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Original Research Article

An Integrated Framework for the Sustainable Development of Historic Urban Fabrics:
A Review of Combining Space Syntax and Visual Analysis for Cultural Heritage Impact Assessment

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ABSTRACT

Historic urban areas, characterized by their rich cultural heritage, face the complex challenge of striking a balance between the imperative of conservation and the demands of contemporary urban development. This research addresses this issue by proposing a theoretical framework for the sustainable assessment of historic urban environments. The core of this framework is an approach that integrates the Space Syntax methodology with the Cultural Heritage Impact Assessment (HIA) process. Through a systematic review of 58 scholarly articles, this research encompasses three key domains: Space Syntax analysis, the historic urban fabric, and visual analysis methods. This review forms the foundation for a conceptual framework comprising four key stages: (1) Data Collection, (2) Visual Analysis, (3) 3D Modeling, and (4) Cultural Heritage Impact Assessment (HIA). Through this meticulous and systematic integration, the study contributes to the formulation of an integrated approach to urban heritage management and sustainable urban development. The findings highlight the framework's value as a tool for reconciling heritage conservation with the demands of contemporary urban development. This approach can be highly beneficial for urban planners, policymakers, and heritage managers. By providing a flexible and practical framework, this study helps to bridge the gap between the imperatives of heritage conservation and the necessities of urban growth. It envisions a future where historic urban areas can thrive as vibrant, sustainable, and culturally significant hubs, continuing to shape present and future urban landscapes. Future research can focus on refining and implementing this framework across diverse historic cities, as well as further exploring the social and cultural dimensions of heritage conservation and urban sustainability.

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Introduction

Two distinct perspectives shape the various approaches to conserving and managing cultural heritage. However, the application of these perspectives in cultural heritage management, particularly within urban contexts, presents significantchallenges(Ginzarlyetal.,2019).Urbanheritage conservationplaysapivotalroleinfosteringsustainableurban development (Guzmán et al., 2017; The future …, 2012). This is achieved through culture-led urban regeneration efforts and the enhancement of social sustainability by fostering a stronger sense of place among local communities (Tan et al., 2018). Consequently, amidst urban development, historic districts undergo significant transformations and conflicts (Lyu et al., 2023). Historically, conservation strategies for traditional historic neighborhoods typically focused on the historical significance of individual buildings, frequently neglecting the need to preserve the overall integrity of the neighborhood's form and character (Wang, 2012). This approach can lead to the loss of collective identity and the cultural values embedded in the overall fabric of historic neighborhoods. To address this shortcoming, the regeneration of historic neighborhoods requires a holistic approach. This approach must align with contemporary urban spatial configurations while simultaneously preserving the cultural heritage and historical significance of these neighborhoods (Diaz-Parra & Dimuccio, 2021). In other words, a balance must be struck between the demands of modern urban development and the imperatives of preserving historical and cultural identity, enabling these areas to continue their vitality as vibrant parts of the city. Space Syntax theory posits a relationship between spatial configuration and social life, offering a synchronic depiction of events rooted in their specific spatio-temporal context (Hillier & Hanson, 1989). This theory examines the configuration of urban space and its influence on social interactions, serving as a powerful tool for understanding patterns of movement and spatial use within cities. In essence, the theory examines not only the physical structure of urban spaces but also the profound influence of these configurations on social life and human interaction. It demonstrates how physical properties of urban space, such as visual and physical transparency and permeability (Penn, 2003), distance and orientation (Dalton & Bafna, 2003), and the potential for enhancing social encounters (Hillier, 2007) can influence social behavior and interpersonal connections, thereby contributing to the creation of spaces that facilitate social engagement. By studying historical spatial patterns, a deeper understanding of how urban spaces have formed and evolved can be achieved, leading to more accurate assessments of a city's spatial heritage. This approach contributes not only to the preservation of physical elements but also to the understanding and safeguarding of the intangible values associated with urban spaces.

Space Syntax theory rests on the premise that spatial organization itself functions as a cultural artifact. In other words, space is considered not merely as a physical container but as a living, dynamic element that reflects a society's identity, history, and culture. By analyzing the spatial properties of a place and its relationship to the local context, it is possible to quantify and articulate its cultural value. This approach contributes to a better understanding of how spatial cultures are formed and evolve. These methods enable researchers to examine how cities have transformed throughout history and to identify and analyze the cultural values embedded within urban fabrics. This approach significantly enriches the study of urban history and enhances the understanding of the cultural and social roots of cities.

Furthermore, these methods allow researchers to investigate how spatial patterns influence the formation and evolution of urban culture, history, and identity, contributing to a deeper understanding of how cities are shaped and the role of space in fostering social and cultural interactions. Jon Hawkes (2001) emphasized that to achieve true sustainability, we must view cultural values as a key element in planning and development, as these values determine a society's direction and priorities for the future. He argued that sustainability is essentially a reflection of the desire for future generations to inherit a world as rich and fruitful as our own. In other words, sustainability is not limited to the preservation of natural resources and the environment but also encompasses the preservation and transmission of cultural, social, and economic values so that future generations can enjoy a similar or better quality of life (ibid.). He expressed concern about how development policies might adversely affect cultural vitality. He suggested the need for tools capable of assessing cultural impacts to protect valuable identities and resources.

The Cultural Heritage Impact Assessment[1] (HIA) is a systematic framework designed and implemented to evaluate the effects of development projects on various aspects of cultural heritage. By employing quantitative and qualitative analytical methods, this approach enables the identification, prediction, and management of both positive and negative development impacts on the historical, cultural, artistic, and spiritual values of heritage. This assessment process is recognized by UNESCO, the World Heritage Centre, ICCROM, ICOMOS, the International Association for Impact Assessment (IAIA), and international development organizations such as the World Bank as a vital mechanism for the

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conservation and management of cultural heritage. As a multifaceted approach, HIA is applicable across a wide range of heritage contexts, including World Heritage sites, historic urban fabrics, individual monuments, and cultural landscapes. The importance and necessity of this approach are particularly emphasized in the Historic Urban Landscape (HUL) Recommendation. This recommendation emphasizes the importance of integrating cultural heritage conservation into the broader goals of sustainable development (Rogers, 2017). By enabling a systematic and comprehensive assessment of the impacts of development projects on heritage values in urban environments, this approach facilitates the integration of conservation considerations into planning processes, thereby helping to ensure the sustainability and preservation of the historical and cultural identity of cities.

The Heritage Impact Assessment process, as a systematic approach, is implemented in five fundamental stages: (1) Identifying the cultural heritage components at risk; (2) Predicting and modeling the potential impacts arising from development policies or actions; (3) Quantitatively and qualitatively evaluating the predicted impacts using validated indicators; (4) Communicating the assessment results to stakeholders and decision-makers; and (5) Integrating the assessment findings into planning and decision-making processes for the optimal management of cultural heritage. The objective of this method is to mitigate negative impacts while enhancing positive outcomes (Sagnia, 2004). When conflicts arise between the preservation of historic landscapes and modern urban development, research is crucial for finding ways to update and adapt historic neighborhoods without compromising their authenticity and historical identity. This approach ensures that urban development is conducted in a manner that also preserves heritage values (McCabe, 2019; Tyler et al., 2018). This highlights the need for a comprehensive approach to heritage conservation within urban regeneration. This approach not only emphasizes the physical aspects of historic buildings but also highlights the importance of considering social impacts and the intangible values inherent in the community (Chen, 2022; Yung et al., 2017). This context highlights the crucial role of Heritage Impact Assessment (HIA) in addressing the complex dilemmas between heritage preservation and the demands of urban development. It also emphasizes the need for a systematic method to harmonize historic areas with contemporary spatial layouts, thereby achieving urban sustainability. The integration of visual methods, Space Syntax analysis, and HIA enhances the efficacy of these individual approaches. By providing tangible and comprehensible visualizations of spatial configurations, architectural forms, and cultural landscapes, this combined methodology offers a deeper understanding of urban heritage management. Furthermore, these methods empower urban planners to make more effective decisions based on precise and observable data.

In the visual approach method, Harper (2012) introduces two main domains: visual methods and visual studies. In visual methods, researchers use photography as a tool for analyzing and assessing social environments. On the other hand, visual studies involve the examination and evaluation of visual culture by researchers. This field allows sociologists to examine the symbols and meanings associated with visual elements in greater depth. Using methods such as photography, mapping, and documentation, visual information can be preserved over time. This practice facilitates the comparison of past and present conditions and also helps identify patterns and trends in urban development. Visual studies focus on examining and interpreting visual symbols and concepts in urban spaces. These assessments contribute to a deeper understanding of cultural identity and societal values, revealing the role of visual elements in shaping urban culture. By providing a comprehensive framework, the visual approach method facilitates a more thorough analysis and understanding of urban transformations and changes. In this way, it enables more precise and data-driven decision-making in fields like urban planning and heritage conservation. Furthermore, this approach helps to advance the goals of sustainable urban development.

In recent years, the European Union (EU) has been at the forefront of promoting sustainable urban development through innovative strategies and policies. A key element in this regard is the concept of ecological cities (eco-cities), which are considered exemplary models of techno-environmental solutions. These cities are designed to advance a social transformation towards sustainability (Bibri, 2023). In parallel, since the 1990s, the EU has sought to encourage and support innovation at the local level by employing the integrated sustainable urban development method (Medina & Huete García, 2020). Sustainable and integrated urban development is an approach widely adopted across Europe. However, a significant challenge for historic cities lies in striking a balance between preserving cultural heritage and meeting the demands of contemporary development. This research addresses this challenge by proposing a comprehensive framework to assess urban sustainability in these contexts. By integrating the methodologies of Space Syntax analysis and Heritage Impact Assessment (HIA), this framework empowers decision-makers

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to make more informed choices regarding urban development. The HIA process is a practical and effective method for resolving the challenges of preserving historic sites amidst urban growth, assisting urban professionals, policymakers, and heritage practitioners in making optimal decisions.

Research Objective

To address the shortcomings in previous research, this study proposes a novel method that integrates Space Syntax analysis with a visual approach. The goal of this integration is to enhance the Heritage Impact Assessment (HIA) process and achieve a deeper understanding of urban heritage management. To achieve greater urban sustainability, a comprehensive examination of the impacts of urban plans is required. Traditional assessment methods rely heavily on quantitative data and often overlook crucial aspects, such as the visual impact of development on cultural heritage. Employing a visual approach alongside quantitative methods enables a more comprehensive understanding of these effects on a city's culture and sustainability. Therefore, a comprehensive and systematic review of Space Syntax and visual methods within the fields of urban heritage management and sustainable urban development is essential. This literature review aims to collect and synthesize the current research landscape to answer two central research questions:

1. How can the integration of Space Syntax analysis with a visual approach help us to better understand the spatial structure and inherent cultural values of historic urban places?
2. How can this integrated method assist us in making better decisions regarding urban development and heritage conservation?

To answer the research questions posed in this study, the methodology section provides a detailed explanation of how the two analytical methods Space Syntax analysis and the visual approach are integrated to conduct the Heritage Impact Assessment (HIA) process. The study initially reviews and summarizes the existing literature on urban heritage and its methods for impact assessment. It then critically analyzes the results obtained from the comprehensive and integrated method, demonstrating the extent to which this approach can be practical in assessing the impacts of heritage. Finally, the paper concludes by summarizing the most significant findings and discussing their role in the sustainable development of cities. It also provides suggestions for future research to refine further and expand this comprehensive method for heritage impact assessment.

Research Method

This study sought to examine the scope and applicability of previous research in fields related to urban sustainability, cultural heritage conservation, historic cities, and spatial analysis methods, to identify potential patterns or contradictions within this domain. During the information-gathering process, an effort was made to compile a comprehensive and credible collection of academic sources that effectively addressed the research questions. A systematic review was conducted and the relationships between urban sustainability, heritage conservation, and historic cities were examined. Using the Scopus database, the researcher searched for relevant academic sources that employed methods such as Space Syntax analysis, Heritage Impact Assessment (HIA) processes, visual approach-based methods, spatial structure analysis, and other spatial analysis techniques in the context of urban development planning. The objective was to identify and review the existing literature in this field to gain a better understanding of the interactions between these concepts. The search strategy involved using specific keywords, including 'Urban Sustainability,' 'Cultural Heritage Conservation,' 'Historic Cities,' 'Space Syntax Analysis,' 'Visual Approach Method,' 'Urban Heritage Conservation,' 'Spatial Configuration Analysis,' 'Built Environment Sustainability,' 'Heritage Impact Assessment,' 'Space Syntax Integration,' 'Urban Development Planning,' 'Sustainable Urban Design,' and 'Spatial Analysis Techniques.' These keywords were selected to retrieve relevant and comprehensive sources in the target fields. An extensive search in relevant databases based on the defined keywords identified approximately 248 articles. Subsequently, the search was narrowed to the specialized fields of engineering and urban planning, resulting in 132 articles. To focus on recent advancements, the search was further filtered by the time frame of 2018 to 2022 and limited to English-language articles, which ultimately yielded 86 articles for final review. Ninety percent of the selected articles are from journals, while approximately ten percent are from conference proceedings.

This study included research that directly addressed topics related to urban sustainability, cultural heritage conservation, and historic cities while simultaneously employing spatial analysis methods such as Space Syntax, cultural impact assessment processes, and visual approach-based methods. These criteria were established to select studies that could clearly examine the relationship between urban sustainability and heritage preservation in the context of historic cities. Following the careful selection of articles, a comprehensive quality assessment was conducted to ensure that the selected works met a

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satisfactory level of consistency and reliability. This assessment, based on predefined criteria tailored to the study's needs, meticulously rated each article on a scale of 1 to 3, representing minimal, average, and superior quality, respectively (Kitchenham et al., 2015). The quality assessment process was based on the following criteria: (1) Appropriateness of the research design and organization; (2) Clarity in the description of the research methodology; (3) Consistency of the findings with the data and analysis; (4) Adequacy of data support for the explanation of results; and (5) Effectiveness of the research design in discovering relevant information to answer the research questions. Fig. 1 shows the research concept.

Literature Review and Theoretical Framework

This study examined fifty-eight significant studies that aligned most closely with the conditions outlined in the previous section. The collected data were analyzed using Microsoft Excel. Table 1 presents details including the study author(s), publication year, methodological approach employed, application of space syntax analysis, assessment of cultural heritage impact, visual approach analysis, and study typology. Fig. 2 provides a detailed analysis of the distribution and significance of the three aforementioned methods across the total corpus of 58 articles.

According to the findings, Space Syntax analysis is the most frequently used method, appearing in 45% of the reviewed articles. Of this number, 20% of the articles utilized this method exclusively, while 65% of the articles applied it in combination with other methods. The Heritage Impact Assessment (HIA) method was employed in approximately 41.67% of the reviewed studies. Notably, 15% of these studies used this method exclusively, while in the remaining cases, it was combined with other research approaches. Visual approach analysis, used in 25% of the articles, is often combined with both Space Syntax analysis and HIA. This distribution underscores the dominant role of Space Syntax analysis.

• Syntax: Analyzing urban spatial structure

Syntax, as a fundamental concept in the field of urban studies, focuses on the analysis of the spatial structure and organization of urban environments. It aims to uncover and understand the complex relationship between the physical patterns of cities and the behaviors of inhabitants within these spaces. In this section, drawing on numerous research findings, the significance and role of this concept in urban studies will be examined in greater detail.

- Interactions and relationships between urban land uses

Understanding the mechanisms of change and interaction between different urban functions (such as residential, commercial, and industrial) is crucial for effective urban planning and development in the context of cultural heritage conservation and urban sustainability. A review of recent research reveals a multifaceted exploration of spatial configuration, cultural heritage conservation,

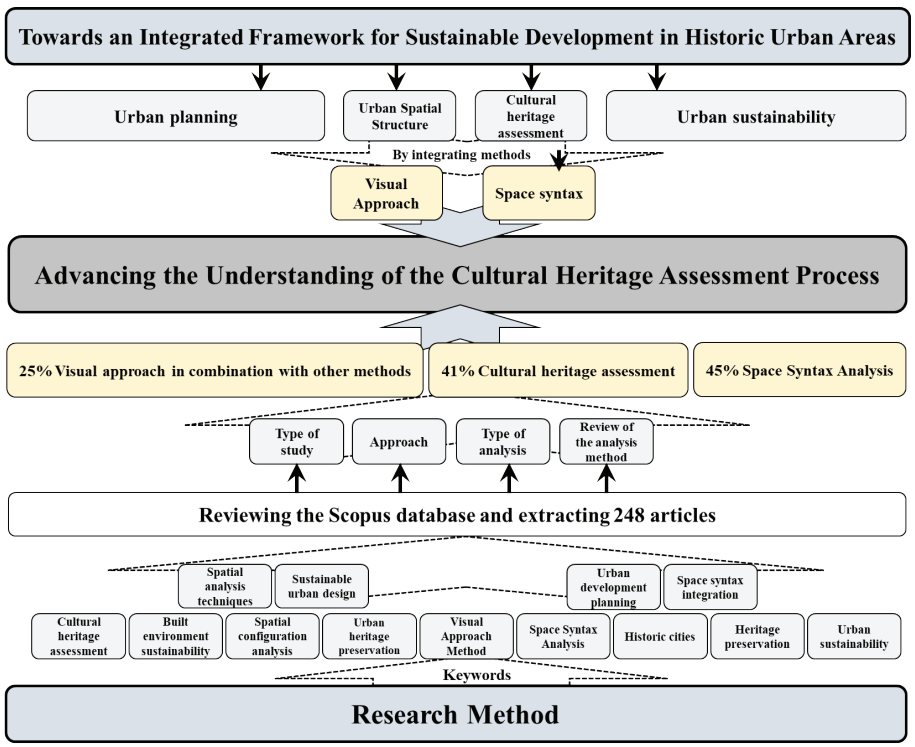

Fig. 1. Conceptual research methodology. Source: Authors.

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Table 1. Summary of study details and analytical methods. Source: Authors.

Author(s)	Analysis method	SSA	HIA	VAA	Type of study
Quesada-Ganuza et al. (2023)	Multicriteria risk assessment methodology, Geographic Information Systems (GIS)	No	No	No	Quantitative analysis, Case study
Wu et al. (2025)	Spatial layout analysis	Yes	Yes	Yes	Heyuan, Geyuan, West Garden
Albayati & Alobaydi (2023)	Bazaar conservation	No	Yes	Yes	Souq preservation strategies
Sakantamis et al. (2023)	Built heritage Resilience	No	Yes	Yes	Resilience workshop in Thessaloniki
Lukashchuk et al. (2023)	Green space planning	No	Yes	Yes	Landscape planning and biodiversity
Safizadeh et al. (2023)	Space syntax	Yes	No	No	Case Study
Zhou et al. (2023)	Space Syntax Models	Yes	No	No	Quantitative analysis of temple space
Tufek-Memisevic (2023)	Space Syntax analyses	Yes	No	No	Case study
Zhao & Han (2023)	The Delphi technique and the CRITIC weight method	Yes	No	Yes	No
Şahin Kórmeçli (2020)	Space syntax and GIS methods	Yes	No	No	No
El-Khouly et al. (2023)	Analytical framework for spatial analysis	Yes	No	No	Case Study
Dimuccio et al. (2023)	Geographical Information Systems (GIS) and geostatistical methods	No	No	No	Quantitative
Wang & Chen (2022)	Spatial syntax analysis using line segment analysis method	Yes	No	No	Qualitative analysis, Case study
Amer (2022)	Spatial structure impact	Yes	Yes	Yes	Heritage impact during events
Kachousangi et al. (2022)	Accessibility analysis	Yes	Yes	Yes	Delft-Campus station case study
Kasemsook et al. (2022)	Space Syntax theories and methodology	Yes	No	Yes	Spatial configuration analysis, building-use survey, heritage building evaluation
Shen & Dong (2022)	GIS, Depthmap tool, historical map translation method	Yes	No	No	Exploration of urban morphology, historical development
Fløstrand et al. (2022)	Review of urban planning methods	Yes	No	No	Feasibility study for urban densification
Ugalde et al. (2022)	Spatial analysis	Yes	No	No	Study of spatial changes in flood-prone areas
Thai & Kim (2022)	Space syntax in urban centers	Yes	Yes	Yes	Spatial network analysis in Hanoi
Follestad et al. (2022)	Urban transformation	Yes	Yes	Yes	Option testing at Skjoldskiftet in Bergen
Piccinini et al. (2022)	The 3D survey obtained through the integrated management of geomatic sensors	Yes	No	No	No
Vardopoulos (2022)	Online survey and regression analysis	No	No	No	Case study
Salameh et al. (2022)	Not specified	No	Yes	No	Case study
Yazar & Edgü (2022)	Space Syntax	Yes	No	No	Case Study
Chiu et al. (2021)	Methodology of Spatial Syntax and Hierarchical Analysis Process	Yes	No	No	Case Study
Urbina (2021)	Quantitative analysis using Space Syntax, Mixed-use index, Urban morphology analysis	Yes	No	No	Case study, Quantitative analysis
Coppola et al. (2021)	Space Syntax Analysis	Yes	No	No	Measurement of place accessibility for crime risk assessment
Esposito et al. (2021)	Multi-risk analysis, Multi-agent modeling, Geomatic techniques	No	Yes	No	Quantitative analysis, Case study
Guo & Cao (2021)	GIS spatial analysis method and improved spatial syntax (sDNA model)	Yes	No	No	No
Sehgal & Kaur (2021)	Heritage preservation	No	Yes	Yes	Urban renewal in Kapurthala
Gyurkovich & Pieczara (2021)	Visual elements impact	No	Yes	Yes	Visual assessment in Poznań
Oumelkheir & Djelal (2021)	Analytical Hierarchy Process (AHP) method, GIS analysis	No	No	No	Quantitative analysis, Case study

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Rest of Table 1.

Author(s)	Analysis method	SSA	HIA	VAA	Type of study
Dong et al. (2021)	Multi-linear regression analysis, Open data analysis	No	No	No	Quantitative analysis, Case study
Adamopoulos & Rinaudo (2021)	Image processing, Photogrammetric techniques, GIS analysis	No	No	No	Quantitative analysis, Case study
Georgiou et al. (2021)	Multidisciplinary approach	No	No	Yes	Documentation of UCH, marine geophysical mapping, photogrammetry
Pafka et al. (2020)	Space Syntax Analysis	Yes	No	No	Theoretical
De Filippi et al. (2020)	Participatory Mapping and Space Syntax	Yes	No	Yes	Relation between criminal activities and spatial features of the street network
Sestraș et al. (2020)	UAV technology, structure from motion software	No	No	Yes	Assessment of heritage building restoration feasibility, spatial analysis
Jagrati et al. (2020)	Not specified	No	Yes	No	Conceptual
Galantucci et al. (2020)	Remote decay survey via reality capture and data processing, automatic segmentation, and computation of dense point clouds	Yes	No	No	No
Daneshmandian et al. (2020)	3D model for visual buffer conservation	No	No	Yes	Case Study
Kabilan (2019)	Temporal, pattern, functional, and morphological studies, Space Syntax analytical models	Yes	No	No	Qualitative analysis, Case study
Alalouch et al. (2019)	Spatial analysis	Yes	No	No	Quantitative analysis, Case study
Pica (2019)	Heritage conservation	No	Yes	Yes	Conservation of the Albaicín quarter
Chen & Wu (2019)	UAV technology, space syntax	Yes	No	Yes	UAV-based light measurement, space syntax visualization
Bo & Tao (2019)	Quantifiable spatial analysis	Yes	Yes	Yes	Preliminary study
Liao et al. (2019)	Spatial Configuration Analysis	Yes	No	No	Case Study
Rokseth et al. (2019)	GIS-based method	Yes	No	No	Quantitative
Chen & Karimi (2019)	Space Syntax Theory and Tools	Yes	No	No	Case study
Raony Silva & Donegan (2019)	Ground and upper floor use and conservation state of properties surveyed, syntactic integration measures	Yes	No	No	No
Martino et al. (2019)	Aggregation of indicators of accessibility, density, and diversity at 800m of each street segment	No	No	No	No
Kubat et al. (2019)	Testing of design strategies developed in line with the concept of view management through space syntax	No	No	Yes	No
Kapp (2019)	Sustainability in preservation	No	Yes	No	Fort Pulaski, Jewellery Quarter
Sánchez & Daamen (2019)	Lisbon's shift to a landscape approach	No	Yes	Yes	Lisbon port-city relationship shift
Jin & Chen (2019)	Application of Arrival City Theory	No	No	No	Case Study
Gregor & Kalasova (2019)	Mapping cultural-historical potential	No	No	No	Case Study
Gandini et al. (2018)	Integrated Value Model	No	Yes	Yes	Risk-based assessment

and sustainable urbanism. Kachousangi et al. (2022) have highlighted the pivotal role of spatial accessibility in urban planning, demonstrating how enhancing connectivity in urban environments can simultaneously contribute to heritage conservation and the promotion of sustainable transportation systems. The findings of Wu et al. (2025) also emphasize the importance of connectivity. Their research analyzes spatial dynamics in urban environments, showing that spatial organization has a profound impact on the efficiency and quality of life in habitable areas. Peca (2019) examines the challenges of preserving historic sites in the face of urbanization pressures, emphasizing the functional aspects of heritage conservation in maintaining cultural identity. Similarly, Amer (2022) examines the dynamic nature of heritage spaces and analyzes the impact of

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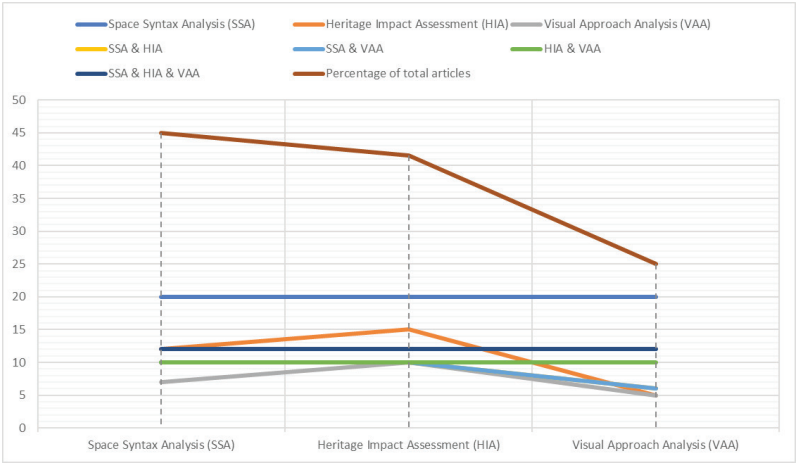

Fig. 2. Distribution of articles in different analytical methods. Source: Authors.

spatial structures on the resilience of these sites in the face of various events, highlighting the importance of adopting flexible approaches in urban planning. Chen & Karimi (2019) have analyzed functional dynamics in urban environments using advanced technologies. By leveraging drone technology and Space Syntax analysis, they have examined spatial representation and the interplay of lighting in these settings. In a similar vein, De Filippi et al. (2020) investigated functional aspects related to crime prevention. Their research demonstrates how the structural characteristics of street networks can enhance safety while simultaneously contributing to the preservation of heritage values. Confronting the future challenges facing cities, Floistrand et al. (2022) have examined the impacts of changes in spatial structure on the urban densification process, proposing solutions for achieving sustainable urban growth. In a similar vein, Ugalde et al. (2022) have emphasized the importance of considering spatial transformations in flood-vulnerable areas. This approach is of great importance for enhancing resilience and developing sustainable urban plans in the face of climate change.

Finally, Kasemsook et al. (2022) conducted a comprehensive study, reviewing theories and methods related to Space Syntax and analyzing the role of the functional dynamics of built environments in conserving cultural heritage and achieving sustainable development. The findings from these studies indicate that spatial configuration, heritage conservation, and urban sustainability are closely intertwined. Accordingly, researchers emphasize the necessity of employing integrated approaches that consider the social, environmental, and cultural aspects simultaneously within urban planning and development processes.

- **Movement and social interaction**

Extensive research investigating movement behaviors and social interactions in urban spaces reveals that these phenomena are characterized by considerable complexity. By providing detailed analyses, these studies offer a better understanding of how people move and participate in collective activities within urban environments. The analysis of movement behaviors and social connections, combined with the synthesis of diverse research findings, provides a more comprehensive understanding of how humans navigate and interact within urban societies. This approach significantly aids in identifying the patterns and factors influencing these processes. Gandini et al. (2018) introduced a model called the 'Integrated Value Model,' which is based on risk assessment and inherently considers social interactions and people's movement patterns in urban environments. By incorporating factors such as accessibility, safety, and impacts on cultural heritage, this model serves as a comprehensive tool for decision-making related to urban planning. Liao et al. (2019) have made a significant contribution to this field by conducting a spatial configuration analysis and focusing on a specific case study. Their findings indicate that spatial organization has a direct impact on movement patterns and social interactions in urban environments, highlighting the importance of informed design in creating vibrant and dynamic urban communities. On the other hand, Shen & Dong (2022) have examined urban structure and the process of historical evolution by employing advanced methods, including Geographic Information Systems (GIS) and historical map analysis. This research provides a deeper understanding of how transportation networks and social spaces have evolved. In their research, Chia et al. (2021) investigated the complex relationship between spatial structures and social interactions by employing the Space Syntax methodology in conjunction with the Analytic Hierarchy Process (AHP). This study demonstrates how the built environment affects people's movement and their social interactions. The findings of this study can serve as a valuable guide for urban planning and design processes, informing and improving decision-making in this

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field. Similarly, Şahin Kórmeçli (2023) has examined movement networks and social interactions in urban environments by integrating the methods of Space Syntax analysis and Geographic Information Systems (GIS). Using Space Syntax analysis, this research investigated the spatial structures influencing pedestrian movement and social interactions, and it offers practical solutions for enhancing the wayfinding experience in urban spaces. Furthermore, Vardopoulos (2022) has investigated preferences related to wayfinding and social interactions in urban spaces in his research, employing online surveys and regression analysis. By providing quantitative data on movement patterns and social behaviors, this study complements the qualitative findings of other research, thereby offering a deeper understanding of urban transformations and dynamics. Collectively, these studies demonstrate that the relationship between wayfinding and social interaction in urban environments is highly complex and multifaceted. By integrating various methods and approaches, valuable insights can be gained that will be instrumental in urban design and planning for creating cities that are easily accessible, inclusive, and have a vibrant social life.

- **Dynamic urbanism and design implications**

The exploration of flexible urbanism reveals a distinct realm where the mobility and dynamism of urban environments intersect with human actions and design elements. As cities continue to evolve and the connections among their inhabitants expand, understanding the complex interplay between urban structure and the flow of human movement becomes a key factor in creating vibrant, inclusive, and sustainable urban spaces. Bu & Tao (2019) laid the initial groundwork by conducting a quantitative spatial analysis, emphasizing the importance of considering flexible elements in urban design to create dynamic public spaces. Building on this foundation, Thai & Kim (2022) employed Space Syntax analysis to explore the spatial configuration of urban areas in greater detail, demonstrating how it affects the interactions and movement activities of residents and thereby providing valuable guidance for designing dynamic and efficient urban spaces. Concurrently, Follestad et al. (2022) provide valuable insights by examining urban transformations through option testing and Space Syntax analysis. Their research demonstrates how design interventions can influence the movement qualities of urban spaces and contribute to the development of sustainable development strategies. Using a multidisciplinary approach, Esposito et al. (2021) have integrated risk analysis and Geomatics² techniques to study the dynamic interaction between urban form, movement activities, and resilience to hazards, offering guidance for designing flexible and dynamic urban environments. Subsequently, Dimuccio et al. (2023) provides a spatio-temporal perspective using GIS and geostatistical methods, contributing to the design of urban spaces that facilitate and enhance movement interactions. Collectively, these studies emphasize the importance of considering flexible and dynamic urbanism in design processes, providing valuable insights for creating sustainable urban environments. This approach facilitates the assessment of the impacts of urban interventions on heritage environments. It guides urban design in a manner that respects heritage values while highlighting the role of movement patterns.

• **Historic heritage conservation: Bridging the past and present**

The conservation of historical heritage is a critical endeavor in the field of urban studies, which helps to preserve cultural identity within rapidly changing urban fabrics by creating a meaningful link between the past and the present. In this context, researchers such as Esfahani & Albrecht (2018), Holtorf (2018), and Foster (2020) have explored the complex challenges and opportunities of heritage conservation through empirical research and the development of theoretical frameworks. Their findings suggest that preserving historic heritage in the face of rapid urban transformations requires a comprehensive approach that is harmonized with the principles of urban planning and sustainable development. These studies emphasize the importance of integrating conservation practices with urban strategies to achieve long-term sustainable development goals. In addition to examining conservation methods, researchers such as Sakantamis et al. (2023) and Sehgal & Kaur (2021) have investigated the intricate relationship between historic heritage conservation and urban regeneration. Through in-depth case studies and innovative proposals, these researchers offer strategies for cities to strike a balance between preserving cultural heritage assets and fostering resilient urban growth. By emphasizing the symbiotic nature of heritage conservation and urban renewal, these scholars provide valuable guidance for urban stakeholders seeking to align with the evolving needs and aspirations of urban communities.

Case Studies and Theoretical Frameworks

This review comprehensively examines various frameworks for understanding the complexities of historic heritage conservation and urban renewal. Daneshmandian et al. (2020) have made a significant contribution to this field by practically examining the principles of historic heritage conservation and utilizing detailed case studies and theoretical frameworks. Their work illuminates the inherent challenges and

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opportunities in balancing cultural heritage conservation with urban renewal, emphasizing the importance of adopting a comprehensive approach that considers both the cultural significance of heritage sites and the socio-economic dynamics of contemporary urban contexts. Similarly, Gyurkovich & Pieczara (2021) offer valuable insights into heritage conservation using case studies and theoretical frameworks. Advocating for a holistic perspective, they stress the necessity of considering both cultural significance and socio-economic dynamics in conservation efforts. Safizadeh et al. (2023) have taken a different approach, using Space Syntax methods to analyze the spatial configurations of cultural heritage sites. Their research demonstrates how the spatial organization of historic urban areas influences human behavior and perception, and these findings are used to formulate conservation strategies that both enhance the visitor experience and preserve cultural authenticity. On another front, Sánchez & Daamen (2020) provide insights into the dynamic changes in urban landscapes and their implications for heritage conservation. Their theoretical framework examines Lisbon's transition towards a landscape-oriented approach in urban planning, emphasizing the need to reconsider traditional conservation methods in light of the evolving urban contexts and socio-cultural values. In another study, Gregor & Kalasova (2019) employed a case study method to investigate cultural-historical potential. Their research underscores the importance of employing novel methods to analyze this potential, particularly with a focus on sustainability concepts, and their findings have significant implications for urban development. Galantucci & Fatiguso (2019) examine how advancements in digital image processing techniques, particularly in architectural photogrammetry and surface analysis, can enhance heritage conservation efforts. Their findings show that by applying these methods, a deeper and more comprehensive understanding of the deterioration processes and restoration requirements of historic buildings and structures can be achieved. These approaches not only enrich our understanding of historic conservation processes but also serve as efficient tools on the path toward achieving sustainable urban development.

Although the review of various frameworks in historic heritage conservation and urban renewal has provided more profound insights, significant gaps still need to be addressed to achieve a more comprehensive approach in the fields of Heritage Impact Assessment, spatial structure analysis, and visual-based methods for sustainability. One of the most significant of these gaps is the insufficient integration of visual methods, including image processing and photogrammetry techniques, with the aforementioned processes. The use of visual methods can provide a more comprehensive understanding of spatial dynamics and heritage conservation by offering rich visual data alongside quantitative and qualitative analyses. Furthermore, there is a need for more research on the practical implementation of these integrated approaches in real-world urban contexts.

• Space syntax: Understanding urban complexity

As a powerful tool, Space Syntax analysis has led to a deeper understanding of complex spatial structures in urban environments. In this section, various aspects of Space Syntax theory and its implications for urban management will be examined, with a special focus on the conservation of urban historic heritage. This approach helps urban planners and managers address the existing challenges in these fields from a more comprehensive perspective.

- Understanding spatial configuration

Space Syntax theory is a fundamental concept in urban studies that has captured the attention of researchers for examining spatial layouts and configurations. Researchers such as Zhu et al. (2023) have utilized Space Syntax models to conduct precise quantitative analyses of temple spaces, demonstrating the effectiveness of this approach in uncovering complex spatial relationships within architectural environments. In a similar vein, Tarabieh et al. (2019) have demonstrated the adaptability of Space Syntax analysis in combination with environmental performance simulation tools for architectural typologies, such as mosques, showing that the method is applicable in diverse spatial contexts. Building on this foundational understanding, researchers such as Tufek-Memisevic (2023) have explored Space Syntax theory in greater depth, examining how spatial configurations affect human behaviors and interactions in urban environments. Similarly, Rokseth et al. (2019) have explored the broader implications of Space Syntax theory on socio-economic activities, offering valuable insights into its role in shaping urban dynamics and spatial hierarchies. Building upon these studies, researchers such as Palaiologou & Griffiths (2019) and Van Nes & Yamu (2021) have applied Space Syntax analysis in specific contexts, including heritage conservation and urban planning. Their work highlights the significance of understanding spatial configurations in preserving cultural heritage and optimizing urban layouts to enhance overall functionality. Furthermore, Şahin Kórmeçli (2023) and Musicco et al. (2021) have explored the practical applications of Space Syntax theory in urban design and architectural analysis, emphasizing its relevance in shaping the built environment. These studies

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collectively contribute to a comprehensive understanding of Space Syntax theory and its multifaceted applications in urban research and design.

- **Enhancing the cultural heritage impact assessment process**

Kasemsook et al. (2022) set the stage for this review, emphasizing the potential of combining these methods to gain insights into the spatial dynamics of urban heritage sites and to improve decision-making processes. Building on this, Arbara (2022) and Vaughan & Griffiths (2021) highlighted the critical importance of integrating spatial analysis techniques, such as Space Syntax, into heritage management practices. Their research contributes to the existing discourse, demonstrating how such integration can enhance cultural heritage conservation and, consequently, lead to more efficient and effective heritage management. This perspective is further supported by Salameh et al. (2022), who demonstrate the relevance of spatial analysis methods in heritage conservation efforts, emphasizing the valuable insights these methods provide into the spatial contexts of heritage sites. Furthering this investigation, Daneshmandian et al. (2020) have explored the benefits of integrating Space Syntax and visual analyses in heritage buildings. Their research supports a multidisciplinary approach to conservation, highlighting the potential synergies between spatial analysis techniques and Heritage Impact Assessment. They thereby emphasize the importance of integrating different methodologies for a comprehensive understanding of urban heritage management. Moreover, Gyurkovich & Pieczara (2021) emphasize the importance of integrating spatial analysis techniques into HIA, particularly in striking a delicate balance between conservation and contemporary development needs. Their study highlights the role of spatial and visual analyses in informing heritage management decisions, affirming the importance of considering spatial configurations. Expanding on this field, Esposito et al. (2021) focus on integrating spatial analysis methods with risk assessment tools in the context of urban resilience and heritage conservation. Their research investigates how decision-making processes can be improved through the integration of analytical methods to mitigate risks and adapt to changing conditions, providing strategies for conserving cultural heritage in vulnerable urban environments.

In summary, this body of research indicates that integrating Space Syntax with visual approaches in Heritage Impact Assessment has significant potential to transform the field. By employing multidisciplinary approaches that combine Space Syntax techniques with Heritage Impact Assessment (HIA) practices, researchers have gained a deeper understanding of the spatial complexities surrounding heritage sites. This ultimately leads to strengthening the foundations for more effective conservation efforts.

- **Applications in urban management**

The analysis of spatial structure is considered a fundamental tool in urban management, playing a decisive role by providing a deep understanding of the structural organization of urban spaces. The study by Garau et al. (2024) represents a significant step forward in this field, focusing on the importance of spatial structure analysis in urban planning and design processes. Their research demonstrates how this method can analyze the complex relationships between urban public spaces and pedestrian behavior, providing necessary tools to improve walkability and increase physical activity and social interactions in cities. In a similar vein, Coppola et al. (2021) have explored spatial changes in urban environments by examining the practical applications of spatial structure theory. Their findings contribute valuable insights to the field of urban management, demonstrating how spatial structure analysis can be effectively applied in formulating urban development strategies. This body of research highlights the role of this framework in fostering sustainable and inclusive urban environments while also addressing the dynamic and variable nature of urban spaces. In his research, Karimi (2023) emphasizes the capabilities of Space Syntax theory in analyzing spatial transformations and guiding urban development strategies. The paper presents a strong argument for the greater integration of urban morphology into the urban design process, showing that combining spatial analyses with socio-economic factors can lead to more comprehensive and efficient urban designs. Using Space Syntax analysis, this research makes a significant contribution to the discourse on designing urban environments that are not only responsive to physical structures but also sensitive to social, economic, and cultural needs. On another front, De Filippi et al. (2020) have investigated the role of Space Syntax theory in examining the relationship between the spatial characteristics of street networks and crime occurrence. Their findings suggest that a precise understanding of spatial layouts can facilitate a more accurate assessment of crime risk and inform the development of effective strategies to enhance public safety. Ultimately, these studies collectively demonstrate that Space Syntax analysis has broad applications in urban management. By influencing decision-making processes, guiding urban development strategies, and addressing challenges such as crime risk assessment and historic heritage conservation, this theory is recognized as

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a key tool in creating dynamic, inclusive, and sustainable urban environments.

Although previous research in the field of historic heritage conservation and urban renewal has provided valuable insights, it still faces shortcomings that necessitate further investigation. One of the most significant shortcomings is the lack of comprehensive frameworks that can simultaneously employ both quantitative and qualitative criteria to measure the multidimensional impacts of urban interventions on historic sites. While some studies have focused on the physical changes to historic buildings, few have addressed the comprehensive assessment of the social and cultural consequences of these interventions. To fill this gap, it is necessary to develop more comprehensive visual approaches that can capture the dynamic interactions between the built environment, human behaviors, and cultural patterns. To address these challenges, interdisciplinary collaboration among experts in urban planning, heritage conservation, the social sciences, and technology is essential for developing comprehensive and context-sensitive approaches to heritage impact assessment and visual representation methods.

Findings and Discussion

The integration of spatial structure analysis and Heritage Impact Assessment (HIA) methods, utilizing a visual approach, provides valuable opportunities for a deeper understanding of urban transformations over time. These methods allow researchers and urban planners to more accurately examine the historical contexts of urban formation while simultaneously envisioning pathways toward achieving sustainable urban patterns in the future. By integrating these methods, the assessment of the impacts of development interventions on cultural heritage is conducted more efficiently.

Furthermore, this integrated approach facilitates inclusive and sustainable economic growth by striking a balance between the imperatives of heritage conservation and the needs of urban development. Fig. 3, based on the systematic review, illustrates the complex interaction between these key topics and provides academic insights into the simultaneous pursuit of urban sustainability and cultural heritage conservation.

The proposed theoretical framework aims to address the existing gaps in the literature by presenting a comprehensive methodology that integrates Space Syntax analysis with a visual approach. By offering an interdisciplinary perspective on the understanding and management of urban heritage environments, this approach contributes to the enhancement of Heritage Impact Assessment (HIA) and urban management methods. The proposed framework, depicted in Fig. 3, consists of four main stages, each playing a distinct role in analyzing the complexities of urban development and heritage conservation. In the first stage, data are systematically collected from diverse sources, including historical documents, architectural plans, and visual records spanning different periods. Once combined and integrated, this extensive dataset provides a solid foundation for more in-depth analyses, enabling researchers to comprehensively examine the structural transformations of cities (Oliveira, 2022). In the second stage, the framework employs a visual approach that incorporates various visualization techniques, including mapping, documentation, and Space Syntax analysis. This stage aims to uncover the complex spatial patterns and configurations of the built environment over time, illuminating the underlying connections of urban development. Through Space Syntax analysis, researchers can identify the spatial hierarchies and connectivity of urban spaces, providing valuable insights into how these factors influence human behavior and interactions within the city (Askarizad & Safari, 2020). In the third stage, advanced 3D modeling techniques are incorporated into the framework to create comprehensive and precise representations of urban changes. This tool allows researchers to observe architectural changes and their impacts on the cityscape with unparalleled precision and clarity. The use of 3D modeling enhances our understanding of the structural dimensions of urban development, offering more profound insights into the evolutionary process of built environments (Chakraborty & Ji, 2023). Finally, in the fourth stage, the Heritage Impact Assessment (HIA) framework is integrated into the analysis, allowing researchers to assess the consequences of urban changes on the conservation of cultural heritage and broader urban landscapes. Through this process, the potential impacts of proposed developments on cultural heritage can be examined, ensuring that conservation efforts are effectively integrated into urban planning processes. This comprehensive approach emphasizes the importance of preserving cultural heritage alongside sustainable urban development (Ashrafi et al., 2022).

The integrated framework presented in this study provides a comprehensive and interdisciplinary methodology for analyzing urban transformations. By combining data collection, visual analysis, 3D modeling, and Heritage Impact Assessment, researchers can gain valuable insights into the complexities of urban development. Furthermore, this framework provides practical guidance for urban planners and stakeholders, supporting data-driven decision-making in urban design and development efforts. Through interdisciplinary

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collaboration and the application of innovative methods, it is possible to pave the way toward more sustainable and culturally sensitive urban environments (Fig. 4).

- **Space syntax tools and 3D modeling**

Space Syntax is a field of study that examines the impact of the spatial organization of the built environment on people's social behaviors and interactions. By employing quantitative methods, this field studies how the design of urban and architectural spaces influences people's daily lives. Software applications for Space Syntax include DepthmapX (2D and 3D), A-graph, Grasshopper for Rhino, and Spacematrix. DepthmapX is considered a more suitable option among urban analysis tools due to its special capabilities. Some of the most important analytical techniques in this software include Axial Map Analysis, Visibility Graph Analysis (VGA), Isovist analysis, and Agent-Based Analysis. For 3D modeling, software such as SketchUp, 3ds Max, and Rhino can be used.

• Theoretical concepts of the integrated framework

1. Advancement of Urban Theories: The proposed framework significantly contributes to the advancement of urban-related theories by providing a systematic and holistic method. This framework not only provides a detailed examination of how cities evolve over time but also enhances our understanding of the complex interplay between historical events, spatial layouts, and cultural influences. This approach illuminates how urban environments evolve and adapt.

2. Interdisciplinary Convergence: This framework transcends the traditional boundaries between the fields of

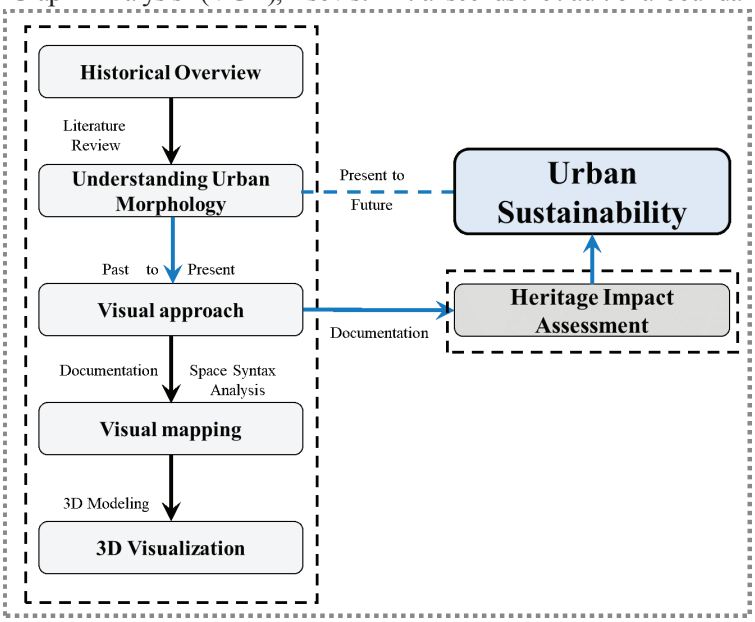

Fig. 3. Creating convergence: Linking research focus areas. Source: Authors.

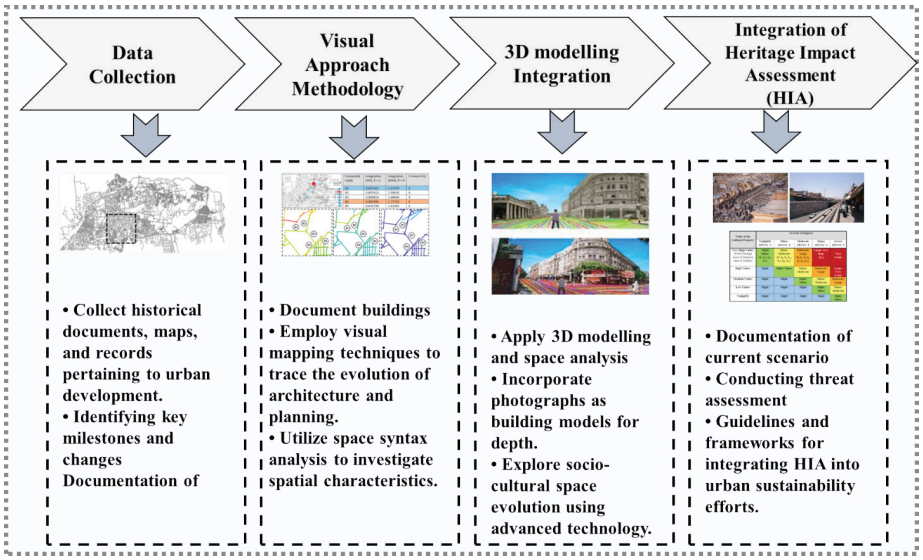

Fig. 4. The Proposed Theoretical Framework: An Integration of Methods. Source: Chen, 2022; Foster, 2020; Kapp, 2019; Garau et al., 2024.

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urban studies, heritage conservation, and spatial analysis, establishing an interdisciplinary approach. By integrating findings and theories from various disciplines, this convergence enables an effective response to complex urban challenges. This, in turn, leads to the formation of more comprehensive and practical theoretical perspectives in the field of urban studies.

3. Understanding Spatial Configuration: The use of Space Syntax analysis within the research framework deepens our theoretical understanding of the organization of urban spaces. Examining the relationship between spatial hierarchies and their connections to human behavior and interactions significantly contributes to the development of Space Syntax theory. This approach clarifies how different spatial arrangements influence social and functional patterns within cities.

4. Comprehensive Heritage Impact Assessment: This framework expands the theoretical underpinnings of Heritage Impact Assessment (HIA) by situating it within a broader framework of urban analysis. This approach not only considers physical changes to heritage sites but also takes into account their social, cultural, and economic impacts. This holistic view highlights the importance of understanding the multifaceted impacts of heritage. It contributes to the development of a more nuanced and theoretically informed approach to Health Impact Assessment (HIA) and its role in urban planning.

5. Visual Representation in Urban Analysis: The application of visual methods such as mapping, documentation, and 3D modeling enriches the theoretical discourse on urban transformations. By offering tangible and objective representations of urban changes, these tools provide a better understanding of the evolutionary process of urban spaces over time. By translating complex spatial changes into visual formats, this framework enables a deeper understanding and more precise analysis of urban transformations and their theoretical implications.

• Practical implications of the integrated framework

1. Informed Urban Planning: This framework provides urban planners with a powerful tool to make informed decisions about urban development. Integrating Space Syntax with Heritage Impact Assessment ensures that planning strategies not only respond to contemporary urban needs but also respect the historical significance of heritage sites. This dual focus helps create balanced urban development plans that honor historical contexts while meeting modern demands, thereby fostering a more thoughtful and comprehensive approach to urban planning.

2. Enhanced Conservation Strategies: Heritage conservators can utilize this framework to develop more effective and targeted conservation strategies. The framework clarifies how urban changes impact cultural heritage and informs the development of strategies that preserve cultural authenticity while adapting to contemporary needs.

3. Community Engagement: The framework enhances community engagement by using compelling visualizations that depict urban transformations. These visual representations present changes to urban areas in a transparent and accessible manner, increasing public awareness of the value and importance of heritage sites. Through this approach, community members can actively participate in dialogues and decision-making processes related to urban development and heritage conservation, ultimately fostering a participatory environment in urban planning.

4. Risk Mitigation: This framework enables urban managers and policymakers to mitigate risks from natural and human-made threats using proactive strategies. Combining multi-risk analysis and geomatics technologies provides a comprehensive approach to assessing and managing hazards that could affect cultural heritage and urban resilience. By anticipating potential threats and facilitating appropriate planning, this framework significantly contributes to increasing the resilience of urban spaces and protecting valuable heritage assets from various threats.

5. Visually Informed Decision-Making: The framework enhances the data-driven decision-making process by utilizing visual tools, including mapping, documentation, and 3D modeling. These visualizations display urban transformations in a clear and comprehensible manner, facilitating the identification of patterns, trends, and potential challenges. By transforming complex data into understandable and actionable information, this visual approach helps decision-makers act with greater awareness and effectiveness.

6. Sustainable Urban Development: The framework's focus on visual approaches, including 3D modeling, provides a better understanding of the environmental impacts associated with urban changes. This approach enables planners to evaluate the ecological impacts of development projects and propose designs that align with sustainability principles.

In the Table 2, based on the theoretical-practical framework discussed, the technical details and implementation considerations are presented.

Conclusion

Aiming to fill a gap in the literature on urban heritage management, this study proposes an innovative

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Table 2. The theoretical framework: Technical details and implementation considerations. Source: Authors.

	No.	Component	Technical Details	Implementation Considerations	Key Outputs
Theoretical	1	Advancement of Urban Theories	Spatio-historical comparative Analysis, spatiotemporal transformation modeling	Collection of stratified historical data, Creation of a spatio-temporal database	Patterns of urban evolution, Identification of key drivers of spatial transformation
	2	Interdisciplinary Convergence	Integration framework for physical, social, and economic data (BIM+ & GIS)	Formation of interdisciplinary teams, Development of a common data platform	Multidimensional predictive models, Balanced development strategies
	3	Spatial Configuration Analysis	Space Syntax, Application of Space Syntax with indicators: Integration, Depth, Choice	Laser scanning of urban environments and movement graph analysis with DepthmapX software	Identification of critical connectivity nodes, Optimization of accessibility
	4	Heritage Impact Assessment	Multi-layered impact matrix: Physical, social, and economic indicators with AHP weighting	Intensive field studies, Continuous monitoring, and analysis of behavioral data	Heritage sensitivity maps, Integrated vulnerability index
	5	Visual Representation	Simultaneous generation: 3D models based on interactive dynamic maps	Digital heritage studios, Collaborative augmented reality (AR) platforms	Development scenario simulations, Interactive urban decision-making tools
Practical	1	Informed Planning	Decision Support System (DSS) with multi-objective optimization algorithms	Joint workshops for planners and conservators, Design of adaptive development scenarios	Balanced historical-contemporary development plans, Physical compatibility guidelines
	2	Enhanced Conservation	Smart monitoring with: Structural sensors, Change monitoring via satellite imagery	Establishment of an integrated heritage monitoring center, Early warning system	Preventive conservation strategies, Adaptive maintenance plans
	3	Community Engagement	Collaborative digital platforms featuring: Virtual Reality (VR), Spatially-interactive surveys	Multimedia awareness campaigns, Citizen think-tanks	40% increase in public participation, Creation of a public ideas bank
	4	Risk Mitigation	Integrated multi-risk analysis (FEMA + ISO 31000) with GIS layering	Design of a risk information system, Periodic crisis management drills	Urban resilience maps, Integrated emergency response plans
	5	Visual Decision-Making	Development of an urban management dashboard featuring: Real-time spatial analysis, Dynamic simulation	Installation of urban screens, Big Data-based Decision Support System	30% reduction in decision-making time, Increased transparency in development processes
	6	Sustainable Development	Project Life Cycle Assessment (LCA) integrating: LEED+ indicators & ICOMOS charters	Dynamic energy audits, Carbon footprint monitoring using remote sensing	Integrated urban sustainability certification, Optimization of resource consumption in historic fabrics

framework derived from a detailed review of 58 academic articles from the Scopus database. The primary objective is to create an integrated approach by combining Space Syntax analysis with a visual approach to enhance Heritage Impact Assessment (HIA) and achieve urban sustainability. To this end, a systematic literature review was conducted on topics related to Space Syntax, Health Impact Assessment (HIA), and visual approach methods. Based on this analysis, a four-stage conceptual framework was developed, comprising Data Collection, Visual Approach, 3D Modeling, and Heritage Impact Assessment. The presentation of this integrated framework, along with the synthesis of findings from the systematic review, is considered a significant advancement in urban heritage management. By offering a multidisciplinary method, the proposed framework enables a more precise assessment of spatial structures, a deeper understanding of urban heritage management, and informed decision-making for sustainable urban development. At each stage of this framework, researchers gain valuable insights into the complexities of architectural changes, the impacts of urban transformations on heritage conservation, and the broader effects on the urban fabric. These findings are significant as they can address key challenges in urban planning and development. By bridging the gap between theoretical foundations and practical implementation, the proposed integrated framework lays the groundwork for data-driven decision-making that aligns with the Sustainable Development Goals for inclusive, safe, resilient, and sustainable cities. Future research should evaluate and refine this framework through empirical studies and real-world applications to further enhance its effectiveness. Furthermore, interdisciplinary collaboration is essential for examining the long-term sustainability

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of heritage conservation projects and for establishing standardized methods that incorporate community perspectives and cultural significance assessments into heritage impact studies.

Theoretically, it contributes by (1) bridging the gap between urban studies, architecture, and building conservation by integrating Space Syntax, visual methods, and HIA; (2) advancing urban theories by focusing on the dynamic interplay of history, culture, and spatial organization; and (3) redefining HIA by considering social, economic, and ecological dimensions.

Practically, it achieves contributions such as (1) facilitating informed urban planning through 3-D modeling and visualization of changes, (2) mitigating the tension between development and conservation by providing data-driven decision-making tools and fostering community participation, and (3) enhancing urban resilience by predicting the risks of strategies at any scale. The theoretical and practical applications of this framework are further detailed in the Tables 3 & 4.

Recommendations

Theoretical significance: This framework advances urban theory by offering a precise understanding of urban evolution, fostering interdisciplinary convergence towards an integrated city, and enriching the theoretical foundations of both Space Syntax and Heritage Impact Assessment (HIA). The framework also validates the use of visual representations as epistemological tools, contributing to a deeper theoretical discourse.

Practical significance: On the practical front, this framework empowers urban planners with informed decision-making capabilities, enables dynamic and flexible conservation strategies, enhances community engagement through accessible visualizations, and strengthens urban resilience. This framework transforms complex data into actionable insights for sustainable urban development.

This combined approach demonstrates that integrating quantitative and qualitative methods not only provides a deeper analysis of cities but also bridges the gap between academic research and the practice of urban planning. This framework stands as a pioneering model for confronting the 21st-century challenges in urban management.

Limitations: Although the framework follows a systematic and orderly method, its applicability may not be uniform across cities and communities with diverse cultures. The specific characteristics of each city or urban area may necessitate modifications to the implementation methods, which could adversely affect the uniformity of the results and their comparability. This inconsistency in implementation could pose a challenge to establishing uniform standards for the framework's application, potentially limiting the universal applicability of the obtained results.

Conflict of Interest

The authors declare that there was no conflict for them in conducting this research.

Endnotes

1. Heritage refers to anything that has been passed down from past generations and is considered valuable in the present. In the context of this study, 'cultural heritage' encompasses both the historic urban fabric and individual historic monuments and sites (Heritage Impact Assessment, or HIA).
2. Geomatics is the scientific and technological field that deals with the collection, storage, processing, analysis, and management of spatial information.

Table 3. Key theoretical contributions of the integrated framework. Source: Authors.

Domain	Contribution
Advancement of Urban Theories	Provides a systematic method for urban evolution; Elucidates the historical-spatial-cultural interplay
Interdisciplinary Convergence	Enables interdisciplinary studies; Fosters an integrated urban theory
Deepening Space Syntax Theory	Enhances understanding of spatial organization; Contributes to the validation of Space Syntax
Comprehensive Heritage Theory	Expands heritage assessment beyond the physical dimension to include socioeconomic impacts
Visual Epistemology	Validates visual representations as tools for deeper understanding and analysis; Enriches theoretical discourse

Table 4. Key practical implications of the integrated framework. Source: Authors.

Domain	Contribution
Informed Urban Planning	Balanced development that respects history while meeting modern needs
Enhanced Conservation Strategies	Effective strategies that preserve authenticity while allowing for adaptation
Enhanced Community Engagement	Increased public awareness; Active participation in the planning process
Risk Mitigation	Proactive mitigation of natural & human-made threats; Enhanced resilience
Data-Driven Decision-Making	Clear data visualization leading to effective, actionable outcomes
Sustainable Urban Development	Assessment of environmental impacts; Fostering of sustainable designs

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