featuring both religious and commercial activities. The urban square serves as a cultural hub, acting as a nexus for both religious and commercial activities. The main access is from the Fort Road through a 15-foot-wide road, located opposite the entrance of the Badshahi Mosque, designated for the marriage solemnizer (Nikah Khawan).



The two rooftop restaurants are situated at the north corner of the courtyard. One is named as Andaaz Restaurant and is located on the right side, and the other is named as Royal Dreamland Restaurant and is located on the left side.

These two restaurants provide visual access to Badshahi Mosque. On the south entrance of the courtyard, Mai Eidaan Imam Bargah is situated. There is a mosque on the first floor of the Imam Bargah, which is used for prayers, five times a day, attended by a small number of devotees from the Shia sect. The Imam Bargah has shops on three sides, facing the Courtyard, adjacent to the main entrance, and on the Neewan / Nicha Chait Ram Road. The house of Mai Eidaan is located on the Neewan/Nichan Chait Ram Road, opposite the Mai Eidaan Imam Bargah. Recently, this house was sold by her family members. The houses on the west side of the courtyard are being used as shoe markets. Few other houses have high architectural value.

Historical Significance of the Selected Area

During the rule of Emperor Akbar, Lahore was divided into 36 districts (Guzars) for administrative and political purposes, and 09 of them are within the walls of the old city of Lahore. Guzar Shahbaz Khan is also Guzar Mang Khan and is named after its administrator, who belongs to the Rajput Kamboh family and was a military General and tutor of Emperor Aurangzeb. He was a generous man, and due to his generosity, the Guzar is famous as Guzar Mang Khan (Sheikh, 2016).

The Shahi Mohallah was populated by the royal family members, state administrators, and the native Governor (Nawabs). The area is linked by circular gardens through the Taxali gate on the west, the Masti gate on the North, and the Bhatti gate on the South. (Latif, 1992). The place was also inhabited by the community, including intellectuals and artisans, who dedicated themselves to entertaining the Royal throne with their skills in the arts, such as music, poetry, and dance (Tufail, 1962). Muhammad Iqbal (Advocate Lahore High Court), also the president of Ustad Damon Academy, a resident near Taxali Gate, Lahore, said in an interview about the reason for dedicating the road to Chait Ram. He said that Chait Ram was a Hindu priest, and he was accustomed to sitting at a place named the Takya (a designated space for spiritual teachings) of Chait Ram to guide the community for noble actions.

The architectural characteristics of the houses surrounding the courtyard reveal the evolution of the area, and it is apparent that they were developed during the British period. A tailor, tenant of the Mai Eidaan Imam Bargah, said in an interview that he is an old resident of the area and a witness to all the past activities. The area had to face the challenges when it was

occupied by the prostitutes, and the Tawaif (artisans) culture was dominated. Initially, these females were called artisans and entertained the elite class with poetry, music, and dance, and afterwards, they were forced into prostitution. The culture sustained until President Zia ul Haq imposed a ban on prostitution and got rid of this culture. The prostitution was initiated during the rule of Ahmad Shah Abdali and promoted by the British soldiers. The Department of Archaeology has initiated the preservation of this area to identify and enhance its potential for urban and cultural tourism and to revitalize it for foreign tourists (Latif, 1992).

Diverse Architectural Heritage within a Compact Area

Mai Eidaan was a devout follower of the Shia sect, and she had purchased land opposite to her house and converted it to perform religious ceremonies during Moharram (name of Islamic month). She initiated holding mourning processions during Moharram to revive the memory of the martyrdom of Hazrat Imam Hussain. In 1954, an Imam Bargah was built at the location (as indicated at the plaque fixed at the front door of Imam Bargah). There is an enclosed space with traditional houses that are being adaptively reused as restaurants and shoe manufacturing factories. The access to this courtyard is from the two 15-foot-wide streets, one from the Fort Road and the other from the Chait Ram Road. There are shops on three sides of Imam Bargah, and the back of it is attached to the boundary of the house.

The selected urban square is situated in a historic and religious context due to the presence of religious activities in the vicinity. On the North is the Badshahi Mosque, and on the south is an Imam Bargah. Commercial activities contribute to transforming the historic character of the area. The residents of the houses utilize the semi-enclosed space for domestic activities, such as drying clothes, and it also serves as a play area. However, rooftop restaurants provide a visual connection from the courtyard to the Royal Mosque for the customers dining on the roofs of these restaurants.

Due to its historic location, the Guzar remained a preferred venue for royal courtiers, state officials, nobles, and royal visitors to entertain the Mughal Emperor with music, poetry, and dance performances. Due to the relevance of people associated with the royal throne, the vicinity is termed as Shahi Mohallah. During its peak times, it was a center of cultural activities, and all these activities were restrained after independence. At present, a significant number of monuments have deteriorated and been abandoned from their original state, and are being adapted to fulfill contemporary challenges.

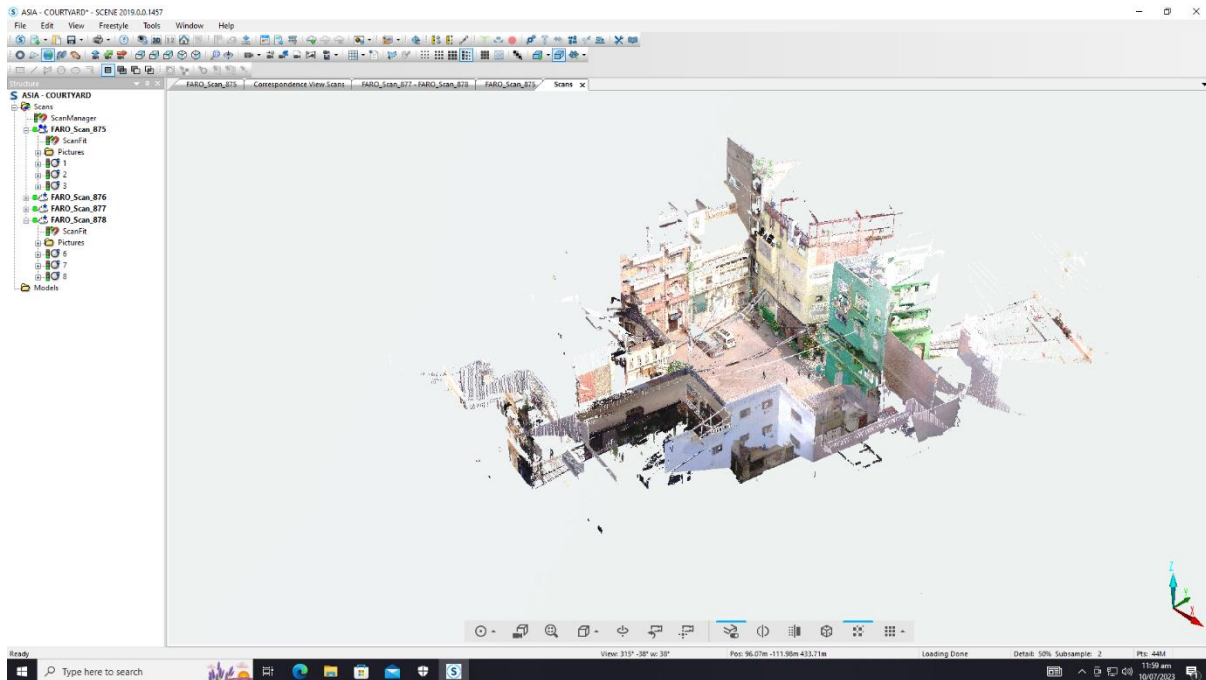


Figure 7-2: HBIM Model of Mai Eidaan Courtyard

Source: Author, 2023 (In collaboration with WCLA)

Among the buildings around the courtyard, Mai Eidaan Imam Bargah is one of the significant structures that maintains its original use. Rooftop restaurants enhanced the tourist value of the area, and shoe factories increased the potential for commercial activities, thereby compromising the privacy of the residents.

Ongoing conservation challenges

Historic monuments with intricate details provide multilayered information for future architects and planners to address the current challenges of conservation, encompassing both form and function. Documentation of heritage sites is a crucial step in the conservation process. Conventional methods have severe constraints in terms of accuracy, precision, and the time required to complete the task, due to human errors, the need for human resources, and their time-consuming nature. The key requirement of the conservation process is to conduct field surveys to document the status of the specific site and its immediate context through photographs and maps. These surveys also document previous interventions, providing documentary evidence of past activities at the site. They also help to maintain and monitor the site after conservation. (Oreilly & Murphy, 2024).

The historic cities in Pakistan are losing their historic character due to natural agents, human neglect, and new constructions. Conventional recording tools, like measuring taps, footsteps, and orthographic drawings, offer various formats to meet the challenges of documentation. Additionally, orthographic drawings provide accurate measurements of the buildings and spaces, thereby reducing human error associated with direct access. Perspective views of the structures simulate the buildings, and photographic records provide the project's outline, quality of light, and physical condition of materials. A physical model of the monuments presents 3D impacts. The writing describes a visual representation and unseen data related to the heritage sites (Haddad & Akasheh, 2005).

In comparison to conventional methods (manual), virtual methods (digital) provide multilayer information more accurately and precisely, consuming a shorter period. A historic building information model (HBIM) provides a database to generate CAD drawings with digital metadata, including horizontal and vertical dimensions, as well as the physical qualities of the materials, such as color and texture. Digital data can be shared among the stakeholders for comparison and analysis with minimal chances of errors due to ambiguity and discrepancies. Additionally, architectural drawings can easily be generated from the digital database. (Dore & Murphy, 2015). Also, the digital database can serve as a foundation for walkthrough analysis and virtual reality tours. Digital tools provide more accurate and authentic multilayer digital data, reducing the time required to complete the task. (Badenko et al., 2017).

7.1.2. Implementation Process

Historic Lahore comprises a varied range of building typologies and historic urban spaces, characterized by imaginative and comprehensive spatial development. (Sheikh, 2016b). These districts are named after the administrator or the physical activities specific to that area. The heritage monuments are categorized into three categories based on their architectural and historical significance, namely high, medium, and low (Talbot & Tahir, 2017), as designated by the Walled City Lahore Authority (WCLA). In 1917, Patrick Geddes (1854-1932) visited Lahore and gave the idea of “Conservative Surgery” based on the improvement of old buildings and the construction of quarters rather than demolition and reconstruction.

The conservation of the historic core of Lahore always persisted as a challenge for conservation experts and authorities due to the constraints and limitations of Conventional methods. New technologies introduced fast-track and authentic surveying, mapping, and

documentation of significant historic buildings. The process of digital preservation has given new life to old structures through an appropriate adaptive reuse. Adaptive reuse of historic buildings is not a new phenomenon; rather, it is a process that has been ongoing since the development of the built environment (Philokyprou, 2014).

Digital documentation using 3D laser scanning

Physical preservation involves a lot of stages to complete the process. It involves the identification, documentation, and conservation of the historic urban landscape. Digital documentation is a phase in preserving heritage monuments and sites. There are four stages to complete the digital documentation process using 3D terrestrial laser scanners. This technique was introduced in Pakistan by LUMS University under the project “Digital Preservation of Pakistan's Heritage,” funded by USAID with a 3D Laser Scanner:

- Model Leica Scan Station P20,
- Range: Up to 120 m,
- Scan rate: Up to 1'000'000 points/s and
- Field-of-view: H 360°, V 270

The Laser scanning technique was initiated in Pakistan by Dr. Murtaza Taj from LUMS University, who selected six sites for digital documentation, using a Leica Scan Station P20. The sites selected for digital documentation include Mosque Wazir Khan in Lahore, Temple of Shiva Johi, Daddu, Takhat-e-Bhai Mardan, Darewar Fort, Bahawalpur Multan, Mosque Khudad Daddu, and the stupa at Julian Huripur. – The sites were digitally documented in collaboration with international agencies, government bodies, and local authorities. Terrestrial Laser scanning was implemented by the Aga Khan Cultural Services of Pakistan (AKCSP) for the documentation and conservation of built heritage, following the example of the Lahore University of Management Sciences (LUMS). Several successful projects were completed by AKCSP in collaboration with WCLA. The most significant were the Conservation of Chauburji gateway, Picture Wall at Lahore Fort, and the Façades of Wazir Khan Mosque. (WCLA, 2016). WCLA has identified zones of special value in the Walled City of Lahore. Out of these identified zones, Bazaar-e-Hakeema and Jogi Mohallah were documented with TLS in 2016 (Arif & Essa, 2017b). Lahore Fort (UNESCO World Heritage Site) was also documented with TLS under the umbrella of WCLA (Arif & Essa, 2017).

Conservation projects completed since 2015 using digital tools encouraged WCLA and the conservation community to implement modern technologies to address the limitations of Conventional methods and to ensure sustainable conservation practices within Walled City Lahore. According to WCLA, the TLS of “Faro Focus” point cloud owned by them is one of the latest versions of Faro Industries, a combination of a 360 digital camera, helping digitization of the cultural heritage of Lahore with minimal time consumption.

Terrestrial Laser Scanning (Field Work)

Terrestrial Laser Scanning (TLS) involves Fieldwork, where the object that needs to be documented is scanned. The data received by the scanner is in the form of 3D point clouds. 3D laser scanning systems that emit a considerable number of laser beams per second and generate thousands of data points. This data is cloud data because it is not a picture but an actual digital representation of the monument with accurate details. We require the appropriate software, such as Cyclones, to convert the raw data to a 3D point cloud.

Surveys of the selected site have been done by using a Faro terrestrial Laser Scanner (owned by WCLA) to digitally document facades of all the buildings around the Mai Eidaan Courtyard (a cultural node). There are constraints regarding TLS surveys within the HCL, specifically regarding the security of the scanners due to their high cost, as the HCL is the most congested area of the city. Also, the application of Terrestrial Laser Scanners at the site has to face environmental limitations, as they are exposed to high temperatures. The sample area has been selected on the connecting road between the historic core of Lahore and the UNESCO World Heritage site, the Badshahi mosque. The selected site comprises historic monuments, most of which are being adaptively reused as restaurants and shoe factories. Considering all the factors, the terrestrial laser scanning of the facades of the buildings around Mai Eidaan Courtyard was conducted from 8:00 am to 11:00 am, scheduled according to the pre-scanning surveys of the site.

Point Cloud Registration

The point cloud data stored on the scanner's memory card, similar to digital cameras and smartphones, requires registration with the help of specialized software, such as Cyclone. The data was in the form of a cloud of points, and the expert had to extract the images from these clouds. This can also be done with the help of various software such as ArchiCAD, Cyclones, etc.

Processing of Scanned Data (Studio Work)

The point cloud data, received after scanning and stored in the memory card of the scanner, is registered with the help of Faro Scene (software) in the studio and imported into Autodesk Recap 360 (*.rcp file format) to get orthographic drawings, 3D models, and panoramic views. The next initiative is to transform the point cloud data into Autodesk Revit to obtain sectional details with maximum accuracy, including multilayer information, thereby minimizing human errors in the shortest possible period.

Development of BIM models for key structures

After registering the point cloud data, we can have a virtual tour of the site to visualize the whole site, and we can move around the monument, avoiding any mistakes while preparing the Conservation Plans for any project. Autodesk Revit, 3D Studio Max, SketchUp, and Rhino can be used to render the 3D image prepared from the point cloud data. These virtual tours enable the experts to adopt an integrated approach rather than a linear one. In the traditional methods, one relies on the other, and the work must be done by individuals. On the other hand, in the integrated approach, all the team members got involved in the project's completion.

Architectural Drawings & 3D CAD Modeling

Architectural Drawings can be generated from cloud data. These drawings are helpful for the preparation of the conservation plan for the selected projects. From Point cloud data, 3D CAD models can be created with the help of different software. These 3D models can present a comprehensive layout of the project and the surrounding environment.

Integration of data into a unified digital platform

The core objective of the research is to evaluate the potential of digital platforms for the conservation of heritage sites by utilizing Total Stations, 3D Laser Scanners, and digital cameras. Digital platforms are landmarks in the evolution of conservation methodologies due to their merits, including ease of use, minimal chances of errors, time and money saving in the long term, and the highest quality of data in terms of accuracy, precision, and authenticity. However, environmental limitations can affect the accuracy of data due to factors such as clouds, air pressure, high temperatures, and rain, which can lead to measurement errors. As an example, the temperature difference of 10°C or a change in air pressure of 35 hPa can cause an error of 1mm/100m (Muralikrishnan, 2021). In high temperatures, there are chances of error

due to the thermal expansion of the objects and a change in the wavelength of the laser beam. Rain and dust can also affect the performance of the digital tool. Additionally, digital platforms must be protected from human vandalism to prevent information leakage and equipment damage. Therefore, it must be avoided in congested spaces for the safety of the tool, which is costly.

Criteria for Site Selection

Considering all the potential, constraints, and limitations, the site has been selected as the pilot case study for implementing and validating the Digital Conservation Framework (DCF) within a historical context, featuring various categories of buildings based on their significance of architectural characteristics and adaptive reuse. The site is multifunctional, serving various purposes at various times of the day and year. Depending on its historical context, it has been assessed that the conservation and refurbishment of the site can enhance the cultural tourism of the courtyard, in addition to its religious value due to the Imam Bargah. To fulfill the research objectives, a strategy has been developed for documenting the selected area.

- Archival data is collected from the Walled City Lahore Authority (WCLA) and local libraries to identify the historic and architectural value of the site and its context.
- A pre-scan survey has been conducted using a DSLR to develop an initial inventory of the buildings in the surroundings of the courtyard.
- The status of the buildings was recorded concerning age, architectural characteristics, and damage spanning an extended period.
- Interviews have been conducted with the residents, employees, shopkeepers, and visitors to evaluate the socio-cultural activities and interventions made in previous times.
- The time for scanning at the site has been selected at 8 am to avoid human traffic and high temperature, as the site is outside, and the work has been completed before noon. It took three hours to complete the fieldwork (scanning at the site). The scanned data was saved in the memory card, inserted into the scanner (by default). Four scans were taken at various points, with the help of spheres, termed as targets, to cover the four sides of the courtyards. The scanned data is in the form of high-resolution point cloud data.

- The video has been recorded to maintain a record of on-site scanning for the evaluation of the whole activity.

With the completion of the scanning at the site, the rest of the work was completed at the workstation in the office.

- The scanned data, saved in a memory card, has been registered to the computer with the application of software “Faro Scene 2019”.
- After registration of scan data in *.rcp format, files have been imported to AutoCAD Architecture 2016 files through “Autodesk Recap 360” due to the opportunities to share the data among stakeholders. This software can support files to measure dimensions of the site, to visualize the detailed images, and describe minute details in terms of damages and materials of construction.
- The 3D models and auto-generated orthographic drawings have been created to develop conservation, and rehabilitation plans for the urban built heritage, maintaining its authenticity and accuracy.

Finally, the data is analyzed to implement and validate the Digital Conservation Framework (DCF) for HCL and other historic cities in South Asia.

7.1.3. Results and Analysis

The primary goal of this research is to assess the potential and limitations of digital platforms for the conservation of built heritage, with a focus on the historic core of Lahore. The historic core of Lahore has been described as the cultural capital of Pakistan. It possesses a wealth of heritage, spanning from imperial palaces and gardens to domestic residences and open urban spaces. (Latif, 1994). The HCL maintained its status as a Royal Capital since the Ghaznavid Dynasty, and it was one of the three metropolitan cities of the Mughal Empire, along with Delhi and Agra. It has neither been developed by a single person nor under a single domain. It has a history of almost a thousand years. In present-day Lahore, three distinct styles: the Mughal Empire, Sikh Monarchs, and British Colonies, with traces of pre-Mughal.

The study of the urban morphology of the HCL identifies that the inner core of the city was walled, and these walls were removed during the British period for political and administrative reasons. The city wall was built with burnt bricks and had 13 gates. There are Primary roads, termed as Bazaars, named after the name of the Gate, starting from the city

gates, leading to the Royal Throne, Lahore Fort, which has been declared a UNESCO World Heritage Site in 1981 (UNESCO, 2011) .

The Historic core of Lahore has wealth of historic monuments of multiple typologies such as religious (Mosques, temples, Gurdwaras, shrines, tombs), residential (houses, Havelis, palaces), Commercial areas (Bazaars, shops, moveable stalls), open urban spaces (Internal courtyards inside cluster of buildings, gardens), Baolies, Stables, Shahi Hammam, Serae and other typologies. Therefore, the city is representing various cultures, maintaining a balance between its inner core and modern developments (Goulding, 1924). The old city was repeatedly ruined by invaders and reconstructed in later periods. Following the end of British rule, riots and rebellions occurred that damaged the city's aesthetic value. The survival of human life and the settlement of the migrants were a challenge for the Government of Pakistan. During this period, the heritage properties were damaged by the people (Hindi, 1990).

The Pakistan Antiquities Act was enacted in 1975 to protect historic monuments and archaeological sites. The legislation was also done at the provincial level, and the historic city came under the purview of the Punjab Premises (Preservation) Ordinance 1985. Lastly, the Walled City Lahore Authority was established in 2012 to protect, conserve, and rehabilitate the historic core.

The efforts for conservation and rehabilitation were not as successful as expected, initiated by the Lahore Improvement Trust (LIT), which afterwards converted into the Lahore Development Authority (LDA). The journey from LIT to WCLA involves national and international organizations to safeguard the historic core of Lahore. The most important roles were played by the Pakistan Engineers, Planners and Architects Council (PEPAC), AKCSP, the Royal Norwegian Embassy (RNE), USAID, and the World Bank in terms of funding and preparation of conservation plans.

Conservation of the historic core failed due to the insufficient human and financial resources, but the key element was poor management and monitoring of the heritage site. The policies and strategies need to be implemented with modern technologies for the protection of this valuable urban heritage. It was not the case with Pakistan only, but globally, it has been realized that innovative methodologies are required to protect the rich wealth of heritage, and conservation of individual structures is not sufficient, and the process must be extended to the macro level.

The success of conservation procedures and practices depends upon the efficacy of the methodologies. Rapid urbanization and modernization influenced the living character of historic cores through the reconstruction of high-rise structures, the demolition of landmark structures, and the neglect of the historic values of these areas. It has also been recognized that the adaptive reuse of heritage sites can conserve energy resources, rather than building new structures, to provide residential facilities for the ever-increasing number of residents.

Accuracy and completeness of digital documentation

The digital documentation of the urban built heritage has revolutionized methodologies for heritage conservation, urban morphology studies, and architectural historiography. The historic core of Lahore is a densely populated historic urban fabric that reflects the footprints of Mughal, Sikh, Colonial, and vernacular architecture, ensuring the accuracy and completeness of digital documentation is a particularly critical element. The historic value of the city extends beyond its architectural aesthetics. Still, it extends to its socio-cultural, religious, and political significance, which necessitates a high degree of reliability in its digital representation.

Accuracy in digital heritage documentation refers to the level to which the recorded data, whether geometric or not, Material, or spatial, connects with the physical and historical reality of the heritage asset. Technologies such as Total Station, Terrestrial Laser Scanner, and HBIM have been employed to varying degrees in the historic core of Lahore under the auspices of WCLA. These tools provided high-resolution and spatially precise outputs, At the same time, the accuracy of the documentation is often influenced by the limitations in equipment calibration, site accessibility, environmental conditions, and the technical expertise of the operators. These challenges are compounded in the case of the Walled City of Lahore, due to its dense urban fabric, narrow winding streets, and encroachments (permanent and temporary), which hinder the acquisition of comprehensive and consolidated data.

Completeness pertains to the extent to which the digital documentation captures all relevant physical, contextual, and intangible dimensions of heritage structures (Parisi et al., 2019). A significant concern in the Walled City of Lahore is the frequent prioritization of monumental architecture, such as the Shahi Hammam, Wazir Khan Mosque, and Delhi Gate, at the expense of more ordinary, vernacular structures and intangible components, including oral stories, ritual practices, and socio-cultural activities. This imbalance results in partial datasets that fail to capture the living heritage holistically. Additionally, due to the piecemeal

nature of the projects, conservation efforts often lacked standardization and interoperability across platforms, thereby hindering the development of a unified digital heritage database.

Moreover, the scarcity of archival references, historical plans, and accurate records of the previous interventions complicates the completeness. In several cases, conservation efforts must rely on speculative or interpolated data, which can result in digital models that may reproduce inaccuracies.

To address these challenges, a robust digital conservation framework for the historic core of Lahore must adopt an integrated and multidisciplinary approach. It includes advanced digital tools, historical research, community participation, and ethnographic methods. However, digital technologies have greatly enhanced the capacity to document and analyse the built heritage of the Walled City of Lahore. However, substantial gaps remain in terms of accuracy and completeness. Therefore, a critical re-evaluation of current practices, combined with digital technologies and participatory methodologies, is essential to safeguard cultural heritage.

Effectiveness of the integrated digital platform

The emergence of integrated digital platforms in heritage conservation reflects a paradigmatic shift in the management, analysis, and dissemination of information related to historic urban environments. In the context of the HCL, the adoption of digital tools has been positioned as a critical strategy for addressing the challenges of preservation, documentation, planning, and public engagement. In this regard, an integrated digital platform refers to a centralized, interoperable system that consolidates various data types, including architectural, topographic, cadastral, historical, and socio-cultural, into a unified digital environment accessible to stakeholders, ranging from conservation professionals to policymakers and local communities.

The effectiveness of such platforms can be evaluated across multiple dimensions: data integration and accessibility, collaboration and stakeholder engagement, monitoring and maintenance, and public communication and awareness. The integrated digital platform holds significant promise for advancing the conservation of the urban built heritage in the historic core of Lahore, offering tools for holistic documentation, strategic planning, stakeholder coordination, and public engagement. In potential, however, it is tempered by systematic limitations in data integration, institutional collaboration, policy alignment, and resource

allocation. To enhance its effectiveness, there is a pressing need for the development of a standardized and consolidated framework to enable sustainable conservation practices.

Identification of conservation priorities

The development of DCF for the historic core of Lahore and its surrounding precincts, which systematizes data collection, documentation, analysis, and management through digital technologies, must be rooted in a rigorous identification of conservation priorities. These priorities serve as both the conceptual and operational foundation upon which such a framework can be constructed, ensuring relevance, sustainability, and impact. To enhance the identification of conservation priorities, there is a pressing need to understand the typological and architectural significance, state of preservation and structural vulnerability, socio-cultural value and community usage, urban context and spatial integration, threat level from developmental pressures, historical documentation and data availability, and policy relevance and institutional alignment. It is a critical precondition for the development of an effective, context-sensitive digital conservation framework. By merging architectural analysis, structural assessment, community engagement, spatial logic, and policy alignment, a comprehensive hierarchy of needs can be established. This hierarchy not only informs the deployment of digital tools but also ensures that conservation efforts are directed toward the most vulnerable, valuable, and culturally significant components of the historic city. An intelligent, adaptable digital conservation framework—grounded in these identified priorities—can significantly enhance the responsiveness, transparency, and sustainability of heritage management in Lahore.

7.2. STAKEHOLDER FEEDBACK AND EVALUATION

The successful implementation of the digital conservation framework for the historic core of Lahore needs a holistic approach to collect feedback from the stakeholders and iterative validation. Considering the nature of the built heritage of the Walled City of Lahore, which encompasses cultural, historical, urban, and technological dimensions, the DCF has been validated through a diverse range of perspectives. The validation process includes collecting feedback from conservation experts, digital heritage specialists, urban planners, local communities, and government institutions. The feedback enhanced the credibility and relevance of DCF, rooted with practical realities and local contexts.

The validation process ensures that the DCF is technically sound, socially inclusive, contextually appropriate, and institutionally viable. By involving the stakeholders, the DCF

gains legitimacy and responsiveness, which enhances the quality and strengthens the collective ownership over the historic core of Lahore, leading to sustainable governance in the digital age.

7.2.1. Expert Reviews

Conservation methodologies are transitioning from conventional to digital, and conservation experts are now applying digital tools and methods to conserve both tangible and intangible heritage. Conservation experts encompass a range of conservation professionals, digital heritage specialists, architects, and town planners. A digital conservation framework for the historic core of Lahore has been developed, employing their expertise in the various developmental phases.

Feedback from Conservation Professionals

The evaluation process involves the critical analysis of DCF by the conservation professionals, architects, historians, engineers, and heritage managers who possess contextual knowledge of the historic core of Lahore. Expert reviews focus on challenging areas such as technical rigor, methodological soundness, and application of digital tools in conservation practices. These reviews provided insights into issues such as data accuracy, appropriateness of conservation methods, and potential for the framework to inform restoration protocols and site management plans. Peer review sessions, workshops, and technical audits are mechanisms to solicit specialized feedback.

Assessment by Digital Heritage Specialists

The proposed framework has been evaluated by the digital Heritage specialist to assess validation of data standards, metadata protocols, platform scalability, User interface design, and long-term digital preservation strategies. They also examine the extent to which the framework adheres to international best practices such as UNESCO guidelines and International Charters, as well as CIPA. Specialist input is particularly critical in ensuring that the digital infrastructure is robust, future-proof, and adaptable to emerging technologies.

Input from urban planners and architects

Urban planners and architects provided their feedback on the spatial integration and policy applicability of the digital conservation framework. Their evaluation includes the analysis of levels of heritage-sensitive urban development, zoning regulations, land use planning, and infrastructure upgrades. Their feedback is essential to align the framework with broader urban governance strategies, master plans, and public infrastructure projects.

Additionally, they provide practical insights into how digital data can inform design decisions, spatial interventions, and sustainable urban growth.

7.2.2. Community Responses

The local community participation is vital for ensuring that the DCF reflects the living heritage and socio-cultural values embedded in the historic core. Feedback is solicited through structured surveys, participatory mapping, interviews, and focus group discussions with residents, business owners, artisans and frequent users of heritage spaces. This participatory approach captures community perception of conservation priorities, attitudes towards digital technologies, and expectations regarding visibility, accessibility, and inclusivity of heritage data.

7.2.3. Government and Institutional Feedback

The formal evaluation of the DCF by government bodies, such as the Walled City Lahore Authority (WCLA) and the Department of Archaeology, Punjab, is aimed at institutionalization. These agencies assess the framework's regulatory alignment, operational feasibility, and potential for integrating into existing heritage management protocols. Their feedback supports the application's legal compliance, budgetary considerations, staffing requirements, and compatibility with national heritage databases.

7.2.4. Refinement of the framework based on feedback

This research proposes the development, implementation, and validation of a comprehensive DCF tailored for the HCL, a culturally rich urban fabric with complex layers of architectural heritage. By leveraging contemporary digital tools, such as Total Stations, 3D Laser Scanners, and 360-degree cameras, the study aims to address the limitations of conventional conservation methodologies, which often lack integrative spatial analysis, real-time data management, and collaborative platforms. This research undertakes a comparative analysis between the proposed digital conservation framework and existing heritage conservation approaches currently employed in Lahore. Through a structured methodology encompassing case studies, stakeholder interviews, and performance metrics such as data accessibility, decision-making efficiency, and historical accuracy, the study evaluates the strengths, weaknesses, and contextual relevance of each approach. Finally, the research aims to reveal how a digital conservation framework not only enhances documentation and preservation practices but also enables participatory governance and long-term sustainability of heritage sites. The findings aim to contribute to the discourse on digital heritage conservation

in South Asian contexts, offering scalable insights for application in other historic urban cores in postcolonial settings.

The proposed research addresses the urgent need for an integrated and technology-driven approach to heritage conservation in South Asia by focusing on the historic core of Lahore, one of the oldest and most architecturally significant urban settlements in Pakistan. This study aims to design, implement, and validate a digital conservation framework that employs contemporary digital tools and methodologies to support more effective, data-informed, and participatory heritage management practices.

Research Rationale and Context

Lahore's Walled City, containing prominent landmarks such as the Lahore Fort (a UNESCO World Heritage Site), the Shahi Hammam, Wazir Khan Mosque, and numerous traditional havelis, presents an intricate tapestry of Mughal, Sikh, colonial, and vernacular architecture. Conservation efforts over the past few decades have ranged from state-led restoration initiatives by the Walled City of Lahore Authority (WCLA) to international collaborations like the Aga Khan Trust for Culture's conservation of Shahi Guzargah. Despite these efforts, much of the historic core remains at risk from unregulated development, inadequate infrastructure, and a lack of comprehensive documentation.

Existing conservation approaches in Lahore often suffer from:

- Fragmented documentation
- Limited stakeholder engagement
- Inadequate monitoring mechanisms
- Dependence on analogue or static data systems

Objective and Scope

This research proposes the development of a Digital Conservation Framework (DCF) tailored to the socio-cultural and spatial context of Lahore's historic core. The framework will be grounded in digital heritage technologies, integrating 3D laser scanning for high-resolution documentation of structures (e.g., Shahi Hammam interiors), Building Information Modelling (BIM) for conservation planning, material inventory, and lifecycle management (e.g., adaptive reuse strategies for havelis), and Interactive digital archives for community engagement and knowledge dissemination.

Methodology

The research proceeded in the following phases:



Diagram 7-2: Flow Diagram of Research Methodology

Expected Contributions

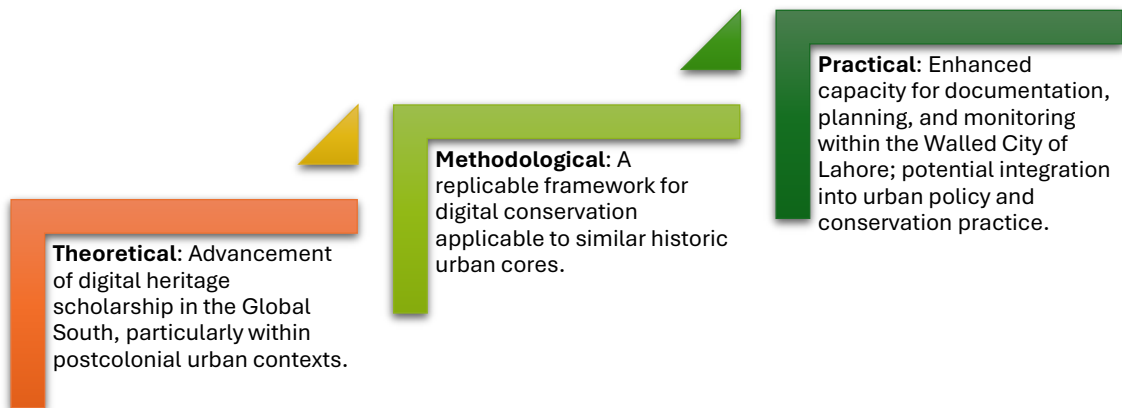


Diagram 7-3: Flow Diagram of Research Contributions

7.3. COMPARATIVE ANALYSIS WITH EXISTING CONSERVATION APPROACHES

7.3.1. Cost-benefit analysis

A comprehensive cost-benefit analysis is a key element in evaluating the viability and sustainability of contemporary conservation strategies in comparison to traditional approaches applied to the historic core of Lahore. This analysis extends beyond the immediate financial amounts to consider broader economic and socio-cultural returns over long term benefits.

Initial Implementation costs vs. Long-term benefits

Digital technologies incur higher initial cost relative to traditional methods. The cost of the digital tool and the expenses associated with carrying and operating these tools are too high compared to conventional tools, which often rely on low-cost, labor-intensive methodologies. The long-term benefits often compensate for these initial costs. The benefits include increased tourist value, generating tourism revenues, extended building lifespans, enhanced urban resilience, and increased community engagement. In comparison, conventional approaches that focus narrowly on material preservation often fail to ensure functional continuity or economic self-sufficiency, leading to a cycle of neglect and periodic, high-cost restorations.

Comparison with Traditional Conservation Methods

Using traditional techniques offers Low cost, is easy for novices to use, needs affordable, readily available equipment, and is helpful in low-light conditions. Everything that is being worked on is based on observation and human perception. Materials from the neighborhood are used to restore and renovate the structure. The drawbacks include low accuracy, lengthy and arduous fieldwork duration, difficulties capturing curved and highly detailed items, difficulties documenting inaccessible elements, and human error.

Digital technology offers quick data capture, low-cost and straightforward software, effective object presentation, color and texture data, ease of use, web page presentation, short fieldwork periods, cost-effective accuracy, non-intrusive data collection, portable equipment, and output processing in CAD software. It provides real-time capability, fast image acquisition, and high accuracy for damage evaluation, identification of hidden structures, and older layers. It is cost-effective, easy to use, and suitable for use in inaccessible and hazardous areas. It can be combined with RGB images and 3D models, providing location coordinates in the global geographical system. It is suitable for documenting mass targets and structural deformation (Fai et al., 2019).

This research explains how to take pictures with a camera and process them, which calls for planning, processing, and viewer software. The accuracy and resolution restrictions of the camera are also mentioned, along with the demand for knowledgeable operators for data processing. The lengthy fieldwork time, the challenge of recording color and texture data, and the requirement for competent operators are all mentioned in the document. It also mentions that data collecting is expensive and not appropriate for indoor settings. In addition, the article

discusses the difficulties associated with processing and storing data owing to high density and limited memory, as well as the effects of barriers, dust reflecting characteristics, sunshine, and wet weather.

Potential for Resource Optimization

By combining conservation objectives with sustainable development goals, such methods leverage available resources, including material, human, and financial resources. For example, adaptive reuse projects can reduce costs through the reintegration of heritage buildings, while public-private partnerships can mobilize non-governmental funding streams. In addition, community-led projects ensure better allocation of resources, community relevance, minimize redundancy, and maximize social return on investments. Immersive technologies offer a more resilient and resource conscious as compared to the conventional paradigms.

7.3.2. Scalability and adaptability

Comparative analysis of conventional and digital methods involves exploration of their cost-effectiveness, scalability, and adaptability. These parameters are critical for determining the feasibility of broader implications both within and beyond the Walled City.

Applicability to other Historic Sites in Lahore

The conservation methodologies piloted within the Walled City of Lahore serve as a valuable prototype for extrapolation. Contemporary approaches that integrate digital technologies demonstrate a high degree of transferability to other historic zones within the historic core of Lahore. The key challenges, such as high population density, infrastructural decay, and informal commercial expansion, remain the same.

The traditional methods are often tailored to singular monuments while integrative models are adopted for urban heritage. Importantly, these approaches promote contextual tailoring rather than a one-size-fits-all methodology, preserving the unique socio-cultural character of each site while maintaining overarching conservation standards.

Potential for Use in Different Urban Contexts

The proposed digital conservation framework exhibits strong potential for adapting to other urban heritage contexts in Pakistan and the broader South Asian Region. For instance, the integration of digital documentation, digital mapping, digital archiving, and stakeholder mapping makes it adaptable to larger metropolitan environments with layered heritage

typologies, such as Rawalpindi, Multan, or Peshawar. Scalability is expedited through mechanisms such as public-private partnerships, heritage-based tourism models, and institutional capacity building. These factors minimize long-term dependency on donor-led conservation. Moreover, policy frameworks like the Walled City of Lahore Authority (WCLA) model can be institutionalized or adapted in other jurisdictions, supporting the diffusion of conservation governance.

7.4. DIGITAL CONSERVATION OF MAI EIDAAN COURTYARD

7.4.1. Comprehensive Digital Documentation

The Mai Eidaan courtyard is documented by the WCLA team to record and evaluate the various operational stages of TLS surveying, mapping, and the processing of scanned data to develop 3D models, as well as auto generated 2D measured drawings. TLS is a device that survey hundreds of thousands of positions per second. The scanned data is in the form of point cloud data in XYZ format. 3D scanning and producing point cloud data is a technique to acquire large volumes of accurate data. Conventional methods of surveying, such as measuring tapes and digital surveying with theodolite and total station, can never compete with the accuracy and speed of TLS, which is 976000 points per second in case of Faro S70 make (Murphy et al., 2013).



Figure 7-3: Faro Focus ^S (TLS) Spheres (Targets) and Scans surveyed at the site

Source: Author, 2023 (In collaboration with WCLA)

Selected case study, Mai Eidaan Courtyard has been scanned with a Faro Terrestrial Laser scanner (Faro Focus^s - Owned by Walled City Lahore Authority). An architectural Plan has been drawn with the help of data collected during the visual and pictorial surveys, to identify the target points in the courtyard for scanning the facades of the surrounding structures. With the help of “Spheres” Artificial Common Reference Objects (targets), four points were fixed to define the range of scanning facades. This range can affect the wavelength of laser beams. Four scans were done with the help of Terrestrial Laser Scanners to cover the facades of the buildings facing the courtyard and the streets linking the courtyard. Each scan is 10 minutes long. The target points were shown in Figure 4.

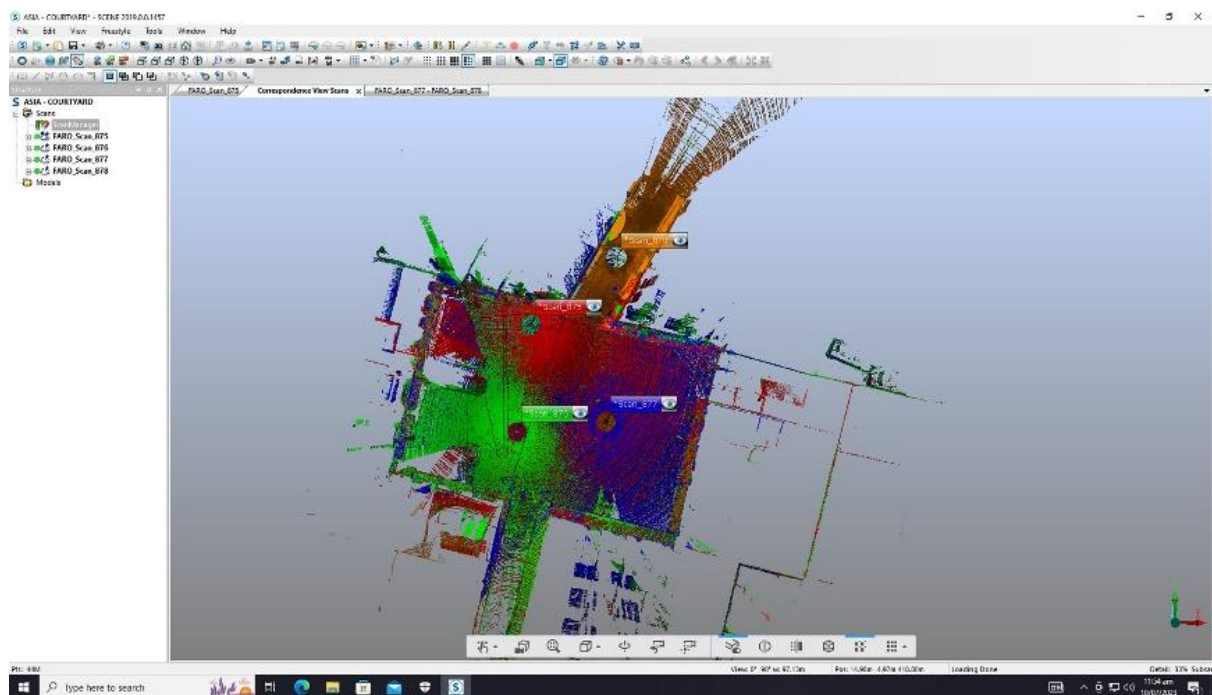


Figure 7-4 :Top view of Mai Eidaan Courtyard showing location of targets (Spheres) with scene no.875, 876, 877, 878

Source: Author, 2023 (In collaboration with WCLA)

The scanned data has been combined using Scan Manager of the software “Faro Scene 2019” to transform a single file. This software will generate a 3D model of the scanned site after combining, and we can delete unwanted elements from the scanned data.

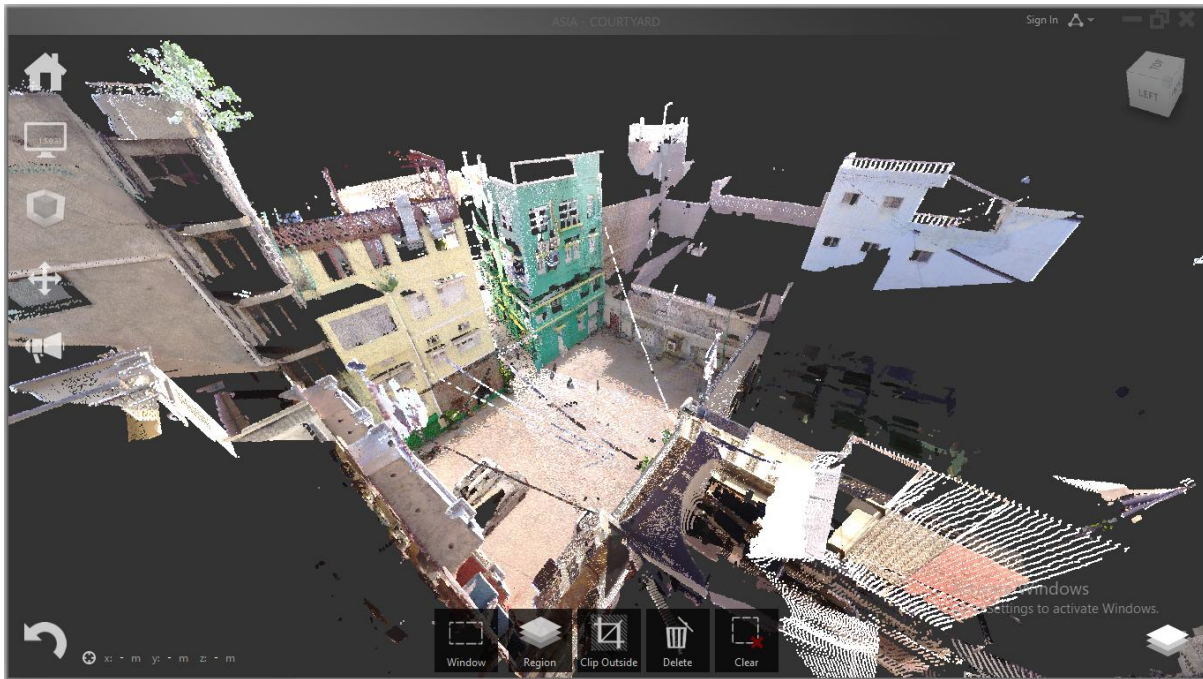


Figure 7-5: Showing Faro scans of the Mai Eidaan Courtyard

Source: Author, 2023 (In collaboration with WCLA)

The site is scanned with the help of TLS of make “Faro S70” and the scanned data is registered with the help of software “Faro Scenes 2019” and this registered data, in the form of *.rcp file has been transformed into 3D models showing all the details with high level of accuracy and in the minimum time duration. All scanning was completed in four scans, each of ten minutes, consuming forty minutes of scanning time and almost ten minutes for the processing time for the preparation of the following scan. The entire processing from the start of the task to the end is almost three hours, and the file is ready to transform into an AutoCAD model to get the multilayer data.

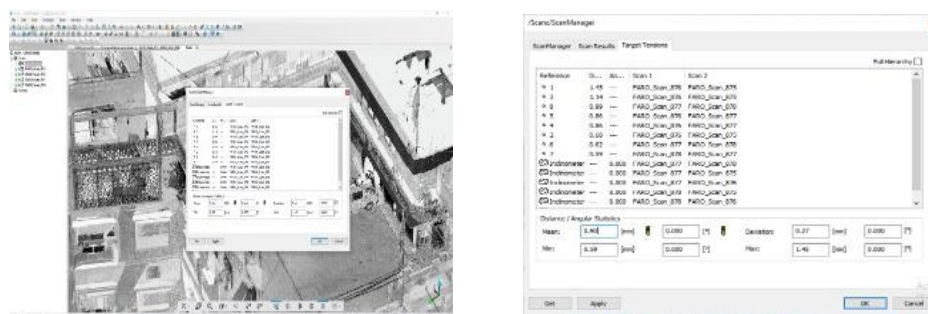


Figure 7-6: Details of the processing of Scan data in 3D model and details of files

Source: Author, 2023 (In collaboration with WCLA)

The scanned data has been combined with the help of “Faro Scene” software. The file format is *.rcp, ready to open with the software “Autodesk Recap 360”. These *.rcp files can

be imported into “Autodesk Recap 360” to develop a Building Information Model of the scanned site.

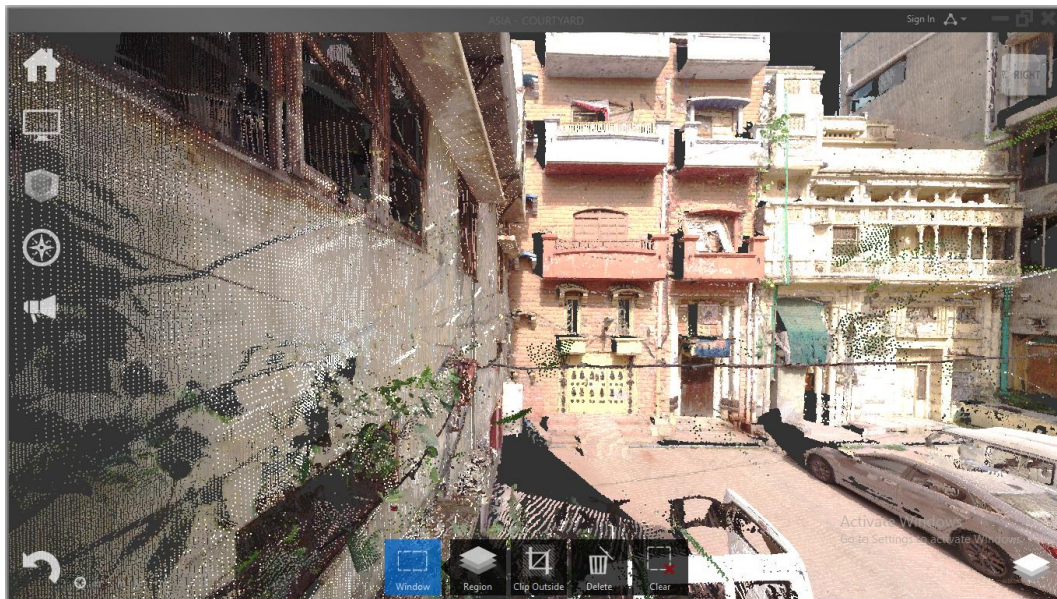


Figure 7-7 : Details showing 3D Models in the *.rcp support files

Source: Author, 2023 (In collaboration with WCLA)

From Scan data to Building Information Modeling

Files edited in “Scenes” in *.rcp format has been transferred “Autodesk Recap 360 Pro” to develop 3D models with multilayer information in RGB colors. In the upper right corner, placement and orientation of targets can be traced to view the desired model.

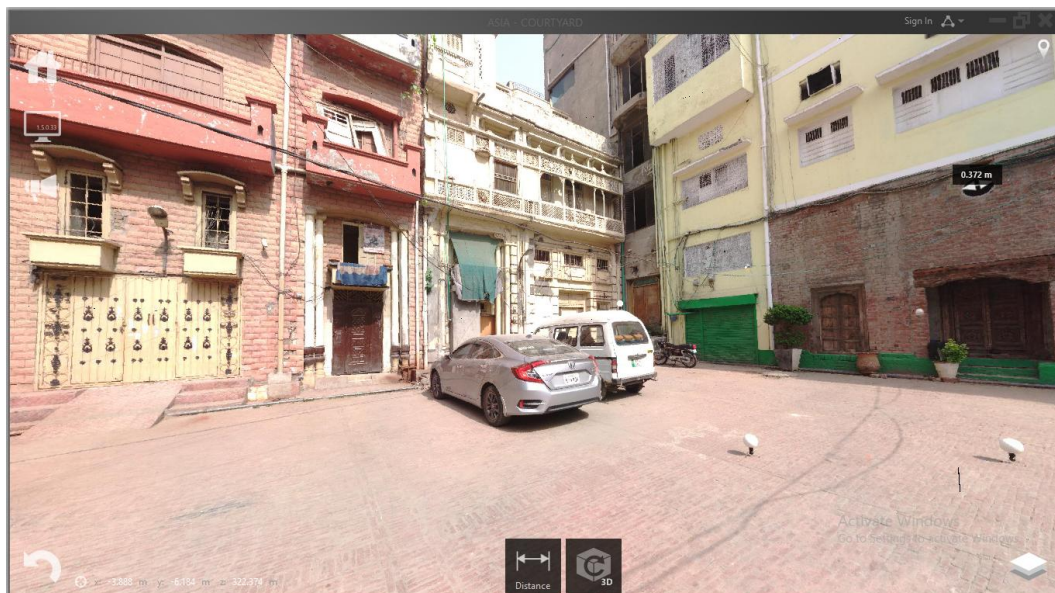


Figure 7-8: Real view of site in Autodesk Recap 360

Source: Author, 2023 (In collaboration with WCLA)

Autodesk Recap can help to develop HBIM models to provide details beyond the limits of conventional methods. Key feature is the use of “Limit box” to visualize the details of the facades in HBIM model.

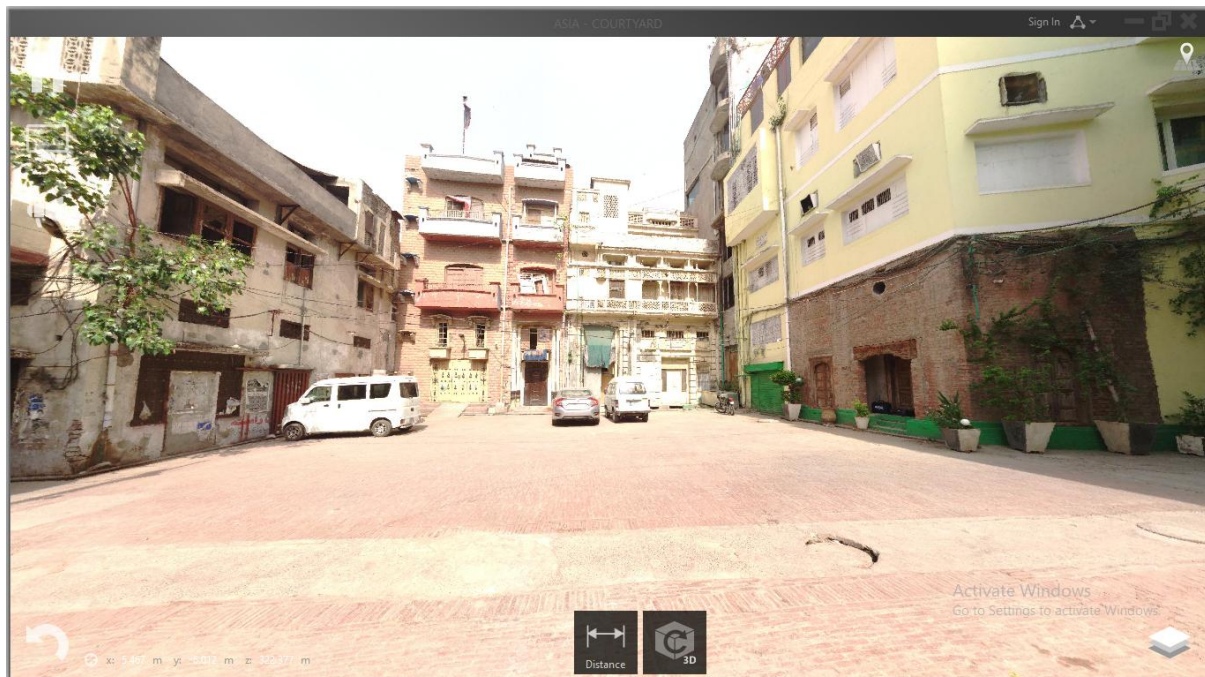


Figure 7-9: HBIM Model

Source: Author, 2023 (In collaboration with WCLA)

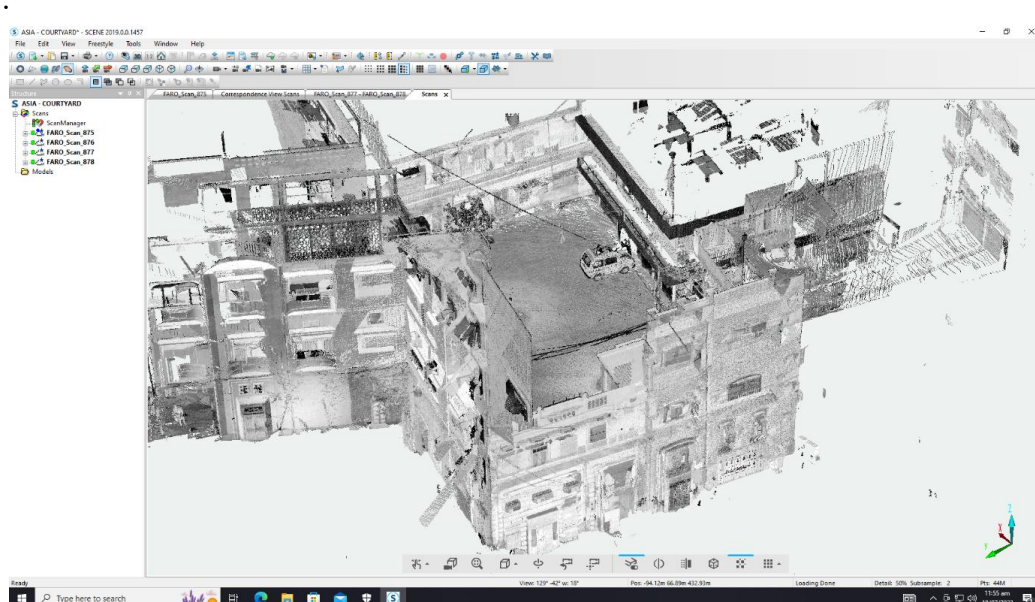


Figure 7-10: HBIM Model showing key feature to extract markups and measurements

Source: Author, 2023 (In collaboration with WCLA)

Measurements can also be taken from these HBIM model, saving time and energy. The manual drawings will consume number of days to develop measured plans but HBIM models can be developed saving time and money both.

In depth details can be extracted from the HBIM model and can be measured and present condition of the deteriorated elements can be recorded, unmatched with any other conventional technique for the development of digital models.

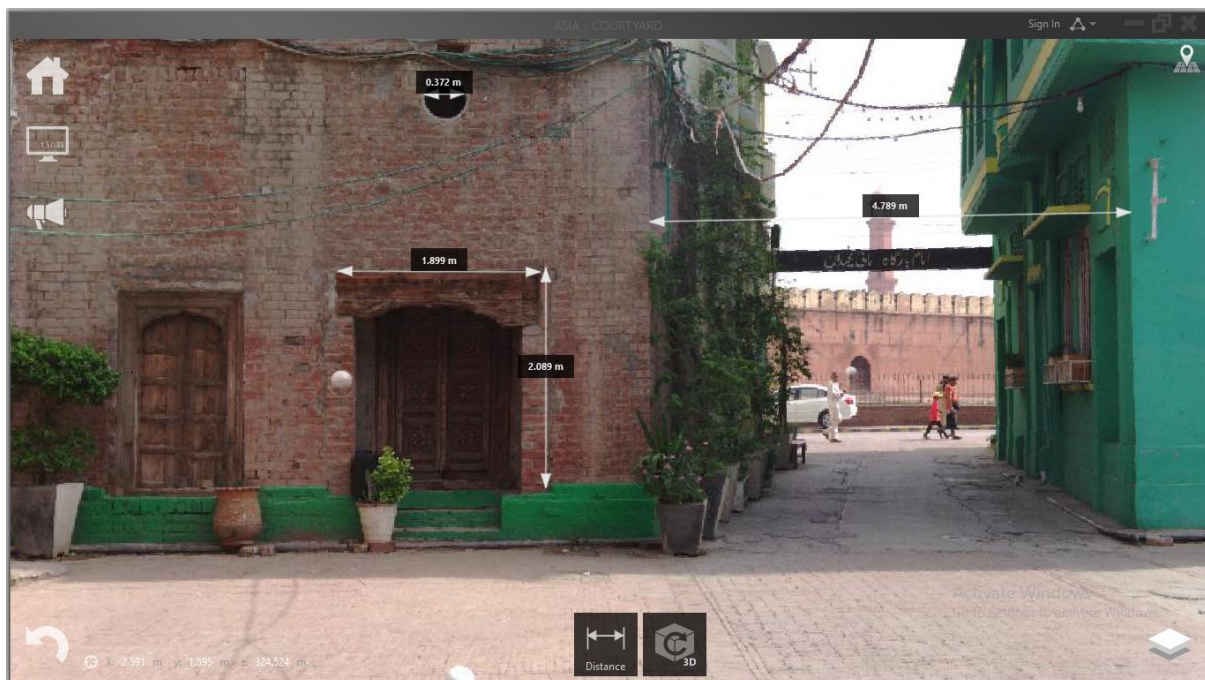


Figure 7-11: HBIM model with extracted detail of historic doors of high architectural value

Source: Author, 2023 (In collaboration with WCLA)

Building heights is also measured through expression of colors. Autodesk Recap has the option to get the heights of buildings. This image is showing the heights at 319 -350 meters at focal length of 50mm. The software can also support to “crop” unwanted objects from the model.

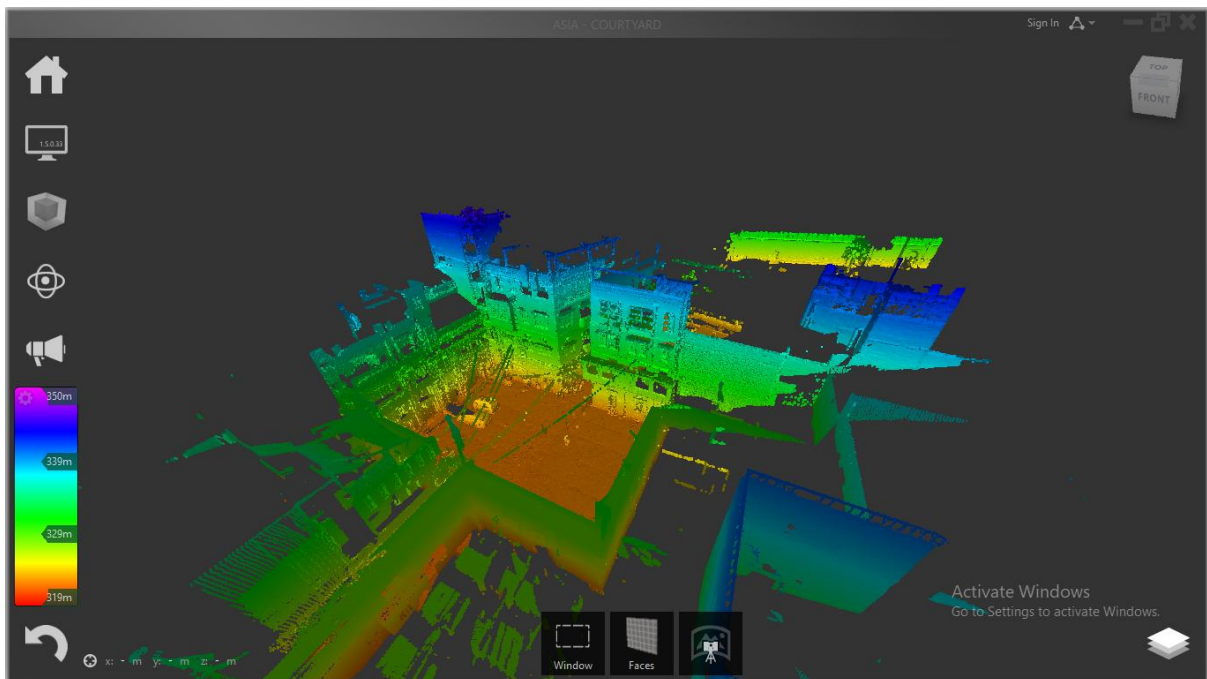


Figure 7-12: image capturing the building's complete inner view showing

Source: Author, 2023 (In collaboration with WCLA)

7.4.2. Development of a detailed BIM model

The files of Autodesk Recap can be transferred through a key feature” import point cloud” to AutoCAD & Revit to develop 3D models for the execution of the projects such as as-built drawings and digital documentation of heritage sites (Bruno et al., 2017).

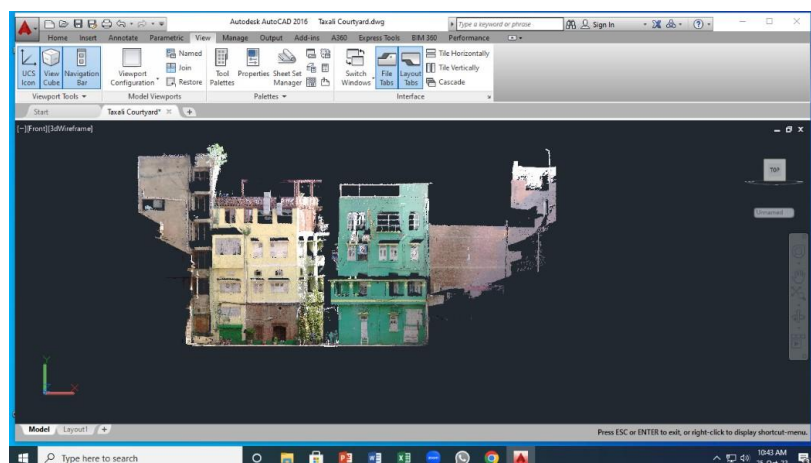


Figure 7-13: Elevation of Northern Façade of the Mai Eidaan Courtyard

Source: Author, 2023 (In collaboration with WCLA)

7.4.3. Analysis of structural integrity using digital tools

Digital technologies are playing a significant role in Building industry to get the best outcome of resources in terms of accuracy, time and money. Heritage conservation community is also trying to convert its processes and practices from conventional to digital for the preservation of historic buildings, urban heritage and archaeological sites. There are various phases of conservation process and documentation is one of the most crucial and substantial part. Conservation experts are trying to find the most authentic methods to document built heritage with the help of digital tools and software.

The journey of remote sensing for digital mapping of heritage sites started from total station to Terrestrial Laser scanning to save multilayer data in terms of intrinsic architectural details, damage valuation in depth, surface deteriorations and structural damages and it was not possible without application of the digital technologies. Application of Terrestrial Laser Scanner revolutionized the heritage community through the opportunities of scanning of urban built heritage in depth and can provide scan data, process-able to get AutoCAD orthographic drawings, Autodesk Revit 3D models and metadata in terms of building age, height, current status, materials deterioration, climatic impacts, usable for the preparation of conservation plans.

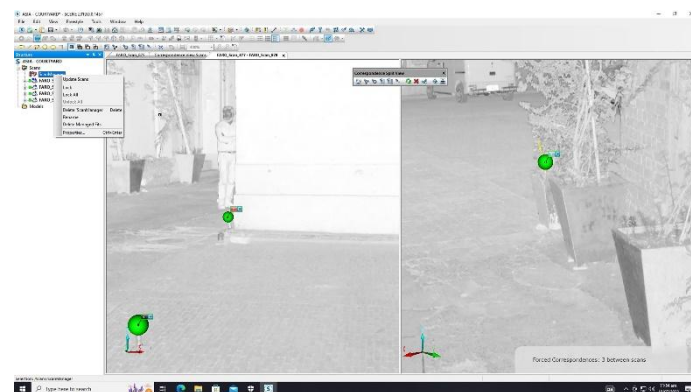


Figure 7-14: Terrestrial Laser Scanner, Scanned images in point cloud data

Source: Author, 2023 (In collaboration with WCLA)

The scan data provides accurate data consuming minimum time span and have been converted in AutoCAD and Revit files, which are latest solutions to get measured details while drawing horizontal and vertical measurements. The courtyard capture was completed in three hours, which would typically take a couple of weeks if done manually, with a risk of human error. Other than, human resources, to document the facades of group of buildings,

encompassing courtyard, there is a need of other equipment for measurements of multistory structures.

The orthographic projections and decorations such as kashi kari, mosaic and engravings cannot be measured, however, they can be scanned with high resolution point cloud data and measured drawings can also be prepared through the conversion of point cloud data into 3D CAD and Revit models. These measured drawings are helpful, in case of project projects planning and execution at site. Finally, Digital technologies also help to develop digital achieve of projects, entertained by various conservation agencies. In this research, digital tools, methods of their application and software for the conversion of scan data to Auto CAD files have been studied as an integrated approach to explore the scope and potentials of the application of Terrestrial Laser Scanner and HBIM approaches for the preservation of Architectural and Urban Heritage in Pakistan.

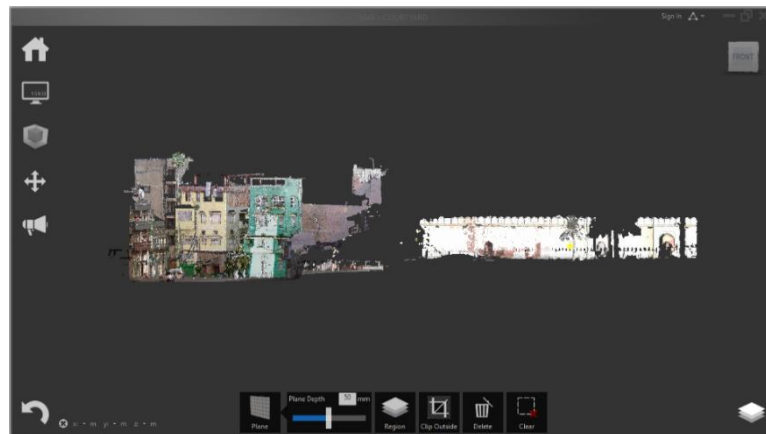


Figure 7-15: Recap data processed from point cloud data

Source: Author, 2023 (In collaboration with WCLA)

The process which once upon a time, was completed in a number of weeks can be done in few hours at site and the work on workstations can also be done in shortest time with maximum details. Although, there are possibilities of errors but they can be minimized through measures and skills. There is a big challenge regarding, cost of the equipment but it can also be justified based on number of projects, depending upon the heritage sites in Pakistan. The scan data can provide structural and surface damages in depth and it can also help to manage and monitor the heritage sites. Equally, can be performed in the preparation of digital achieve, usable for the future projects and data can be utilized for the sustainable development of the historic cities, saving loss of heritage in Pakistan.

7.4.4. Virtual restoration scenarios and simulations

Virtual restoration scenarios and simulations have emerged as transformative tools in the field of heritage conservation, offering non-invasive, precise, and reversible methods for exploring the potential restoration of historic structures. Utilizing advanced technologies such as 3D modeling, Building Information Modeling (BIM), and augmented or virtual reality (AR/VR), these simulations enable researchers, conservationists, and stakeholders to visualize and assess different restoration approaches before any physical intervention occurs. They provide a dynamic platform for testing materials, evaluating structural stability, and understanding the aesthetic and historical implications of restoration decisions. By reconstructing damaged or lost architectural elements digitally, virtual restoration not only aids in planning accurate conservation strategies but also serves as an educational and interpretive tool for the public, enhancing engagement with cultural heritage. In contexts where physical restoration may be constrained by political, financial, or technical challenges, such simulations offer a sustainable and insightful alternative that preserves the integrity and authenticity of heritage sites.

7.4.5. Development of a Digital Conservation Plan

A guideline for the Digital conservation framework has been proposed through a structured approach for implementing the digital conservation framework, with a particular focus on the historic core of Lahore.

A plan has been proposed to develop an educational campaign to raise public awareness about importance of the tangible and intangible cultural heritage and role of digital technologies for the protection of historic environment. The community participation can be enhanced through interactive sessions, educational resources and encouragement to involve in historic preservation efforts.

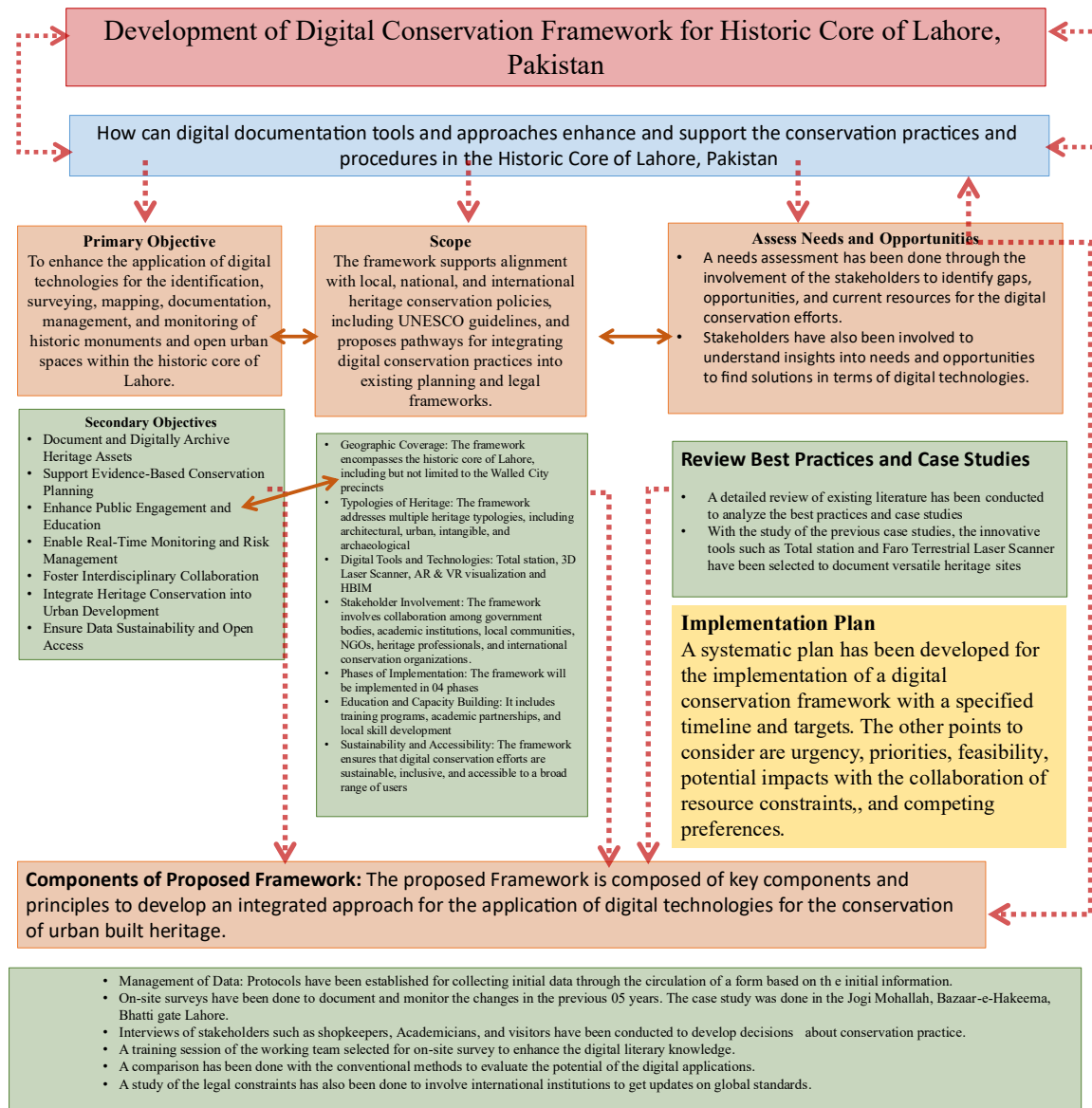


Diagram 7-4: Flow Chart of the Development of the Digital Conservation Framework and its Implementation

A step-by-step guide is available for developing a digital conservation framework.

Objectives and Scope

The core objective of the framework is to enhance the application of digital technologies for the identification, surveying, mapping, documentation, management, and monitoring of historic monuments and open urban spaces within the historic core of Lahore. However, the Walled City Lahore Authority (WCLA) has already taken the initiative to apply digital technologies, with the collaboration of National Institutes such as Aga Khan Cultural

Services of Pakistan (AKCSP) and International funding Agencies such as the World Bank, USAID, etc.

The historic core of Lahore is facing multiple issues due to rapid urbanization and commercialization. These two processes deteriorated the historic environment and old city faced the issues of out-migration, vehicular movement to the inner parts of the city, replacement of old buildings by new constructions, horizontal and vertical encroachments, squatted shop due to the ever increasing commercialization, collection of heaps in around historic monuments, illegal occupancies, intervention done by LESCO, SNGPL, WASA and other local authorities, neglecting the integrity and authenticity of the historic core.

The result of all these issues came in the form of loss of heritage assets and in the absence of a comprehensive mechanism, this loss was not reversible and the historic core needed a holistic approach for the protection of its valuable assets.

Assessing Needs and Opportunities

A needs assessment was conducted through the involvement of stakeholders to identify gaps, opportunities, and current resources for digital conservation efforts. Stakeholders were also involved to gain insights into needs and opportunities for finding solutions through digital technologies.

Review Best Practices and Case Studies

A detailed review of existing literature has been conducted to analyze best practices and case studies that have already been implemented to learn lessons. With the study of the previous case studies, the innovative tools such as Total Station and Faro Terrestrial Laser Scanner have been selected to document versatile heritage sites such as Barood khana, Sheesh Mahal Lahore Fort, Mai Eidaan Courtyard, Jogi Mohallah, Bazaar-e-Hakeema, Bhatti Baazar and Wazir Khan Chowk to address the challenges at various phases of conservation procedures and practices.

Components of Proposed Framework

The proposed Framework is composed of key components and principles to develop an integrated approach for the application of digital technologies for the conservation of urban built heritage. This may include:

- **Management of Data:** Protocols have been established for the collection of initial data through circulation of a form based on initial information.
- **On-site surveys** have been done to document, monitor the changes in the previous 05 years. The case study was done in the Jogi Mohallah, Bazaar-e-Hakeema, Bhatti gate Lahore.
- **Interviews of stakeholders** such as shopkeepers, Academicians and visitors have been conducted to develop decision about conservation practice.
- **A training session of the working team** selected for on-site survey to enhance the digital literary knowledge.
- **A comparison has been done** with the conventional methods to evaluate the potential of the digital applications.
- **A study of the legal constraints** has also been done to involve international institutions to get updates on global standards.

Implementation Plan

A systematic plan has been developed for the implementation of a digital conservation framework with a specified timeline and targets. The other points to consider are urgency, priorities, feasibility, potential impacts with the collaboration of resource constraints,, and competing preferences.

Guidelines have been prepared for the development of digital conservation strategies according to architectural, historic and tourist value of the properties within historic core of Lahore. The technology solutions, compatible with conservation regulations and policies have been designed to refine conservation strategies.

7.5. INTEGRATION WITH URBAN DEVELOPMENT PLANS

The historic core of Lahore encompassing the Walled City and its adjoining zones—faces critical challenges related to rapid urbanisation, infrastructural strain, and the erosion of cultural heritage. In response, this thesis proposes a Digital Conservation Framework (DCF) that strategically leverages digital technologies such as mapping, 3D scanning, Building Information Modelling (BIM), and heritage databases to document, monitor, and manage the built environment. The DCF operates as both a diagnostic and strategic tool. It provides dynamic, real-time data on the physical condition, spatial usage, and socio-economic parameters of heritage sites. This data integration enhances decision-making processes and

supports adaptive reuse, risk mitigation, and policy interventions. Furthermore, the framework enables a participatory approach by incorporating inputs from local stakeholders, thus fostering community ownership of conservation efforts.

7.5.1. Alignment with Lahore's Master Plan

To ensure the framework's relevance and operational feasibility, its alignment with the Lahore Master Plan 2050 is critically examined. The Master Plan envisions Lahore as a polycentric, resilient, and environmentally sustainable metropolis. Within this vision, the historic core is recognised as a cultural asset that must be preserved while contributing to broader developmental objectives.

The DCF complements the Master Plan by proposing the integration of heritage data layers within city-wide planning tools, thereby enabling heritage-sensitive zoning, development controls, and transport planning. It further recommends the institutionalisation of heritage impact assessments (HIAs) within urban development approval processes. This ensures that all infrastructural and real estate projects within or near the historic core are subject to scrutiny from a conservation standpoint.

7.5.2. Strategies for Balancing Conservation and Development

The dichotomy between heritage conservation and urban development is addressed through a set of interrelated strategies grounded in international best practices and local realities:

- **Contextual Zoning:** Introducing heritage-based zoning overlays that allow differentiated levels of intervention based on a building or area's historical significance and current usage.
- **Incentivised Conservation:** Developing policy mechanisms such as transferable development rights (TDRs), tax relief, and public-private partnerships (PPPs) to incentivise the conservation of private historic properties.
- **Integrated Infrastructure Upgrades:** Coordinating the upgrade of utilities (water, sanitation, waste management) with heritage conservation to avoid the destructive impact of retrofitting or haphazard interventions.
- **Community Engagement and Livelihood Integration:** Embedding local economic activities such as crafts, tourism, and micro-enterprises into conservation initiatives to ensure their social sustainability.
- **Regulatory Synergy:** Enhancing coordination between the Walled City of Lahore Authority (WCLA), Lahore Development Authority (LDA), and other planning bodies to harmonise conservation and development policies.

7.5.3. Proposals for Sustainable Urban Regeneration

Urban regeneration in the historic core is envisioned not merely as physical restoration but as a holistic socio-spatial transformation. Sustainable regeneration is proposed through the following pathways:

- **Cultural Economy Framework:** Positioning heritage as an economic driver by supporting creative industries, cultural tourism, and knowledge-based activities in heritage precincts.
- **Resilient Urban Morphology:** Encouraging adaptive reuse of heritage buildings to accommodate contemporary functions while preserving their architectural integrity, thereby ensuring long-term viability.
- **Green and Blue Infrastructure Integration:** Restoring and integrating traditional water systems (such as baolis and nullahs) and green pockets (gardens, courtyards) into contemporary ecological networks.
- **Mobility and Accessibility Enhancement:** Redesigning pedestrian and public transport systems within the historic core to reduce vehicular pressure, improve air quality, and promote inclusive mobility.
- **Digital Governance and Monitoring:** Establishing a real-time urban monitoring system supported by digital twins, sensor networks, and AI-based analytics to continuously assess the impact of regeneration initiatives.

Through these integrated strategies, the proposed framework seeks to transform Lahore's historic core into a living heritage district—resilient to contemporary challenges, rooted in local identity, and aligned with the city's broader urban development trajectory.

7.6. GUIDELINES FOR LARGE-SCALE IMPLEMENTATION

The conservation works also involves stakeholder identification such as ownership status, local communities Authorities, National & International Organizations, funding agencies, technical experts, and tailored approaches towards modern technologies. All the stakeholders can participate through their unique perspective about conservation, preservation, rehabilitation and regeneration of urban built heritage.

Development of maps based on the inter-relationship of the stakeholders and potential contribution towards the conservation project according to the expertise, resources and level of involvement.

The key areas are;

- Development of strategies for the participation of stake holders through dialogues, meetings, workshops, academic plate forms and online webinars. Strategies have been developed, ensuring inclusive participation of stakeholders.
- There is a need to establish formal agreements, memoranda of understanding (MoU, or partnership details to define the role & responsibilities.
- There is a need to enhance the training opportunities to strengthen the technical expertise, foster the leadership qualities among local communities and sense of respect for the heritage sites.
- There is need for the mobilization of financial, human and technical sources for the implementation of digital technologies. International funding agencies are playing vital role with the collaboration of National Institutes.
- The transparent system of finding solutions in case of conflicts, with mutually consented goals.
- There is a need to establish a mechanism for the monitoring and evaluating the conservation procedures and practices to enhance the conservation efforts. A solicitation system is required to evaluate the feedback from the stakeholders.

7.6.1. Technical Requirements and Infrastructure Needs

An evaluation of digital methods based on electric distance measurements and point cloud data has been conducted for the documenting, development of digital archives, real-time monitoring of heritage sites and sharing of data among stakeholders.

7.6.2. Capacity Building and Training Programs

A systematic approach has been developed to generate awareness among stakeholders, conservation practitioners, and local communities through digital literacy and skills development. However, there is a need to foster a culture to develop knowledge and skill-sharing concepts for practical conservation efforts.

The success of a digital conservation framework (DCF) for the historic core of Lahore depends on the technical infrastructure and human capital required to operate, sustain, and evolve such a system. Capacity building, technical and institutional, is a fundamental pillar of

this framework. It includes targeted education, training, and skill enhancement for the key stakeholders. This section outlines strategic training initiatives aligned with operational needs in the local context.

Capacity Building for Conservation Professionals

Conservation professionals, including architects, engineers, heritage managers, and digital documentation specialists, play a central role in managing digital conservation. The following training modules are proposed:

- Digital Documentation and Survey Techniques
- Heritage Building Information Modelling (HBIM)
- Spatial Heritage Analysis
- Data Governance and Archival Standards
- Interdisciplinary Collaboration

These trainings can be conducted within academic institutions through professional short courses offered in collaboration with UNESCO, ICOMOS, and ICCROM.

Skill Development for Local Craftsmen and Artisans

Local craftsmen and artisans are custodians of intangible heritage practices that are essential for the authentic restoration and maintenance of built heritage. However, the rapid decline of traditional craft knowledge and the lack of engagement with contemporary conservation practices pose a significant risk to this heritage.

The following capacity-building initiatives are proposed:

- Craft Documentation and Digital Archiving
- Digital Design and Fabrication Techniques
- Conservation Literacy Workshops
- Apprenticeship and Mentorship Programs

These programs must be implemented in local languages and should be sensitive to the socio-economic realities of artisans, including stipends or income-support schemes during training phases.

Training for Government Officials and Urban Planners

Government officials and urban planners at institutions such as the Lahore Development Authority (LDA), the Walled City of Lahore Authority (WCLA), and the Metropolitan Corporation Lahore (MCL) play a crucial role in translating digital conservation strategies into regulatory frameworks and implementation plans. Their capacity development requires a policy-technical nexus approach.

Key components include:

- Digital Planning and Regulatory Tools
- Smart Heritage Management Systems
- Legal and Institutional Frameworks for Conservation
- Stakeholder Engagement and Participatory Governance

The digital transformation of heritage conservation in Lahore's historic core cannot be sustainably achieved without an accompanying human development strategy. By investing in capacity building across professional, artisanal, and bureaucratic domains, the Digital Conservation Framework ensures not only technical competence but also social legitimacy and long-term resilience. These training programs must be institutionalised through formal curricula, continuing education, and cross-sector partnerships to embed digital conservation practices into the structural fabric of urban governance and cultural heritage management in Lahore.

7.6.3. Data Management and Security Protocols

A protocol has been developed for collecting data from primary and secondary sources, ensuring precision and accuracy while considering ethical implications. Guidelines have been developed for data sharing among stakeholders. Rules have been established to ensure the quality of work done, thereby authenticating the data collected at the site. The digitization of heritage assets necessitates the establishment of comprehensive data management and security

protocols. These protocols ensure the integrity, confidentiality, accessibility, and long-term sustainability of digital heritage records. As data becomes central to conservation planning, urban development, and heritage policymaking, robust data governance mechanisms must be institutionalised to safeguard digital heritage against technical failures, misuse, and obsolescence.

Data Structuring and Metadata Standards

Effective data management begins with the adoption of standardised data models and metadata schemas:

- Metadata and Documentation Protocols
- Data Taxonomies and Classification
- Interoperability Protocols

Centralised and Distributed Data Storage Architecture

To support accessibility and redundancy, a hybrid storage model is recommended:

- Centralised Data Repositories
- Distributed and Cloud-Based Backups
- Data Versioning and Change Tracking

Access Control and User Management

Data security in a DCF demands a multi-tiered access control framework:

- Role-Based Access Control (RBAC)
- Authentication and Encryption
- Audit Trails and Logging.

Legal, Ethical, and Institutional Safeguards

Heritage data, particularly when it includes community knowledge or private properties, must be governed by ethical and legal frameworks:

- Data Ownership and Intellectual Property Rights
- Compliance with National and International Frameworks
- Memoranda of Understanding (MoUs)
- Data Sustainability and Preservation

To ensure long-term accessibility and usability of digital heritage records:

- Digital Preservation Strategies
- Redundancy and Disaster Recovery Plans:
- Periodic Audits and Quality Control

The successful deployment of a Digital Conservation Framework for Lahore's historic core is dependent on a rigorous, transparent, and ethically sound data management architecture. Through the implementation of secure storage systems, standardised metadata protocols, controlled access, and sustainability measures, the framework not only safeguards the digital representation of heritage assets but also enhances their utility for planning, research, and public engagement. Institutionalising these data management and security protocols is essential to embedding digital conservation practices into the urban governance fabric of Lahore and ensuring their resilience into the future.

7.6.4. Funding Strategies and Potential Partnerships

The realisation of a comprehensive Digital Conservation Framework (DCF) for the historic core of Lahore necessitates substantial and sustained financial investment. This includes initial capital for infrastructure development, long-term operational costs, and capacity-building initiatives. Given the multi-dimensional nature of digital conservation spanning heritage documentation, urban planning integration, public engagement, and ICT development it is imperative to adopt a diversified funding model and cultivate cross-sectoral partnerships. This section outlines strategic funding approaches and identifies potential collaborators that can support the planning, implementation, and sustainability of the DCF.

Public Sector Funding and Governmental Budget Allocations

Governmental support is essential for legitimising and institutionalising digital conservation efforts:

- **Development Budgets and Urban Regeneration Schemes:** Funding can be sought from provincial and federal development programs under the Planning & Development Board Punjab, Ministry of Information Technology, and Ministry of Culture. The DCF can be embedded within broader urban revitalisation and smart city agendas, such as the *Punjab Spatial Strategy* or *Lahore Development Plan 2050*.
- **Heritage Conservation Allocations:** The Walled City of Lahore Authority (WCLA), Punjab Archaeology Department, and the Lahore Development Authority (LDA) may allocate specific conservation grants for digital documentation, monitoring systems, and public heritage interfaces.
- **ICT and Digital Innovation Funds:** National and provincial digital innovation initiatives (e.g., Punjab Information Technology Board - PITB) may co-fund infrastructure such as cloud storage, open data platforms, or mobile heritage applications under the umbrella of e-governance or digital transformation.

International Funding and Multilateral Donor Support

Heritage conservation in Lahore's historic core presents an opportunity for international collaboration and development financing:

- **UNESCO and ICCROM:** As agencies deeply invested in cultural heritage preservation, UNESCO and ICCROM offer technical assistance and funding through World Heritage Fund grants, capacity-building programs, and digital heritage initiatives.
- **World Bank and Asian Development Bank (ADB):** Multilateral development banks have increasingly supported heritage-led urban regeneration projects under sustainable cities programs. The *Punjab Intermediate Cities Improvement Investment Program (PICIIP)* provides a precedent for aligning conservation with infrastructure upgrades and resilience planning.
- **European Union (EU) and GIZ (Germany):** Through programs such as the *EU Culture for Development* or GIZ's *Urban Development and Local Governance*, grants and technical partnerships may be leveraged for digital innovation in heritage management.
- **British Council, Aga Khan Trust for Culture (AKTC), and the Getty Foundation:** These institutions have a history of engagement in cultural heritage conservation in South Asia and may support pilot initiatives, training programs, or public outreach components of the DCF.

Private Sector Involvement and Corporate Social Responsibility (CSR)

Engaging the private sector through Corporate Social Responsibility (CSR) programs and Public-Private Partnerships (PPPs) can provide alternative and sustainable financing streams:

- **CSR Contributions:** Real estate developers, telecom companies, banks, and infrastructure firms operating in Lahore can be invited to contribute to heritage conservation as part of CSR obligations. Sponsorship of digital installations, educational campaigns, or virtual tourism platforms are feasible avenues for private sector involvement.
- **PPP Models for Digital Infrastructure:** Partnerships with private ICT firms can support the development and maintenance of cloud platforms, data analytics systems, and geospatial infrastructure. In return, these firms may be granted non-exclusive licensing for tools or public branding opportunities.
- **Cultural Tourism Ventures:** Collaborations with tour operators, digital storytelling platforms, and media production companies may generate revenue through the monetisation of digital heritage assets (e.g., 3D heritage experiences, virtual walking tours).

Academic and Research Collaborations

Academic institutions serve not only as sources of expertise but also as conduits for research grants and student-led innovation:

- **University Partnerships:** Institutions such as the National College of Arts (NCA), University of Engineering and Technology (UET) Lahore, and Punjab University can be engaged for research-driven documentation, data analysis, and prototyping. Faculty-led research projects may secure funding from the Higher Education Commission (HEC) or international academic networks.
- **Joint Research Grants:** Funding applications through global heritage research platforms (e.g., Newton Fund, Horizon Europe, or the Global Challenges Research Fund - GCRF) can enable international academic partnerships focused on digital conservation, sustainable urbanism, and community heritage.

Community-Based and Crowdfunding Approaches

Involving local communities in funding conservation initiatives fosters ownership and long-term sustainability:

- **Community Heritage Funds:** Mechanisms such as neighbourhood heritage funds or endowments can be established with seed funding and community contributions to finance small-scale interventions, oral history projects, or digital archiving.

- **Crowdsourcing and Micro-Donations:** Platforms such as GoFundMe, Kickstarter, or Pakistan-based portals can be used to raise funds for specific digital heritage initiatives (e.g., 3D documentation of a threatened building or creation of a digital museum).
- **Civic Engagement Incentives:** Municipal authorities can incentivise citizen participation by linking donations or volunteer hours to cultural benefits, such as access to digital archives or guided heritage walks.

The sustainability of a Digital Conservation Framework for Lahore’s historic core hinges on the creation of a resilient and diversified funding ecosystem. By combining public sector commitments, international donor engagement, private sector collaboration, academic partnerships, and community participation, the DCF can be effectively resourced and operationalised. Establishing a central coordination body responsible for fund mobilisation, grant writing, and partnership development is critical to navigating the complex funding landscape and ensuring the long-term viability of digital heritage initiatives in Lahore.

7.6.5. Policy recommendations for digital heritage conservation

The impacts of digital technologies have been assessed, and strategies have been refined to enhance key performances. A plan has been proposed for the effective implementation of digital technologies in the area of heritage preservation.

The preservation of Lahore’s historic core—comprising Mughal, Sikh, and colonial urban fabrics—demands a nuanced integration of conservation imperatives with the dynamics of a rapidly modernising city. The development and deployment of a Digital Conservation Framework (DCF) presents a transformative opportunity to manage, monitor, and valorise cultural heritage in data-driven, participatory, and sustainable ways. However, to translate this potential into practice, an enabling policy environment is essential. This section outlines a set of policy recommendations designed to facilitate digital heritage conservation through institutional reform, regulatory alignment, technological integration, and multi-stakeholder engagement.

Institutional Integration and Governance Reform

- **Establish a Centralised Heritage Data Authority:** A dedicated institutional body or digital heritage unit within the Walled City of Lahore Authority (WCLA) or the Punjab Heritage and Tourism Department should be established to coordinate digital documentation, data management, and inter-agency collaboration.

- **Mandate Interdepartmental Data Sharing:** Formalise data-sharing protocols between WCLA, LDA, Punjab Archaeology Department, and municipal IT departments to facilitate integrated planning, zoning regulation, and heritage monitoring through a shared platform.
- **Create a Digital Heritage Coordination Committee:** Form an intersectoral policy advisory committee comprising conservationists, planners, technologists, local government officials, and community representatives to guide strategic decisions and ensure transparency.

Legal and Regulatory Frameworks

- **Amend Existing Heritage Laws to Recognise Digital Assets**
Update the Antiquities Act (1975) and Punjab Special Premises Act (1985) to include provisions for digital records, virtual reconstructions, and digitally mapped conservation zones as legally recognised tools for heritage management.
- **Mandate Digital Documentation as a Prerequisite for Interventions**
Require digital documentation—including 3D scanning, GIS mapping, and condition assessments—before any physical restoration, development approval, or adaptive reuse of heritage properties is permitted.
- **Incorporate Heritage Sensitivity in Urban Planning Bylaws**
Introduce heritage sensitivity overlays within the Lahore Master Plan and zoning codes, supported by spatial data from the DCF, to ensure that development in and around the historic core adheres to conservation guidelines.

Technical Standards and Infrastructure

- **Adopt Open Data and Interoperable Platforms:** Mandate the use of open formats (e.g., IFC, GeoJSON, XML) and international metadata standards (e.g., CIDOC-CRM) for all heritage data to ensure interoperability across institutions and platforms.
- **Ensure Data Security and Long-Term Preservation:** Enforce protocols for data encryption, access control, and cloud-based backups. Create public-private partnerships to build robust digital infrastructure for data storage and dissemination.

- **Standardise Digital Survey and Documentation Methods:** Publish national guidelines for digital survey techniques such as LiDAR, photogrammetry, and HBIM, with emphasis on accuracy, scale, and cultural sensitivity.

Capacity Building and Education

- **Institutionalise Training for Conservation Professionals and Technicians:** Develop continuous professional development programs through HEC-accredited institutions to train architects, archaeologists, engineers, and GIS specialists in digital conservation tools and platforms.
- **Support Traditional Artisans through Digital Literacy Programs:** Equip local craftsmen with digital tools for documentation, design translation, and collaboration with professionals, preserving intangible heritage through digital media.
- **Incorporate Digital Heritage into Academic Curricula:** Encourage architecture, urban planning, archaeology, and IT programs to integrate courses on digital heritage conservation, historical GIS, and virtual reconstruction.

Community Engagement and Public Access

- **Create an Open Access Heritage Portal:** Launch a multilingual digital platform to share interactive heritage maps, 3D models, oral histories, and archival materials, encouraging public interaction, education, and stewardship.
- **Support Participatory Mapping and Crowdsourced Documentation:** Encourage residents and heritage enthusiasts to contribute photographs, stories, and building data through mobile apps and civic engagement platforms, enhancing community ownership and data richness.
- **Foster Heritage Awareness through Digital Media:** Use digital storytelling, virtual tours, and social media campaigns to raise awareness of Lahore's historic significance and the value of conservation in the digital age.

Financial and Funding Policies

- **Create a Heritage Innovation Fund:** Allocate public funds to support digital heritage initiatives through competitive grants, prioritising projects that align with conservation, education, and tourism objectives.
- **Provide Fiscal Incentives for Digitally Compliant Projects:** Offer tax reliefs, subsidies, or fast-track approvals to private owners and developers who undertake digital documentation and conservation of heritage properties.
- **Promote International Collaborations for Funding and Expertise:** Facilitate partnerships with global heritage bodies (UNESCO, ICCROM, World Bank) and academic networks for funding, knowledge exchange, and technical assistance.

To preserve the cultural and architectural integrity of Lahore’s historic core while enabling its sustainable integration into the modern urban fabric, a shift toward digital heritage conservation must be underpinned by progressive and context-sensitive policies. These recommendations serve as a strategic roadmap for national and provincial authorities to institutionalise digital practices, empower stakeholders, and safeguard cultural memory through technological innovation. Implementing these policies will not only enhance Lahore’s global cultural standing but also provide a replicable model for digital conservation in other historic urban centres across Pakistan.

7.7. FUTURE DIRECTIONS AND POTENTIAL EXPANSIONS

Conduct studies on the long-term sustainability of digital conservation efforts, including the environmental impact of data storage and energy consumption. Explore green computing solutions and best practices for minimizing the carbon footprint while maximizing the utility of digital tools for heritage preservation.

- AI Analysis and Prediction:
- VR/AR Enhancements:
- Blockchain for Data Integrity:
- 3D Printing for Conservation:
- Machine Learning Interpretation:
- Cloud-Based Collaboration:

These developments hold the potential to overcome existing challenges in conservation, accelerate innovation, and ensure the long-term preservation and accessibility of cultural heritage.

7.7.1. Integration of AI and machine learning for predictive conservation

The research area of Machine learning and AI tools requires more attention to assess the damage, predictive modelling, conservation workflows, and analysis of large data sets. As the historic core of Lahore presents a rich, fragile cultural landscape, the traditional conservation practices, while valuable, are facing challenges of data availability, reactive planning, and a fragmented monitoring mechanism. The integration of Artificial Intelligence (AI and Machine Learning (ML) into the Digital Conservation Framework introduces a transformative capacity for predictive conservation – a forward-looking strategy.

Conceptual Framework for Predictive Conservation

Predictive conservation refers to the use of historical, environmental, and structural data—analysed through AI algorithms—to anticipate future risks to heritage sites and propose timely interventions. It shifts the conservation paradigm from reactive restoration to anticipatory planning.

Key objectives include:

- Identifying patterns of deterioration before visible damage occurs.
- Assessing vulnerability to environmental and anthropogenic stressors.
- Optimising maintenance cycles and resource allocation.
- Enabling automated monitoring and early warning systems.

AI and ML Applications in Heritage Conservation

Structural Health Monitoring

- Sensor Integration and Data Fusion
- ML for Damage Detection

Environmental and Climate Impact Prediction

- Time-Series Forecasting
- Heat Island Mapping

Urban Development and Risk Modelling

- Change Detection Algorithms
- Predictive Zoning Models

Material and Craft Analysis

- Machine Vision for Material Typology
- Algorithmic Craft Simulation

Data Requirements and Integration Strategies

To effectively deploy AI/ML models, comprehensive and high-quality datasets are essential. These include:

- **Geospatial Data:** Historical and contemporary GIS layers, cadastral maps, and land use data.
- **Visual Archives:** Photographic surveys, drone imagery, and 3D scans of monuments.
- **Environmental Data:** Historical climate data, air quality indices, and flood maps.
- **Sensor Data:** Real-time data streams from IoT-based monitoring systems.

Integration should occur through a centralised heritage data infrastructure, with open APIs enabling cross-platform machine learning training and inference.

Institutional and Ethical Considerations

- Data Governance
- Skill Development
- Collaborative Innovation Ecosystems

Case Application: A Predictive Conservation Pilot for Lahore

A pilot project could focus on a high-priority heritage cluster (e.g., Mai Eidaan Courtyard , Shahi Guzargah or the Wazir Khan Mosque precinct), integrating:

- Drone-based orthophotography for real-time spatial updates.
- IoT-based humidity and vibration sensors for structural monitoring.
- CNN-based visual analysis of stonework and frescoes.
- AI dashboards for risk assessment and conservation priority ranking.

Such a project would serve as a replicable model for data-driven conservation within the broader context of Lahore’s heritage governance. The application of AI and ML in Lahore’s historic core holds immense potential to revolutionise conservation by enabling predictive, scalable, and cost-effective strategies.

7.7.2. Development of virtual and augmented reality applications for public engagement

The development of a consolidated platform initiative, enabling residents to participate in the sustainability of a locality. The bottom-up approach can foster the implementation of digital technologies. Extending the application of AR/VR, virtual tours can be managed for the timely completion of the visit. Audience participation can be enhanced by incorporating storytelling. This section examines the rationale, applications, technical frameworks, and implications of integrating immersive technologies into Lahore’s Digital Conservation Framework (DCF) to foster inclusive and dynamic heritage experiences.

Rationale for Immersive Heritage Technologies

Virtual and augmented reality technologies enable a paradigm shift from passive observation to active experience. They make heritage accessible beyond physical or geographic constraints, and foster affective learning, empathy, and contextual understanding—key elements in cultivating public support for conservation (Furferi et al., 2024).

Key benefits include:

- Enhanced historical storytelling through spatial and temporal reconstructions.

- Accessibility for those unable to visit heritage sites due to distance, disability, or preservation-related restrictions.
- Preservation of intangible cultural heritage (e.g., oral traditions, crafts, rituals) through multi-sensory documentation and interaction.

Application Typologies for VR and AR in Lahore's Historic Core

Virtual Reality (VR) Experiences

- Reconstruction of Lost or Altered Sites
- Historic Time-Travel Narratives
- Museum Extensions

Augmented Reality (AR) Applications

- On-site Mobile AR Tours
- Craft and Ritual Demonstrations
- AR Wayfinding Systems

Technical and Design Frameworks

Data Sources

- High-resolution Laser scans of monuments and urban spaces.
- Archival images, historical maps, and oral histories curated through the Digital Conservation Framework.
- Georeferenced building databases for accurate spatial modelling.

Software Platforms

- Game engines such as Unity and Unreal Engine for immersive environment design.
- ARCore (Android) and ARKit (iOS) for mobile AR development.

- WebVR and WebAR solutions for browser-based experiences to ensure broader accessibility without specialised headsets.

UX Design Considerations

- Multilingual interfaces (Urdu, Punjabi, English) for inclusivity.
- Layered narrative paths to cater to diverse audiences (e.g., school groups, historians, tourists).
- Embedded feedback and educational quizzes for interactivity and engagement measurement.

Public Engagement and Educational Strategies

- School and University Integration
- Community Co-creation
- Gamified Heritage Experiences

Challenges and Mitigation Strategies

Table 7-1: List of Challenges and Mitigation Strategies (Source: Author)

Challenge	Mitigation Strategy
Limited digital infrastructure	Deploy lightweight web-based versions; partner with mobile providers.
High development costs	Seek academic and industry partnerships; apply for cultural tech grants.
Heritage authenticity risks	Engage historians and conservation experts in content validation.
Exclusion of non-digital users	Develop hybrid experiences combining analog and digital formats.

Pilot Project Proposal: “Walking through Mai Eidaan Courtyard”

A pilot VR-AR application titled *"Walking through Mai Eidaan Courtyard"* could be developed to digitally reconstruct the ceremonial route from Taxali Gate to the Lahore Fort. Features may include:

- Interactive VR walk-throughs of key monuments
- AR overlays of historical photographs along the corridor.
- Oral histories from residents and traders are embedded within the user interface.
- Real-time cultural activity simulations (e.g., Qawwali sessions, processions).

This project would serve as a proof of concept for immersive heritage storytelling and could be scaled across the wider urban heritage network of Lahore.

7.7.3. Creation of a city-wide digital twin for comprehensive urban conservation

The historic core of Lahore comprising dense urban morphology, layered architectural heritage, and socio-cultural landscapes—is under increasing pressure from urbanisation, environmental degradation, and fragmented governance. Traditional conservation practices, often reactive and isolated, struggle to address the systemic and interdependent challenges that the historic city faces in the 21st century. In this context, the creation of a city-wide digital twin emerges as a critical tool for enabling data-driven, integrative, and predictive conservation planning.

A digital twin, in the context of urban heritage, refers to a dynamic, real-time, virtual replica of the physical environment that integrates multi-source data—including spatial, structural, environmental, and socio-economic layers—into a unified simulation environment (Nashaat Darwish & Elsayed Yoseph, 2019). This section elaborates on the development, structure, and potential of a digital twin framework for the conservation and sustainable management of Lahore’s historic urban core.

Defining the Urban Heritage Digital Twin

A digital twin for the historic core of Lahore is not merely a static 3D model, but an intelligent, interoperable system that synchronises real-time data with a multi-scale virtual model to:

- Monitor and predict structural and environmental changes in heritage assets.
- Simulate urban development scenarios and their potential impact on historic sites.

- Facilitate cross-sectoral coordination between planning, conservation, infrastructure, and tourism authorities.
- Support community engagement through interactive visualisation tools.

Structural Components of the Digital Twin

Spatial and Geometric Layer

- High-resolution 3D models of heritage buildings using photogrammetry and LiDAR.
- GIS-based mapping of street networks, plot boundaries, land use, and utilities.
- HBIM (Heritage Building Information Modelling) for architectural components and materials.

Environmental Monitoring Layer

- Integration of real-time sensor data for air quality, temperature, humidity, and vibrations.
- Climate change simulation models for stress testing building materials and public spaces.

Socio-Economic and Cultural Layer

- Demographic, land ownership, and property value datasets.
- Mapping of intangible cultural assets (e.g., festivals, crafts, oral histories).
- Crowd-sourced data and community narratives geotagged to specific locations.

Governance and Policy Layer

- Zoning, heritage protection overlays, building bylaws, and development control regulations.
- Infrastructure and mobility plans, layered to assess conservation impacts.
- Linkages to Lahore's Master Plan and local area plans.

Technical Architecture and Platform Design

- Cloud-based Architecture: Scalable data storage and computing resources enabling real-time updates and multi-user access.
- APIs and Interoperability: Use of open standards (e.g., CityGML, IFC, GeoJSON) to ensure integration with legacy systems and municipal databases.

- **AI and Simulation Engines:** Incorporation of machine learning algorithms to predict risks, such as structural failure or urban encroachment, and simulate urban growth trajectories.
- **User Interfaces:** Multi-level dashboards for various stakeholders—from policymakers to conservationists to the general public—offering tailored access and interactivity.

Implementation Phases

- **Baseline Digital Survey and Data Consolidation**
 - Conduct comprehensive 3D scanning and mapping of the historic core.
 - Consolidate archival, cadastral, and environmental data from government agencies and research institutions.
- **Model Development and Platform Integration**
 - Build layered spatial and analytical models through modular architecture.
 - Create a centralised digital platform hosted by the Walled City of Lahore Authority (WCLA) or Punjab Urban Unit.
- **Pilot Deployment and Feedback Loop**
 - Implement a prototype digital twin in a key precinct (e.g., Shahi Guzargah) to test functionality and public engagement.
 - Gather feedback from conservation professionals, urban planners, local residents, and tourists.
- **City-Wide Rollout and Adaptive Governance**
 - Scale the digital twin incrementally across the entire historic core and adjoining buffer zones.
 - Use real-time data insights to inform adaptive planning, enforcement, and public communication.
- **Strategic Benefits for Urban Conservation**

Table 7-2 : Advantages of Digital Twin

Function	Digital Twin Advantage
Risk Assessment	Real-time structural and environmental monitoring for early intervention.
Urban Policy Simulation	Scenario-based testing of zoning changes, infrastructure upgrades, or tourism initiatives.
Public Engagement	Immersive storytelling and visualisations to build community support for conservation.
Investment Planning	Identification of high-risk and high-potential zones for targeted funding and incentives.
Inter-agency Coordination	Shared digital platform for synchronising heritage, planning, and infrastructure data.

Table 7-3: Challenges and Mitigation Strategies for Digital Urban Conservation

Challenge	Mitigation Strategy
Data fragmentation	Establish data-sharing agreements and centralised governance via a lead heritage agency.
High cost of digitisation	Seek international funding, use open-source tools, and phase deployment.
Skill and capacity gaps	Train municipal staff and conservation professionals in digital tools and platforms.
Community exclusion	Involve local stakeholders in model development, validation, and interpretation.

The creation of a city-wide digital twin for Lahore’s historic core represents a paradigm shift in heritage management, offering a scalable and intelligent infrastructure for conservation in the digital age. By enabling predictive, participatory, and policy-aligned decision-making, the digital twin model aligns closely with the goals of sustainable urban regeneration, inclusive governance, and cultural resilience. For a city like Lahore, where heritage is deeply embedded

in the fabric of everyday life, a digital twin is not merely a technical innovation but a critical mechanism for ensuring the continuity of memory, identity, and spatial justice across generations.

Conclusion

The successful implementation and validation of the Digital Conservation Framework for Lahore's historic core marks a significant advancement in heritage management, transitioning from reactive preservation to anticipatory and participatory governance. Future expansions incorporating AI, immersive technologies, and digital twins offer transformative potential to safeguard the city's invaluable heritage within a rapidly changing urban context. Strategic investment, institutional commitment, and community collaboration remain essential to realizing this vision and fostering sustainable urban regeneration that honors Lahore's rich cultural legacy.

Chapter 8: Conclusion and Future Directions

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8. CONCLUSION AND FUTURE DIRECTIONS

Digital preservation has a significant impact on maintaining the historic values of built heritage and urban areas and providing innovative solutions to protect the decaying properties within the historic core of Lahore. It provided a way to modernization through the adaptation of the heritage, correlating with the traditional character of the area. There are a few goals that focus the attention of authorities, other collaborative institutes, and funding agencies.

Documentation and Preservation:

The conservation techniques based on digital tools, such as Total Station, Terrestrial Laser Scanner, and Photogrammetry, have empowered the collection of multilayer data in the form of 3D models and autogenerated orthographic drawings through digital documentation. It has also enhanced the development of digital archives as a research resource in the conservation effort, ensuring precision and accuracy.

Public Awareness and Engagement:

These efforts of digital conservation provide platforms for public participation and awareness among the stakeholders. Digital documentation, virtual tours, fascinating websites, panoramic views, and mobile applications provide opportunities to explore the new horizons of cultural heritage.

Data-driven Decision Making:

Digital techniques and practices facilitate the processes of data collection through archival research and on-site mapping, data analysis, the development of data archives, planning for management and monitoring of sites, and implementation of conservation plans. With the help of these tools and software, it is possible to share data reliability and to create a balance between the conservation community, stakeholders, and policymakers.

Risk Mitigation and Disaster Management:

The process was investigated to identify risks to heritage and to mitigate risks such as structural damage, environmental impacts, or natural disasters. Real-time monitoring procedures and predictive techniques are empowered to investigate hands-on measures for protecting valuable properties within the historic areas.

Capacity Building and Collaboration:

Digital processes encourage participation of all the stakeholders, including authorities, institutions, and funding agencies. Capacity-building programs provide opportunities for training conservation experts, policymakers, and site workers to visualize the whole phenomenon and to play an active role in conservation practices.

Tourism and Economic Development:

The preservation and adaptive reuse of historic monuments and archaeological sites can enhance tourism and economic improvements in historic cities. Heritage-led policies can be initiated through digital apps to attract tourists through the panoramic and virtual tours of the site. It will lead to the sustainable development of the historic cities.

8.1. SUMMARY OF KEY FINDINGS

This research establishes a comprehensive Digital Conservation Framework tailored for the historic core of Lahore, addressing the complex interplay of heritage preservation, urban development, and digital innovation. The key findings are summarized as follows:

Integrated Value-Based Approach:

The study emphasizes the need to adopt a value-based conservation approach that integrates both tangible and intangible heritage values. Through stakeholder engagement and heritage mapping, the framework emphasizes cultural significance as defined by local communities, experts, and institutional bodies, moving beyond traditional monument-centric preservation practices.

Spatial and Data-Driven Analysis:

Utilizing advanced digital tools, including spatial analysis, 3D documentation, and building information modelling (BIM), the research demonstrates that digital technologies significantly enhance the accuracy and efficiency of heritage documentation. These tools facilitate condition assessments, vulnerability mapping, and urban morphology analysis, which are critical to informed decision-making.

Stakeholder-Centric Framework Development:

The participatory methodology emphasizes the importance of multi-stakeholder collaboration, including governmental agencies, heritage experts, local communities, and urban planners, in shaping conservation priorities. The framework positions digital tools as

enablers of dialogue and consensus, allowing for more inclusive and sustainable conservation outcomes.

Digitization as a Catalyst for Heritage Management:

The study highlights that digitization not only supports documentation but also acts as a catalyst for long-term heritage management, including monitoring, policy-making, and public engagement. It promotes the creation of dynamic databases that can be continuously updated to respond to evolving urban and environmental pressures.

Context-Specific Adaptation:

The framework recognizes the socio-political and infrastructural realities of Lahore's historic core. It is designed to be adaptive to local conditions, resource constraints, and institutional capacities, ensuring its practical applicability and long-term viability in the context of Global South heritage cities.

Digital Literacy and Institutional Readiness:

One of the critical findings is the gap in digital literacy and institutional preparedness for implementing digital conservation practices. The study recommends capacity-building initiatives and institutional reforms to bridge this gap, enabling a smoother integration of digital tools within existing conservation workflows.

Potential for Replicability and Scalability:

While tailored to Lahore, the framework holds potential for replication in other historic urban environments with similar socio-cultural dynamics. Its modular structure allows for customization based on local heritage typologies, governance models, and technological infrastructure.

8.2. Contributions to Knowledge and Practice

8.2.1. Theoretical Contributions

Advancement of Digital Heritage Discourse in the Global South Context:

This research significantly contributes to the theoretical body of knowledge by situating digital conservation within the socio-cultural and political realities of postcolonial South Asian cities, particularly Lahore. It challenges Eurocentric models of heritage preservation by proposing a context-sensitive framework that foregrounds local narratives, practices, and epistemologies (Cristina & Gordon, 2018).

Synthesis of Value-Based Conservation and Digital Technologies

The study offers a novel theoretical synthesis between value-based conservation principles and emerging digital methodologies. It articulates a framework wherein digital tools are not merely technical enablers but epistemic instruments that facilitate the representation, interpretation, and negotiation of multiple heritage values.

Conceptualization of a Multi-Scalar Conservation Paradigm

The research conceptualizes conservation not as a site-specific practice but as a multi-scalar process that encompasses architectural, urban, and socio-spatial dimensions. It introduces the idea of 'digitally augmented heritage governance'—a theoretical construct that positions digital tools as mediators between heritage objects, urban policies, and stakeholder interests.

Integration of Participatory and Data-Driven Methodologies

By embedding participatory mapping, community engagement, and spatial analytics into a cohesive framework, the study contributes to the theoretical understanding of hybrid methodologies that merge qualitative and quantitative conservation paradigms.

8.2.2. Practical Implications

Development of Digital Conservation Framework

The research presents a contextually grounded and practically implementable framework for digital conservation, tailored specifically for the historic core of Lahore. This framework can guide conservation authorities, urban planners, and heritage managers in integrating digital tools into routine conservation and urban management practices.

Enhanced Heritage Documentation and Decision-Making

The application of Total Station, photogrammetry, and 3D scanning technologies demonstrates significant improvements in the documentation, analysis, and interpretation of built heritage. The framework supports data-driven decision-making, enabling more precise interventions, prioritization of resources, and risk assessments.

Institutional Capacity Building and Policy Integration

The research underscores the critical need for institutional reform and digital capacity-building within heritage governance structures. It provides actionable recommendations for

integrating digital conservation within existing policy frameworks, including heritage legislation, municipal planning, and infrastructure development schemes.

Community Engagement and Heritage Awareness

By employing digital tools to facilitate participatory processes, the framework enhances community inclusion and heritage awareness. It promotes co-creation of knowledge, allowing local stakeholders to become active agents in the conservation process, thereby improving the legitimacy and sustainability of conservation outcomes.

Scalability and Replicability of the Framework

While designed for Lahore, the framework exhibits high adaptability and can be scaled or replicated in other historic urban centers with similar challenges. Its modular structure allows for context-specific customization, making it a valuable model for heritage professionals working across diverse geographies in the Global South.

8.3. LIMITATIONS OF THE STUDY

Despite all the efficacies, there are challenges in terms of implementation and accessibility. Provide access to technology due to budget constraints. Continual upgrading and maintenance of digital tools and software are mandatory. There are issues related to authenticity and digital ethics that require comprehensive consideration to ensure that virtual tours perform positively, rather than surpass the authorities and heritage sites. Require careful consideration to ensure that virtual representations complement, rather than overshadow, the tangible heritage of Lahore. In conclusion, the discussion on digital conservation has evolved into an innovative tool for protecting the historic city of Lahore, developing a complex relationship between heritage protection and the sustainable development of historic cities in this digital era. Considering the potential of technical tools and software, all participants can work collaboratively to ensure the safety of the cultural legacy for future generations.

Table 8-1: Limitations of the Digital Conservation

Conclusions	Remarks
Lack of technical resources and expertise	There is a lack of technical resources and expertise, particularly in the field of remote sensing and mapping. There is also limited access to digital tools, and a lack of appropriate efforts is a great hindrance among key stakeholders.
Data Reliability	The work done through digital technologies is very challenging due to the environment. These technologies operate in the medium of waves; the total station works in electromagnetic waves, and the Faro TLS works in a laser environment. The environment influences the result of incomplete or biased data, which can lead to inaccuracies while preparing conservation plans.
Training opportunities	Limited technical knowledge and skills among stakeholders pose a challenge for implementing digital tools in terms of understanding, converting, and sharing digital data. A capacity-building program can reduce these inaccuracies.
Budget and Resource Constraints	The high cost of digital tools and associated software, including Total Station and Faro TLS, is the main prohibitive factor for resource-constrained organizations. Ongoing maintenance costs, software updates, and training to enhance expertise can increase expenses, which can impact the smooth operation of applications.
Collaborations among Stakeholders	Efforts to integrate various disciplines, including authorities, funding agencies, and training departments, can bridge the gap between technical experts and conservation experts. This integration between various departments can foster the initiatives for the implementation of digital technologies.
Inadequate policies and Regulatory Framework	Inadequate policies and regulatory frameworks may deter the application of digital conservation strategies, particularly in transboundary contexts. Appropriate policies for data ownership, copyright, and data sharing need to be established.
Community participation	Meaningful and positive participation of communities, indigenous groups, and demoted stakeholders is essential for the practical application of digital technologies. Ensuring language barriers, cultural variations, and authorities need a holistic approach.
Monitoring and Evaluation	The development of an evaluation mechanism to assess the impacts and efficacy of digital technologies is a challenge. Appropriate indicators must be defined for data collection methods, and a mechanism for measuring outcomes and tracking progress needs careful planning. Organizations and conservation practitioners can enhance the efficacy and longevity of digital conservation methods by addressing these challenges and constraints directly. This modern approach can play a significant role in fostering conservation efforts.

8.4. RECOMMENDATIONS FOR FUTURE RESEARCH

It has been recommended that further research is required to improve the efficacy of digital technologies and reduce the challenges in implementing digital tools.

Advanced Imaging Techniques: Enquire about the integration of digital imaging technology, including TLS and multispectral imaging technology, for capturing finer details of geometry and ornamentation. This methodology needs more comprehensive data to conserve the urban fabric within a historic context.

Machine Learning and AI Applications: The research area of Machine Learning and AI tools necessitates investigations to assess damage, predictive modeling, conservation workflows, and analysis of large datasets.

Community Participation and Crowdsourcing: Develop a comprehensive community participation platform that empowers residents to contribute to the sustainable development of their local area. This bottom-up approach can foster the implementation of digital technologies.

Virtual Reality (VR) and Augmented Reality (AR): Extend the application of virtual and augmented reality to develop an experience where tours can be managed for the in-time completion of the visit. Audience participation can be enhanced by incorporating storytelling.

Open Data and Collaboration Networks: Develop data repositories and a sharing network to facilitate collaborative approaches among the conservation community, heritage researchers, academic institutions, legal bodies, and funding agencies. Encourage transparency and accessibility of digital resources to support informed decision-making and innovation.

Sustainable Preservation Strategies: Conduct studies on the long-term sustainability of digital conservation efforts, including the environmental impact of data storage and energy consumption. Explore green computing solutions and best practices for minimizing the carbon footprint while maximizing the utility of digital tools for heritage preservation.

Policy and Governance Frameworks: Advocate for the development of policies and governance frameworks that prioritize the conservation of cultural heritage in urban planning processes. Promote the integration of digital conservation strategies into heritage management plans and regulatory frameworks to ensure institutional support and continuity of funding.

Ethical Considerations and Digital Rights: Address ethical concerns related to digital representation, intellectual property rights, and cultural sensitivities in the context of digital conservation. Respect local communities' perspectives and heritage values and engage in

meaningful dialogue to navigate potential conflicts and ensure equitable access to digital heritage resources.

Anticipated Developments in Digital Conservation Technologies to Revolutionize the Preservation and Understanding of Cultural Heritage:

- **AI Analysis and Prediction:** AI algorithms will analyze large datasets to detect deterioration patterns and predict future damage, enhancing conservation decision-making.
- **VR/AR Enhancements:** VR and AR technologies will offer more immersive experiences for exploring heritage sites, with advanced rendering and interaction capabilities.
- **Blockchain for Data Integrity:** Blockchain technology will ensure the integrity and authenticity of digital conservation data, reducing the risk of fraud and unauthorized alterations.
- **3D Printing for Conservation:** 3D printing will facilitate the replication of missing or damaged artifacts with high precision, aiding restoration efforts and enhancing accessibility to cultural heritage.
- **Machine Learning Interpretation:** Machine learning algorithms will automatically categorize and interpret cultural artifacts and historical texts, unlocking new insights into the past.
- **Cloud-Based Collaboration:** Cloud-based platforms will facilitate seamless collaboration among conservation teams, streamlining workflows and fostering interdisciplinary collaboration.
- These developments hold the potential to overcome existing challenges in conservation, accelerate innovation, and ensure the long-term preservation and accessibility of cultural heritage.

8.5. Concluding Remarks

Towards a Digital Conservation Framework for Lahore: Technologies, Policies, and Participatory Strategies

8.5.1. Introduction

Lahore, a city renowned for its architectural palimpsest and layered cultural histories, faces growing challenges in heritage conservation amidst rapid urbanization, infrastructural pressures, and climate vulnerability. Recent advancements in digital technology present new

opportunities for documenting, managing, and disseminating architectural heritage. However, to translate these potentials into sustainable outcomes, Lahore requires a comprehensive digital conservation framework that is technologically robust, policy-oriented, and community-centric.

This document outlines a contextually grounded framework for Lahore, incorporating appropriate technologies, policy considerations, and stakeholder engagement strategies. It draws on comparative international case studies, national experiences, and interdisciplinary theoretical models, including participatory planning theory, socio-technical systems theory, and digital heritage ethics.

8.5.2. Technological and Methodological Integration

Digital Documentation Tools

- 3D Laser Scanning & Photogrammetry: Useful for accurate modeling of historic monuments (e.g., Shahi Hammam, Badshahi Mosque) for conservation and analysis.
- UAVs and Drone Surveys: Ideal for urban-scale documentation and monitoring of heritage precincts.
- GIS and SDI: Enables spatial analysis and integration of heritage data into urban planning systems (Cheng & Li, 2021).
- Advanced Modeling and Visualization
- Heritage Building Information Modeling (HBIM): Supports the aggregation of structural, material, and historical data (Volk et al., 2014).
- Scaled Digital Twins: Pilot models for areas like the Walled City can simulate structural degradation and environmental stressors, providing valuable insights.
- AR/VR Applications: Enhance education and heritage tourism through immersive storytelling (Champion, 2016).
- Archival Systems
- Digital Repositories: Centralized platforms for storing historical maps, photographs, architectural drawings, and oral histories.
- Interactive Platforms: Web-based story maps and crowd-sourced heritage atlases to democratize access.

8.5.3. Policy Considerations for Digital Heritage

- **Regulatory Integration:** Align digital practices with the Punjab Special Premises Act and Master Plan 2050. Mandate digital documentation for any intervention on registered heritage assets.
- **Data Governance:** Establish interoperable standards and metadata protocols for heritage data. Define clear custodianship and access rights (Giaccardi, 2012).
- **Institutional Coordination:** Create a Lahore Digital Heritage Coordination Cell involving WCLA, LDA, academia, and civil society. Embed digital heritage within broader urban resilience and cultural development strategies.

8.5.4. Legal and Ethical Considerations

Protect intellectual property and sensitive cultural data. Avoid epistemic violence by ensuring inclusive narratives (Smith, 2006).

Stakeholder Engagement and Capacity Building

Table 8-2: Stakeholder Mapping

Stakeholder	Role/Interest	Mode of Engagement
WCLA, Department of Archaeology	Policy, restoration, management	Strategic coordination
Academic Institutions	Research, training, innovation	Curricula, fellowships, labs
Local Communities	Custodians of lived heritage	Participatory mapping, oral histories
IT Professionals/Startups	Tool development, platform maintenance	Hackathons, co-design workshops
NGOs and Cultural Collectives	Advocacy, community engagement	Capacity building programs

Participatory Planning: Integrate residents into decision-making through ward-level heritage committees (Healey, 1997). Use digital platforms to facilitate co-authorship of heritage narratives.

Capacity Building: Establish certificate courses and internships in digital heritage with NCA, UET, and LUMS. Provide technical training to heritage artisans in digital methods.

Innovation Ecosystems: Encourage tech incubators focused on low-cost heritage tools. Promote public-private partnerships in digital infrastructure.

8.5.5. Theoretical Underpinnings

- Participatory Planning Theory: Stresses the role of inclusive, deliberative processes in shaping urban futures. In Lahore, participatory digital heritage can counter-top-down narratives and promote spatial justice (Friedmann, 1987).
- Socio-Technical Systems Theory: Highlights the co-evolution of technology and society. Lahore's heritage sector must be viewed as a socio-technical assemblage where digital tools are co-produced with cultural, institutional, and material realities (Geels, 2004).
- Digital Heritage Ethics: Raises questions of representation, access, and authorship. The framework must resist reproducing colonial or elite perspectives and prioritize local, plural, and minoritized voices.

8.5.6. Conclusion

The digital conservation of Lahore's heritage requires more than technological intervention; it demands a holistic, participatory, and ethical reframing of heritage practice. By adopting appropriate tools, reforming institutional frameworks, and empowering stakeholders, Lahore can develop a resilient, inclusive, and forward-looking conservation model. This framework is a step toward that transformation, anchoring digital innovation within the city's socio-cultural landscape and historical consciousness.

REFERENCES

- Abbas, M., & Wakil, I. (2023). Exploring and Analyzing the Drivers of Urban Sprawl in Pakistan: A Case Study of Lahore. *3rd RASTA CONFERENCE*.
- Aboushal, E. A., & Gharib, M. S. (2020). Restoration and Development of Urban Heritage Sites (Rehabilitation of Middle cities and Heritage towns). *Journal of Engineering Research*, 167(September), 18–39. <https://doi.org/10.21608/erj.2020.139530>
- Akbar, S. H., Plevoets, B., & Iqbal, N. (2022). Preserving the Tangible and Intangible Values of the Baltit Fort in Gilgit-Baltistan Pakistan, through Adaptive Reuse. *SPACE International Journal of Conference Proceedings*, 2(1), 1–9. <https://doi.org/10.51596/sijocp.v2i1.20>
- AKCSP. (2005). *Sustainable development Walled City of Lahore Cultural heritage and tourism The Shahi Guzargah Pilot project August 2005*.
- AKCSP. (2010). *CONSERVATION OF THE WAZIR KHAN MOSQUE LAHORE PRELIMINARY REPORT ON CONDITION AND RISK ASSESSMENT AGA KHAN TRUST FOR CULTURE*.
- AKCSP. (2012). *Conservation of the Wazir Khan Mosque Lahore, Agha Khan Trust for Culture, Part III: Conservation & Restoration*.
- AKTC. (2017). *Wazir Khan Masjid*. WCLA, Lahore / AKTC.
- Alhasawi, M. (2019). The Policies and Process of Preserving the Historical and Heritage Buildings in Dubai City: Case Study of Historical District. *The Academic Research Community Publication*, 3(4), 39–48. <https://doi.org/10.21625/archive.v3i4.537>
- Ali Al-Shomali, M. (2020). Establishing evaluation criteria of modern heritage conservation in historic city centers in Jordan. *International Journal of Environmental Science and Development*, 11(12), 561–571. <https://doi.org/10.18178/ijesd.2020.11.12.1308>
- Ali, R. H. (1990a). Urban Conservation in Pakistan: a Case Study of the Walled City of Lahore. In *Architectural and Urban Conservation in the Islamic World* (Vol. 1, pp. 74–88).
- Ali, R. H. (1990b). *Urban Conservation in Practice" A case Study of the Walled City of Lahore*.
- Ali, S. H., & Sherzad, M. F. (2022). *Managing Strategies to Revitalize Urban Cultural Heritage after Wars : The Center of the Old City of Mosul as a Case Study*.
- Almerich-Chulia, A. I., & Moreno-Puchalt, J. (2023, January 10). *Potential perspectives of 3D laser scanner for real-life domains*. <https://doi.org/10.4995/bmt2022.2022.15619>

- Alsuwaidi, F., Sabri, R., & Belpoliti, V. (2021). Investigating the Values of Modern Architectural Heritage in Dubai, UAE. *IOP Conference Series: Materials Science and Engineering*, 1203(2), 022056. <https://doi.org/10.1088/1757-899x/1203/2/022056>
- Arif, R., & Essa, K. (2017). *EVOLVING TECHNIQUES OF DOCUMENTATION OF A WORLD HERITAGE SITE IN LAHORE*.
- Asghar, Q., Jalil, A., & Zaman, M. (2021). Use of Innovative Tools and Techniques for Heritage Preservation in the Digital Era: Academic Research on Asaf Khan's Tomb in Lahore. *Journal of Art, Architecture and Built Environment (JAABE)*, 4.
- Ayaz Mahmood, J., Gulzar, S., Ali, I., Rehman, N., & Wali Shah, M. (2022). ADAPTIVE REUSE OF NOOR MAHAL PALACE AT BAHAWALPUR: A CASE STUDY OF BALTIT FORT, GILGIT BALTISTAN, PAKISTAN. In *PJSEL* (Vol. 9, Issue 1). Online.
- Azeem, M., Hameed, M., Nadeem, R., Bhatti, W., & Ismat, S. (2024). An Overview on the History and Architecture of Kharpocho Fort Baltistan. *Bulletin of Business and Economics (BBE)*, 13(1). <https://doi.org/10.61506/01.00250>
- Azhar, S., Khalfan, M., & Maqsood, T. (2012). Building information modeling (BIM): Now and beyond. *Australasian Journal of Construction Economics and Building*, 12(4), 15–28. <https://doi.org/10.5130/ajceb.v12i4.3032>
- Badenko, V., Zotov, K., Zotov, D., Garg, R. D., Zhang, L., Bolsunovskaya, M., & Fedotov, A. (2017). Laser Scanner Survey Technologies for Historic Building Information Modeling of Heritage Resources in Saint-Petersburg , Russia. *Construction of Unique Buildings and Structures*, 1(52), 93–102.
- Bahadur, A. N. (2022). *ANALYSING PAKISTANI ARCHITECTURE IN THE CONTEXT OF CRITICAL REGIONALISM*. izmir Institute of Technology, Egpy.
- Baig, S. (2011). Conservation of The Shahi Hammam. In *Agha Khan Trust For Culture* (Issue May).
- Baik, A., Alitany, A., Boehm, J., & Robson, S. (2014). Jeddah historical building information modeling “JHBIM”-object library. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 2(5), 41–47. <https://doi.org/10.5194/isprsannals-II-5-41-2014>
- Baik, A., & Boehm, J. (2015). Building information modelling for historical building Historic Jeddah - Saudi Arabia. *2015 Digital Heritage International Congress, Digital Heritage 2015*, 125–128. <https://doi.org/10.1109/DigitalHeritage.2015.7419468>

- Baik, A., Boehm, J., & Robson, S. (2013). Jeddah Historical Building Information Modeling “Jhbim” Old Jeddah – Saudi Arabia. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XL-5/W2(September), 73–78.
<https://doi.org/10.5194/isprsarchives-xl-5-w2-73-2013>
- Bajpai, V., & Perelman, V. (2012). A Cross-Platform Open Source 3D Object Reconstruction System using a Laser Line Projector. *ISPRS*.
- Bandarin, F., & Oers, R. van. (2012). *The Historic Urban Landscape*. Wiley-BlackWell.
- Banfi, F., Brumana, R., & Stanga, C. (2019). Extended reality and informative models for the architectural heritage: From scan-to-bim process to virtual and augmented reality. *Virtual Archaeology Review*, 10(21), 14–30. <https://doi.org/10.4995/var.2019.11923>
- Baratin, L., Gasparetto, F., & Tronconi, V. (2023). What communication about heritage conservation? a challenge for digital documentation content. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 48(M-2–2023), 183–194. <https://doi.org/10.5194/isprs-Archives-XLVIII-M-2-2023-183-2023>
- Bartolini, G., De Falco, A., Giuliani, F., & Martino, M. (2024). Digital Techniques for the Documentation, Diagnosis, and Safety Assessment of Architectural Heritage. In *RILEM Bookseries* (Vol. 47, pp. 641–653). Springer Science and Business Media B.V.
https://doi.org/10.1007/978-3-031-39603-8_52
- Batool, T. (2017). Conservation in the Walled City of Lahore: How State Efforts Affect Historic Cores. *Вестник Росздравнадзора*, 4, 9–15.
- Bersani, E., Giambruno, M., & Pistidda, S. (2014). Planning for the Historic Built in Developing Countries: Challenges and Opportunities Through the Case Study of Multan (Pakistan). In *Built Heritage: Monitoring Conservation Management*.
- Bertolin, C. (2019). Preservation of cultural heritage and resources threatened by climate change. In *Geosciences (Switzerland)* (Vol. 9, Issue 6).
<https://doi.org/10.3390/geosciences9060250>
- Boussaa, D. (2014). Urban Heritage and Tourism in the Gulf: The Case of Dubai in the UAE. In *Journal of Tourism and Hospitality Management* (Vol. 2, Issue 4).
<http://www.lonelyplanet.com/maps/middle-east/united-arab-emirates/>.
- Bruno, N., & Roncella, R. (2019a). HBIM for conservation: A new proposal for information modeling. *Remote Sensing*, 11(15). <https://doi.org/10.3390/rs11151751>
- Bruno, N., & Roncella, R. (2019b). HBIM for conservation: A new proposal for information modeling. *Remote Sensing*, 11(15). <https://doi.org/10.3390/rs11151751>

- Brusaporci, S. (2017a). Digital innovations in architectural heritage conservation: Emerging research and opportunities. In *Digital Innovations in Architectural Heritage Conservation: Emerging Research and Opportunities* (Issue March).
<https://doi.org/10.4018/978-1-5225-2434-2>
- Brusaporci, S. (2017b). Digital innovations in architectural heritage conservation: Emerging research and opportunities. In *Digital Innovations in Architectural Heritage Conservation: Emerging Research and Opportunities*. IGI Global.
<https://doi.org/10.4018/978-1-5225-2434-2>
- Brusaporci, S., Maiezza, P., Marra, A., Tata, A., & Vespasiano, L. (2023a). Scan-to-HBIM Reliability. *Drones*.
- Brusaporci, S., Maiezza, P., Marra, A., Tata, A., & Vespasiano, L. (2023b). Scan-to-HBIM Reliability. *Drones*.
- Carbonari, G., Stravoravdis, S., & Gausden, C. (2015). Building information model implementation for existing buildings for facilities management: a framework and two case studies. *Building Information Modelling (BIM) in Design, Construction and Operations, 1*, 395–406. <https://doi.org/10.2495/bim150331>
- Caroti, G., Zaragoza, I. M. E., & Piemonte, A. et. al. (2021). The use of image and laser scanner survey archives for cultural heritage 3D modelling and change analysis. *Acta IMEKO, 10*(1), 114–121. https://doi.org/10.21014/ACTA_IMEKO.V10I1.847
- Chan, R. C. (2011). *Old Buildings, New Ideas: Historic Preservation and Creative Industry Development as Complementary Urban Revitalization Strategies* [University of Pennsylvania]. http://repository.upenn.edu/hp_theses/175
- Charola, Elena. A. (2007). *Theory and practice in conservation*.
- Cinquepalmi, F., & Tiburcio, V. A. (2023). Sustainable Restoration of Cultural Heritage in the digital era. *Vitruvio, 8*(2), 76–87. <https://doi.org/10.4995/vitruvio-ijats.2023.20545>
- City, T. W. (2007). *Walled City of Lahore , Pakistan Cultural Heritage for Economic Development*. 1–5.
- Cody, J., & Fong, K. (2017a). Built Heritage Conservation Education. *Built Environment*.
- Cody, J., & Fong, K. (2017b). *Built Heritage Conservation Education*. 33(3), 264–274.
- Conejos, S., Langston, C., & Smith, J. (2018). *Improving the implementation of adaptive reuse strategies for historic buildings IMPROVING THE IMPLEMENTATION OF ADAPTIVE REUSE STRATEGIES FOR HISTORIC BUILDINGS*. March.
- Cristina, L., & Gordon, C. (2018). *Digital Data Heritage Preservation (DHP) Modelling and Design Submitted for the Degree of Doctor of Philosophy Computer Systems School of*

Electrical and Data Engineering (SoEDE) Global Big Data Technologies Centre (GBDTC).

Cyark. (2020). *Projects*. Architectural Archive Website.

Das, A. (2024). *Food, heritage and affect: an urban ethnography of Shahjahanabad, Delhi*.

Diara, F., & Rinaudo, F. (2018). Open source hbim for cultural heritage: A project proposal. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(2), 303–309. <https://doi.org/10.5194/isprs-archives-XLII-2-303-2018>

Dice, M. (2018a). *Digital Commons @ Michigan Tech PRESERVATION FOR FUTURE GENERATIONS : DIGITAL TECHNOLOGIES , DIGITALIZATION , AND EXPERIMENTS WITH CONSUMERS AS PRODUCERS OF INDUSTRIAL HERITAGE*.

Dice, M. (2018b). *PRESERVATION FOR FUTURE GENERATIONS: DIGITAL TECHNOLOGIES, DIGITALIZATION, AND EXPERIMENTS WITH CONSUMERS AS PRODUCERS OF INDUSTRIAL HERITAGE DOCUMENTATION* [Michigan Technological University]. <https://doi.org/10.37099/mtu.dc.etr/572>

Din, N. U. (2018). *Shadows of Empire : The Mughal and British Colonial Heritage of Lahore*. In *City University of New York (CUNY)*.

DOAM. (2022). *Department of Archaeology & Museums*. Government of Pakistan.

Dore, C., & Murphy, M. (2017). Current state of the art historic building information modelling. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(2W5), 185–192. <https://doi.org/10.5194/isprs-archives-XLII-2-W5-185-2017>

Duca, G. Del, & Machado, C. (2023). Assessing the Quality of the Leica BLK2GO Mobile Laser Scanner versus the Focus 3D S120 Static Terrestrial Laser Scanner for a Preliminary Study of Garden Digital Surveying. *Heritage*, 6(2), 1007–1027. <https://doi.org/10.3390/heritage6020057>

Džikić, V., & Radin, M. (2019a). *Digital Technologies in Conservation of Cultural Heritage: Digitization and Values*. 34, 39–48. <http://www.icom-cc.org/242/about/terminology-for-conservation/#.XPobf62B1Bw>

Džikić, V., & Radin, M. (2019b). *Digital Technologies in Conservation of Cultural Heritage: Digitization and Values*. 34, 39–48.

E. K. Webb. (2015). 2015 Digital Heritage. *2015 Digital Heritage*, 1(October), 51–54. <https://doi.org/10.1109/DigitalHeritage.2015.7413832>

- Elashry, A. (2019a). *Digital Documentation and Conservation of Urban Heritage*.
https://www.academia.edu/download/65999939/Digital_documentation_and_conservation_of_urban_heritage.pdf
- Elashry, A. (2019b). *Digital Documentation and Conservation of Urban Heritage*.
- Eppich, R., Mahessar, K. A., & Nawaz, S. (2019). MONITORING MOVEMENT at MAKLI. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(2/W15), 443–447. <https://doi.org/10.5194/isprs-archives-XLII-2-W15-443-2019>
- Fai, S., Graham, K., Duckworth, T., Wood, N., & Attar, R. (2011). *Building Information Modeling and Heritage Documentation HBIM parametric libraries View project The VR Kiosk View project BUILDING INFORMATION MODELLING AND HERITAGE DOCUMENTATION*.
- Fatiguso, F., De Fino, M., & Bruno, S. (2017). *Historic Building Information Modeling towards Building Diagnostic Data Management. A case study* (Vol. 3, Issue 2).
- Fayez, H. (2024). From ‘Objects’ to ‘Sustainable Development’: The Evolution of Architectural Heritage Conservation in Theory and Practice. In *Buildings* (Vol. 14, Issue 8). Multidisciplinary Digital Publishing Institute (MDPI).
<https://doi.org/10.3390/buildings14082566>
- Feilden, B. (2003). *Conservation of Historic Buildings, Third Edition*. 404.
<https://www.amazon.co.uk/Conservation-Historic-Buildings-Bernard-Feilden/dp/0750658630>
- Fondazione, S. G., Kessler, B., Fondazione, F. R., Rizzi, A., Voltolini, F., Girardi, S., Gonzo, L., & Remondino, F. (2009). *Digital preservation, documentation and analysis of paintings, monuments and large cultural heritage with inf Morphological characterization of architectural elements View project DIGITAL PRESERVATION, DOCUMENTATION AND ANALYSIS OF PAINTINGS, MONUMENTS AND LARGE CULTURAL HERITAGE WITH INFRARED TECHNOLOGY, DIGITAL CAMERAS AND RANGE SENSORS*. <https://www.researchgate.net/publication/228645992>
- Furferi, R., Colombini, M. P., Seymour, K., Pelagotti, A., & Gherardini, F. (2024). The Future of Heritage Science and Technologies: Papers from Florence Heri-Tech 2022. In *Heritage Science* (Vol. 12, Issue 1). Springer Science and Business Media Deutschland GmbH. <https://doi.org/10.1186/s40494-024-01248-8>

- Geng, S., Chau, H. W., Jamei, E., & Vrcelj, Z. (2023). Urban Characteristics, Identities, and Conservation of Chinatown Melbourne. *Journal of Architecture and Urbanism*, 47(1), 20–34. <https://doi.org/10.3846/jau.2023.17383>
- Goel, S., Gandhi, I., & Wankar, M. (2024). *Governance and Quality of Life in Shahjahanabad: A Comprehensive Analysis*. <https://doi.org/10.48047/AFJBS.6.Si2.2024.4185-4192>
- Gomes, A. M. (2023a). Heritage Building Information Modelling Implementation First Steps Applied in a Castle Building : Historic Evolution Identity , Data Collection and Stratigraphic Modelling. *Heritage*, 6472–6493.
- Gomes, A. M. (2023b). Heritage Building Information Modelling Implementation First Steps Applied in a Castle Building : Historic Evolution Identity , Data Collection and Stratigraphic Modelling. *Heritage*, 6472–6493.
- Goulding, C. H. R. (1924a). *Old Lahore*. Survey of India, Map Department, Lahore.
- Goulding, C. H. R. (1924b). *Old Lahore*. Survey of India, Map Department, Lahore.
- Goulding, H. R. (1924). *Old Lahore*. Universal Books Lahore.
- Groat, L., & Wang, D. (2013). *Architectural Research Methods*. John Wiley & Sons, Inc., Hoboken, New Jersey.
- Guidi, G., IEEE Computer Society. Spanish Chapter, European Association for Computer Graphics, Institute of Electrical and Electronics Engineers, International Conference on Virtual Systems and MultiMedia (21st : 2015 : Granada, S., & EUROGRAPHICS (13th : 2015 : Granada, S. (n.d.). *2015 Digital Heritage International Congress (2015 Digital Heritage) : federating the 21st Int'l VSMM, 13th Eurographics GCH, plus special sessions from CIPA ICOMOS/ISPRS Special Heritage Documentation Workshop, CAA Fall Symposium, 7th Int'l Meeting Arqueológica 2.0, Space2Place, Archeovirtual, ICOMOS Digital Interpretation Panel, EU projects, et al.*
- Guidi, G., Russo, M., & Angeleddu, D. (2014). 3D survey and virtual reconstruction of archeological sites. *Digital Applications in Archaeology and Cultural Heritage*, 1(2), 55–69. <https://doi.org/10.1016/j.daach.2014.01.001>
- Gul, Z., Talpur, B. D., Rehman, S., Memon, R. M., & Karachi, T. (2023). *Architectural Survey of Cultural Heritage : A Case Study of Hyderabad , Architectural Survey of Cultural Heritage : A Case Study of Hyderabad , Pakistan. April*. <https://doi.org/10.37896/JXAT15.4/31854>

- Gulzar, S. (2017). Traditional Dwellings: An Architectural Anthropological Study from the Walled City of Lahore. *International Journal of Research in Chemical, Metallurgical and Civil Engineering*, 4(1), 152–158. <https://doi.org/10.15242/ijremce.ae0317113>
- Haggag, M., & Rashed, A. (2003). *Urban conservation in practice: evidence from the United Arab Emirates*.
- Hankey, D. (1999). *Culture in Sustainable Development Case Study : Lahore, Pakistan Conservation of the Walled City*.
- Hanson, A. J., Bass, S., Bouzaher, A., & Samdani, G. M. (2000). *PAKISTAN'S NATIONAL CONSERVATION STRATEGY: RENEWING COMMITMENT TO ACTION Report of the Mid-Term Review*.
- Haroon, F., Nawaz, M. S., Arsha, H. S. H., & Khilat, F. (2019). Urban Heritage of the Walled City of Lahore: Critical Analysis and the Way Forward for Policy. *Journal of Architectural and Planning Research*, 36(4), 289–302.
- Haroon Muhammad Shafaat Nawaz Faiqa Khilat Hafiz Syed Hamid Arshad, F. (2019). URBAN HERITAGE OF THE WALLED CITY OF LAHORE: CRITICAL ANALYSIS AND THE WAY FORWARD FOR POLICY. In *Journal of Architectural and Planning Research* (Vol. 36, Issue 4). Winter. <https://www.jstor.org/stable/27098713>
- Hashmi, A., & Taj, M. (2016). *Digital Preservation of Pakistan's Heritage*.
- Hassan Naqvi. (2023). WCLA Gets Control Of Historic Sites Including Lahore Fort, Shalimar Gardens. *Friday Times*. <https://thefridaytimes.com/15-May-2023/wcla-gets-control-of-historic-sites-including-lahore-fort-shalimar-gardens>
- Hassani, F., Studies, W. H., Process, C., Technology, D., & Heritage, C. (2015). *Documenting of Cultural Heritage Techniques, Potentials and Constraints*. <https://doi.org/10.5194/isprsarchives-XL-5-W7-207-2015>
- Henchoz, N., & Crank, A. (2018). *Digital heritage*. *January*, 375–380. <https://doi.org/10.1145/3202918.3203089>
- H.R.Goulding. (1924). *Old Lahore*. Universal Books Lahore.
- Husnain, G. (2024). Revitalizing Historic Urban Centers: The Case of Lahore's Walled City. *Journal of Asian Development Studies*, 13(2), 1190–1200. <https://doi.org/10.62345/jads.2024.13.2.94>
- Iamandi, C. (2015). Planning for The Conservation and Development of Historic Towns and Urban Areas. *Reader*, August.

- ICOMOS. (1987a). Charter for the Conservation of Historic Towns and Urban Areas (Washington Charter 1987). *Icomos, October*, 1–3.
- ICOMOS. (1987b). *CHARTER FOR THE CONSERVATION OF HISTORIC TOWNS AND URBAN AREAS (WASHINGTON CHARTER 1987) PREAMBLE AND DEFINITIONS*.
- Iftikhar, R. (2019). Lahore Fort- a Mughal Monument on the Verge of Decline. *Journal of the Research Society of Pakistan Volume*, 56(1), 27–40.
- India, G. (1908). *Archaeological Survey of India 1905 .pdf*.
- Institute, T. G. C. (2010). Historic Urban Environment Conservation Challenges and Priorities for Action Experts Meeting , March 12-14 , 2009. In *Historic Cities and Urban Settlements Initiative*.
- International Charter for Digital Heritage (2009).
- Intignano, M., Biancardo, S. A., Oretto, C., Viscione, N., Veropalumbo, R., Russo, F., Ausiello, G., & Dell’acqua, G. (2021). A scan-to-bim methodology applied to stone pavements in archaeological sites. *Heritage*, 4(4), 3032–3049.
<https://doi.org/10.3390/heritage4040169>
- Jodidio, P. (2019). *Lahore: A Framework for Urban Conservation*.
- Jokilehto, J. (2001). A History of Architectural Conservation. In *Journal of the American Institute for Conservation* (Vol. 40, Issue 2). <https://doi.org/10.2307/3180030>
- Jordan-Palomar, I., Tzortzopoulos, P., García-Valdecabres, J., & Pellicer, E. (2018). Protocol to Manage Heritage-Building Interventions Using Heritage Building Information Modelling (HBIM). *Sustainability*. <https://doi.org/10.3390/su10030908>
- Jouan, P., & Hallot, P. (2020). Digital twin: Research framework to support preventive conservation policies. *ISPRS International Journal of Geo-Information*, 9(4).
<https://doi.org/10.3390/ijgi9040228>
- Kamran, M., Awan, M. Y., & Gulzar, S. (2016). History of Conservation of Shish Mahal in Lahore-Pakistan. *International Journal of Research in Chemical, Metallurgical and Civil Engineering*, 3(1). <https://doi.org/10.15242/ijrcmce.ae05160318>
- Karasaka, L., & Ulutas, N. (2023). Point Cloud-Based Historical Building Information Modeling (H-BIM) in Urban Heritage Documentation Studies. *Sustainability (Switzerland)*, 15(13). <https://doi.org/10.3390/su151310726>
- Kaur, A. (2019). *Adaptation and Attainment of Colonial Character : The Transformation of Lahore*. 3085(04), 955–958.

- Khalid, A. (2021a). Conservation Challenges and Emerging Trends of Digital Preservation for UNESCO Architectural Heritage, Pakistan. *Conservation*, 2(1), 26–37.
<https://doi.org/10.3390/conservation2010003>
- Khalid, A. (2021b). Conservation Challenges and Emerging Trends of Digital Preservation for UNESCO Architectural Heritage, Pakistan. *Conservation*, 2(1), 26–37.
<https://doi.org/10.3390/conservation2010003>
- Khan, M. (2017). *INTEGRATED PLANNING AND MONUMENT CONSERVATION (2013-17) -THE 'MASTER CONSERVATION AND REDEVELOPMENT PLAN FOR THE WALLED CITY OF LAHORE*.
- Koch, E. (2008). Mughal Architecture. *Indian Islamic Architecture*, 27–33.
<http://www.jstor.org/stable/10.1163/j.ctv4cbgx7.7>
- Kumar, R. (2011). *Research Methodology*.
- Kumar, V., Singh, R., Ahuja, I. P. S., & Hashmi, M. S. J. (2020). On technological solutions for repair and rehabilitation of heritage sites: a review. *Advances in Materials and Processing Technologies*, 6(1), 146–166.
<https://doi.org/10.1080/2374068X.2019.1709310>
- Kwanda, T. (2009). *Western Conservation Theory and the Asian Context: The Different Roots of Conservation*.
- LAH, L. (2018). From architectural conservation, renewal and rehabilitation to integral heritage protection (theoretical and conceptual starting points). *Urbani Izziv - Rehabilitation – The Built Environment*, 12(1), 129–137.
- Lahore Development Authority, W. B. and I. D. A. (1980). *Lahore Urban Development and Traffic Study (LUDTS)*.
- Latif, S. M. (1994a). *Tarikh e Lahore*.
- Latif, S. M. (1994b). *Tarikh e Lahore*.
- Li, Y., Du, Y., Yang, M., Liang, J., Bai, H., Li, R., & Law, A. (2023). A review of the tools and techniques used in the digital preservation of architectural heritage within disaster cycles. *Heritage Science*, 11(1), 1–20. <https://doi.org/10.1186/s40494-023-01035-x>
- Liang, W., Ahmad, Y., & Mohidin, H. H. B. (2023a). The development of the concept of architectural heritage conservation and its inspiration. *Built Heritage*, 7(1).
<https://doi.org/10.1186/s43238-023-00103-2>
- Liang, W., Ahmad, Y., & Mohidin, H. H. B. (2023b). The development of the concept of architectural heritage conservation and its inspiration. *Built Heritage*, 7(1).
<https://doi.org/10.1186/s43238-023-00103-2>

- Lindsay, F. C. H. (2002). *India Past and Present*.
- London, K., & Ostwald, M. (2004). Architectural Research Methods. In *Nexus Network Journal* (Vol. 6, Issue 1). <https://doi.org/10.1007/s00004-004-0006-7>
- Lu, H., Yao, L., Lin, J., & Liu, S. S. (2023). *DIGITAL HERITAGE AND PRESERVATION : AERIAL PHOTOGRAMMETRY AND LIDAR APPLIED TO THE MAPPING OF KAPAYUWANAN , IND I GENOUS PAIWAN SETTLEMENTS , TAIWAN. XLVIII*(June), 25–30.
- Mansuri, L. E., Patel, D. A., Udeaja, C., Makore, B. C. N., Trillo, C., Awuah, K. G. B., & Jha, K. N. (2021). A systematic mapping of BIM and digital technologies for architectural heritage. *Smart and Sustainable Built Environment*. <https://doi.org/10.1108/SASBE-11-2020-0171>
- Masciotta, M. G., Morais, M. J., Ramos, L. F., Oliveira, D. V., Sánchez-Aparicio, L. J., & González-Aguilera, D. (2021a). A Digital-based Integrated Methodology for the Preventive Conservation of Cultural Heritage: The Experience of HeritageCare Project. *International Journal of Architectural Heritage*, 15(6), 844–863. <https://doi.org/10.1080/15583058.2019.1668985>
- Masciotta, M. G., Morais, M. J., Ramos, L. F., Oliveira, D. V., Sánchez-Aparicio, L. J., & González-Aguilera, D. (2021b). A Digital-based Integrated Methodology for the Preventive Conservation of Cultural Heritage: The Experience of HeritageCare Project. *International Journal of Architectural Heritage*, 15(6), 844–863. <https://doi.org/10.1080/15583058.2019.1668985>
- Maxwell, I., Heath, D., & Russell, P. (2004). Accreditation in Historic Building Conservation: The Work of the Edinburgh Group. *Journal of Architectural Conservation*, 10(1), 36–48. <https://doi.org/10.1080/13556207.2004.10784905>
- McArthur, J. J. (2015). A Building Information Management (BIM) Framework and Supporting Case Study for Existing Building Operations, Maintenance and Sustainability. *Procedia Engineering*, 118, 1104–1111. <https://doi.org/10.1016/j.proeng.2015.08.450>
- Megahed, N. A. (2015). TOWARDS A THEORETICAL FRAMEWORK FOR HBIM APPROACH IN HISTORIC PRESERVATION AND MANAGEMENT. In *International Journal of Architectural Research Naglaa A. Megahed Archnet-IJAR* (Vol. 9).
- Moyano, J., Carreño, E., Nieto-Julián, J. E., Gil-Arizón, I., & Bruno, S. (2022a). Systematic approach to generate Historical Building Information Modelling (HBIM) in architectural

- restoration project. *Automation in Construction*, 143(March).
<https://doi.org/10.1016/j.autcon.2022.104551>
- Moyano, J., Carreño, E., Nieto-Julián, J. E., Gil-Arizón, I., & Bruno, S. (2022b). Systematic approach to generate Historical Building Information Modelling (HBIM) in architectural restoration project. *Automation in Construction*, 143.
<https://doi.org/10.1016/j.autcon.2022.104551>
- Moyano, J., Carreño, E., Nieto-Julián, J. E., Gil-Arizón, I., & Bruno, S. (2022c). Systematic approach to generate Historical Building Information Modelling (HBIM) in architectural restoration project. *Automation in Construction*, 143(March).
<https://doi.org/10.1016/j.autcon.2022.104551>
- Mughal, M. R. (1995). *Legislation for The Protection and Management of Archaeological Heritage of Pakistan*.
- Mughal, M. R. (2011a). Heritage management and conservation in Pakistan: the British legacy and current perspective. *Pakistan Heritage*, 3, 119–134.
- Mughal, M. R. (2011b). *HERITAGE PRESERVATION IN PAKISTAN FROM NATIONAL AND INTERNATIONAL PERSPECTIVES*.
- Mughal, R. (1995). *Legislation for the Protected and management of Archaeological Heritage of Pakistan*. Department of Archaeology and Museums Government of Pakistan Karachi.
- Mughal, R. (2010). *Heritage Preservation in Pakistan*. 1–27.
- Mumtaz, K. K. (1985). *Architecture in Pakistan*.
- Muralikrishnan, B. (2021). Performance evaluation of terrestrial laser scanners - A review. *Measurement Science and Technology*, 32(7). <https://doi.org/10.1088/1361-6501/abdae3>
- Murphy, M., Chenaux, A., Keenaghan, G., Gibson, V., Butler, J., & Pybus, C. (2017). Armagh observatory -historic building information modelling for virtual learning in building conservation. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 42(2W5), 531–538.
<https://doi.org/10.5194/isprs-archives-XLII-2-W5-531-2017>
- Murphy, M., McGovern, E., & Pavia, S. (2013). Historic Building Information Modelling - Adding intelligence to laser and image based surveys of European classical architecture. *ISPRS Journal of Photogrammetry and Remote Sensing*, 76, 89–102.
<https://doi.org/10.1016/j.isprsjprs.2012.11.006>
- Murphy, M., & others. (2023). Community Engagement in Cultural Heritage A Digital Context. *Level 3*, 18(1), 1.

- Naeem, N. S. (2010). *Life at the Lahore Darb ā r : 1799-1839*. 25(2), 283–301.
- Nashaat Darwish, A., & Elsayed Yoseph, W. (2019). *Digital Documentation and Conservation of Urban Heritage*.
- Orbasli, A. (2017). *Conservation Theory in the 21st Century: Slow Evolution or a Paradigm shift*.
- Oreilly, R., & Murphy, M. (2024). *Historical BIM Workflow Russ Borough House Interiors - A case*. February.
- Osello, A., Lucibello, G., & Morgagni, F. (2018a). HBIM and virtual tools: A new chance to preserve architectural heritage. *Buildings*, 8(1).
<https://doi.org/10.3390/buildings8010012>
- Osello, A., Lucibello, G., & Morgagni, F. (2018b). HBIM and virtual tools: A new chance to preserve architectural heritage. *Buildings*, 8(1).
<https://doi.org/10.3390/buildings8010012>
- Parisi, P., Lo Turco, M., & Giovannini, E. C. (2019). THE VALUE of KNOWLEDGE THROUGH H-BIM MODELS: HISTORIC DOCUMENTATION with A SEMANTIC APPROACH. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 42(2/W9), 581–588. <https://doi.org/10.5194/isprs-archives-XLII-2-W9-581-2019>
- Patias, P. (2006). *Cultural Heritage Documentation*. April, 24–29.
- Patias, P., Stylianidis, E., Pateraki, M., Chrysanthou, Y., & Contozis, C. (1996). *3D DIGITAL PHOTOGRAMMETRIC RECONSTRUCTIONS FOR SCOLIOSIS SCREENING. 1*.
- Pendlebury, J., & Townshend, T. (1999). The conservation of historic areas and public participation. *Journal of Architectural Conservation*, 5(2), 72–87.
<https://doi.org/10.1080/13556207.1999.10785244>
- PEPAC - LDA. (1986). *Conservation Plan for the Walled City of Lahore*.
- Philokyprou, M. (2014). Adaptation of new university uses in old buildings: The case of rehabilitation of listed buildings in limassol cyprus for university purposes. *International Journal of Architectural Heritage*, 8(5), 758–782.
<https://doi.org/10.1080/15583058.2012.738282>
- Pocobelli, D. P., Boehm, J., Bryan, P., Still, J., & Grau-Bové, J. (2018). BIM for heritage science: a review. In *Heritage Science* (Vol. 6, Issue 1). Springer.
<https://doi.org/10.1186/s40494-018-0191-4>
- Qadeer, M. A. (1996). *An Assessment of Pakistan's Urban Policies, 1947-1997*.

- Qadeer, M. A. (2023). Lahore in the 21st Century. *Journal of Research in Architecture and Planning*.
- Qasim. Qasim Ali. (2014). *Makli Hills Monument Thatta: History, Architecture, Conservation*.
- Quintero, M. S., Blake, B., & Eppich, R. (2007). Conservation of Architectural Heritage: The Role of Digital Documentation Tools: The Need for Appropriate Teaching Material. *International Journal of Architectural Computing*, 5(2), 239–253.
<https://doi.org/10.1260/1478-0771.5.2.240>
- Rahaman, H. (2018). Digital heritage interpretation: a conceptual framework. *Digital Creativity*, 29(2–3), 208–234. <https://doi.org/10.1080/14626268.2018.1511602>
- Rana, I. A., & Bhatti, S. S. (2018a). Lahore, Pakistan – Urbanization challenges and opportunities. *Cities*, 72, 348–355. <https://doi.org/10.1016/j.cities.2017.09.014>
- Rana, I. A., & Bhatti, S. S. (2018b). Lahore, Pakistan – Urbanization challenges and opportunities. *Cities*, 72, 348–355. <https://doi.org/10.1016/j.cities.2017.09.014>
- Rehman, A., & Arshad, M. (2012). The British Vision of Lahore: An Examination of Concepts of Architecture and Urban Design Through Literary Sources. *Journal of Research in Architecture and Planning*.
- Remondino, F. (2011). Heritage recording and 3D modeling with photogrammetry and 3D scanning. *Remote Sensing*, 3(6), 1104–1138. <https://doi.org/10.3390/rs3061104>
- Reynolds, J. P. (1975). A Special Issue to Commemorate European Architectural Heritage Year. In *Source: The Town Planning Review* (Vol. 46, Issue 4).
- Ricca, S. (2018). *Urban Heritage in the Arabian Peninsula, the Experiences of Jeddah and Dubai Heritage and Modernity in the Arabian Urban Context* (Issue 3).
- Rizvi, F. (2011a). a Study of Urbanization in Context of Future Mega City of Lahore. *Paradigms*, 5(1), 68–87. <https://doi.org/10.24312/paradigms050104>
- Rizvi, F. (2011b). A STUDY OF URBANIZATION IN CONTEXT OF FUTURE MEGA CITY OF LAHORE. In *Paradigms: A Research Journal of Commerce, Economics and Social Sciences* (Vol. 5, Issue 1).
- Rizzi, a, Voltolini, F., Girardi, S., Gonzo, L., Remondino, F., & Kessler-irst, F. B. (2007). Digital Preservation , Documentation and Analysis of Paintings , Monuments and Large Cultural Heritage With Infrared Technology , Digital Cameras and Range Sensors. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 36((Part5/C53)), 1–6.
- Rocha, Mateus, Fernández, & Ferreira. (2020). A Scan-to-BIM Methodology Applied to Heritage Buildings. *Heritage*, 3(1), 47–67. <https://doi.org/10.3390/heritage3010004>

- Rodriguez Gomez, G. (2008). Community-Based Sustainable Conservation in Calakmul Fields of Power, Forests of Discontent: Culture, Conservation, and the State in Mexico . By Nora Haenn. Tucson: University of Arizona Press, 2005. . *Current Anthropology*, 49(4), 759–760. <https://doi.org/10.1086/588537>
- Rodwell, D. (2006). Managing historic cities: The management plans for the bath and Edinburgh world heritage sites. *Journal of Architectural Conservation*, 12(2), 41–61. <https://doi.org/10.1080/13556207.2006.10784968>
- Ruffino, P. A., Permadi, D., Gandino, E., Haron, A., Osello, A., & Wong, C. O. (2019a). Digital technologies for inclusive cultural heritage: The case study of serralunga d'alba castle. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 4(2/W6), 141–147. <https://doi.org/10.5194/isprs-annals-IV-2-W6-141-2019>
- Ruffino, P. A., Permadi, D., Gandino, E., Haron, A., Osello, A., & Wong, C. O. (2019b). Digital technologies for inclusive cultural heritage: The case study of serralunga d'alba castle. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, 4(2/W6), 141–147. <https://doi.org/10.5194/isprs-annals-IV-2-W6-141-2019>
- Sajjad, F. (2009). *Mega-Project Politics: The Evolution of Lahore's First BRT Corridor* Signature redacted Signature redacted. Lahore University of Management Sciences, Lahore, Pakistan.
- Sampaio, A. Z., Gomes, A. M., Sánchez-Lite, A., Zulueta, P., & González-Gaya, C. (2021). Analysis of bim methodology applied to practical cases in the preservation of heritage buildings. *Sustainability (Switzerland)*, 13(6). <https://doi.org/10.3390/su13063129>
- Sasaki, I., & Baba, S. (2024). Shades of Cultural Marginalization: Cultural Survival and Autonomy Processes. *Organization Theory*, 5(1). <https://doi.org/10.1177/26317877231221552>
- Saygi, G., Agugiaro, G., Hamamcioğlu-Turan, M., & Remondino, F. (2023). *Evaluation of GIS and BIM Roles for the Information Management of Historical Buildings*.
- SDWCL. (2009). *The Walled City of Lahore*.
- Seraj, M. (2019). *Significance of Preservation of Cultural resources on Development of a Micro Destination: A Case of Shahi Guzargah Walled city Lahore*.
- Sheikh, M. (2016a). Guzars' that made up the south of Akbar's Lahore. *Dawn*.
- Sheikh, M. (2016b). The 'guzar' named after great Kamboh general. *Dawn*.
- Shuja, H. A. (1988). *Lahore ka chelsea*. Packages Limited Lahore.
- Singh, A., Dennis, M., & Beinart, J. (2002). *Confrontation, Compromise and Reconstruction of The Walled City of Shahjahanabad*.

- Sohail, J. (2020). *Conservation-Led Marginalization : Making Heritage in the Walled City of Lahore*. 12.
- Sohail, J., Studies, U., & Krivý, M. (2020). *Conservation-Led Marginalization: Making Heritage in the Walled City of Lahore*.
- Stefano, Musso., & Marco, L. De. (2008). *Teaching Conservation / Restoration of the Architectural Heritage Goals , Contents and Methods*.
- Stengel, J., & Schultmann, F. (2023). *Recommended articles Corrigendum to “ Building Information Modeling (BIM) for existing buildings — Literature review and future needs ” [Autom . 2023*.
- Street, B. (2005). Identification of Historic Methods of Construction Using Digital Photogrammetry and Laser Scanning. *Most, May*, 6–9.
- Taj, M. (2015). Digital Preservation of Pakistan ’ s Heritage. *LUMS*.
- Taj, M., & Hashmi, A. (2016). *DIGITAL PRESERVATION OF PAKISTAN’S HERITAGE*.
- Tania Qureshi. (2018). Barood Khana — An arsenal depot of British era. *Daily Times*.
- Tariq, F., Gul, A., & Malik, S. (2020). Evaluation of Environmental & Physical Impacts of Mega Transportation Projects: A Case of Lahore. *Technical Journal*.
<https://www.researchgate.net/publication/344235827>
- Temple, P. (2008). Learning spaces in higher education: An under-researched topic. *London Review of Education*, 6(3), 229–241. <https://doi.org/10.1080/14748460802489363>
- Teneketzi, A., Alexandridis, G., Christodoulou, Y., & Konstantakis, M. (2024). *Digital Cultural Heritage Management for Local Heritage : Overcoming Barriers to Accessibility with Regional Digital Infrastructures Journal of Integrated Information Management*. August. <https://doi.org/10.26265/jiim.v9i1.38585>
- Theodossopoulos, D. (2018). Nineteenth-century housing preventive conservation in Edinburgh and its Western European context. In *Journal of Cultural Heritage Management and Sustainable Development* (Vol. 8, Issue 2, pp. 95–110). Emerald Group Holdings Ltd. <https://doi.org/10.1108/JCHMSD-06-2017-0041>
- Trillo, C., Aburamadan, R., Mubaideen, S., Salameen, D., & Makore, B. C. N. (2020a). Towards a Systematic Approach to Digital Technologies for Heritage Conservation. Insights from Jordan. *Preservation, Digital Technology and Culture*, 49(4), 121–138. <https://doi.org/10.1515/pdte-2020-0023>
- Trillo, C., Aburamadan, R., Mubaideen, S., Salameen, D., & Makore, B. C. N. (2020b). Towards a Systematic Approach to Digital Technologies for Heritage Conservation.

- Insights from Jordan. *Preservation, Digital Technology and Culture*, 49(4), 121–138.
<https://doi.org/10.1515/pdte-2020-0023>
- Trillo, C., Aburamadan, R., Udeaja, C., Moustaka, A., Baffour, K. G., & Makore, B. C. N. (2020a). enhancing heritage and traditional architecture conservation through digital technologies. developing a digital conservation handbook for as-salt, jordan. *Smart Innovation, Systems and Technologies*, 177 *SIST*, 211–219. https://doi.org/10.1007/978-3-030-52869-0_18
- Trillo, C., Aburamadan, R., Udeaja, C., Moustaka, A., Baffour, K. G., & Makore, B. C. N. (2020b). Enhancing Heritage and Traditional Architecture Conservation Through Digital Technologies. Developing a Digital Conservation Handbook for As-Salt, Jordan. In *Smart Innovation, Systems and Technologies: Vol. 177 SIST*. Springer International Publishing. https://doi.org/10.1007/978-3-030-52869-0_18
- Trillo, C., Aburamadan, R., Udeaja, C., Moustaka, A., Baffour, K. G., & Makore, B. C. N. (2020c). enhancing heritage and traditional architecture conservation through digital technologies. developing a digital conservation handbook for as-salt, jordan. *Smart Innovation, Systems and Technologies*, 177 *SIST*, 211–219. https://doi.org/10.1007/978-3-030-52869-0_18
- Tufail, M. (1962a). *Naqoosh - Lahore Issue*. Naqoosh Press, Lahore.
- Tufail, M. (1962b). *Naqoosh - Lahore Issue*. Naqoosh Press, Lahore.
- Tyler, I. R., & Dilcher, A. K. (2010). Sustainable Heritage Conservation: Pere Marquette Railroad Depot in Michigan. In *Source: APT Bulletin: The Journal of Preservation Technology* (Vol. 41, Issue 1).
- UNESCO. (2010a). *Managing Historic Cities*. World Heritage Center UNESCO.
- UNESCO. (2010b). *Managing historic cities - World Heritage Papers*. UNESCO World Heritage Centre.
- UNESCO. (2021). *As-Salt - The Place of Tolerance and Urban Hospitality*.
- UNESCO, W. H. C. (2010c). *Managing Historic Cities*. World Heritage Center UNESCO.
- United Nations. (2018). *World Urbanization Prospects*.
- Ursini, A., Grazzini, A., Matrone, F., & Zerbinatti, M. (2022a). From scan-to-BIM to a structural finite elements model of built heritage for dynamic simulation. *Automation in Construction*, 142(January 2021), 104518. <https://doi.org/10.1016/j.autcon.2022.104518>
- Ursini, A., Grazzini, A., Matrone, F., & Zerbinatti, M. (2022b). From scan-to-BIM to a structural finite elements model of built heritage for dynamic simulation. *Automation in Construction*, 142. <https://doi.org/10.1016/j.autcon.2022.104518>

- Vitae. (2010). Researcher development framework. *Careers Research and Advisory Centre (CRAC) Limited*, 23. <http://www.vitae.ac.uk/researchers/428241/Vitae-Researcher-Development-Framework.html>
- Waqar, A. K. J., Jing Fu, C., Saengkrod, W., Ghaffar Mastoi, A., & Khan Jatoo, A. (2016). 243. *Urbanization in Pakistan: Challenges and Way Forward (Options) For Sustainable Urban Development*.
- Waqar, A. K. J., Jing Fu, C., Saengkrod, W., & Mastoi, A. G. (2016). Urbanization in Pakistan: Challenges and Way Forward (Options) For Sustainable Urban Development. *Proceedings of the 4th International Conference on Energy, Environment and Sustainable Development, 2016*(Eesd).
http://eesd.muet.edu.pk/sites/default/files/imagecache/EESD_2016_paper_243.pdf
- Warracih, N. K., Baig, M. F., Liaqat, M., Baig, Z., & Watoo, F. A. (2014). *Problems & Methods for Restoration of Walled City Lahore*.
https://www.academia.edu/32313037/Problems_and_Methods_for_restoration_of_Walled_City_Lahore
- WCLA. (2009). *The Walled City of Lahore*. Lahore Development Authority.
- WCLA. (2016). *Master Conservation & Redevelopment Plan (MCRP)*.
- WCLA/PEPAC. (1993). *Walled City Lahore*.
- Webb, N. J. (2012a). *Digital Re-analysis of Lost or Unbuilt Architecture*. August.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.425.4647&rep=rep1&type=pdf>
- Webb, N. J. (2012b). *Digital Re-analysis of Lost or Unbuilt Architecture*.
- Woodward, A., & Heesom, D. (2019). Implementing BIM on conservation heritage projects: Lessons from renovation case studies. *International Journal of Building Pathology and Adaptation*.
- World Bank, P. (2005). *Sustainable development Walled City of Lahore Cultural heritage and tourism The Shahi Guzargah Pilot project* (Issue August).
- Wu, S. W. P. (2010). A strategy framework for digital heritage. *Handbook of Research on Technologies and Cultural Heritage: Applications and Environments*, 462–480.
<https://doi.org/10.4018/978-1-60960-044-0.ch023>
- Younus, I., Al-hinkawi, W., & Lafta, S. (2023a). The role of historic building information modeling in the cultural resistance of liberated city. *Ain Shams Engineering Journal*, 14(10), 102191. <https://doi.org/10.1016/j.asej.2023.102191>

- Younus, I., Al-hinkawi, W., & Lafta, S. (2023b). The role of historic building information modeling in the cultural resistance of liberated city. *Ain Shams Engineering Journal*, 14(10), 102191. <https://doi.org/10.1016/j.asej.2023.102191>
- Yuan, W. (2008). The conservation of intangible cultural heritage in historic areas. *16th ICOMOS General Assembly and International Symposium: Finding the Spirit of Place – between the Tangible and the Intangible*, 1–10.
- Zachar, J., Hornak, M., & Novakovi, P. (2018). 3d Digital Recording of Archaeological, Architectural and Artistic Heritage. In *3d Digital Recording of Archaeological, Architectural and Artistic Heritage: Vol. I*. <https://doi.org/10.4312/9789612378981>
- Zahid, A., & Misirlisoy, D. (2021). Measuring place attachment, identity, and memory in urban spaces: Case of the walled city of lahore, pakistan. *Journal of Architecture and Urbanism*, 45(2), 171–182. <https://doi.org/10.3846/jau.2021.15183>
- Zappino, V. (2010). *The Sustainability of Urban Heritage Preservation The Case of Edinburgh, UK*. www.iadb.org
- Zheng, H., Chen, L., Hu, H., Wang, Y., & Wei, Y. (2024). Research on the Digital Preservation of Architectural Heritage Based on Virtual Reality Technology. *Buildings*, 14(5). <https://doi.org/10.3390/buildings14051436>