

# Investigating Cultural Dimensions in Sustainable Tourism: Carrying Capacity Assessment and GIS-based Management Strategies for Historic Buildings

Sana SIMOU<sup>1\*</sup>, Khadija BABA<sup>1</sup>, Yassine RAZZOUK<sup>1</sup>, Abderrahman NOUNAH<sup>1</sup>

<sup>1</sup> Civil Engineering and Environment Laboratory, Civil Engineering, Water, Environment and Geosciences Centre (CICEEG), Mohammadia School of Engineering, Mohammed V University  
Rabat, Morocco

sanae.simou@gmail.com

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**Abstract.** This research delves into the sustainability of tourism at Tour Hassan, a historic building in Morocco, by examining its carrying capacity and implementing GIS-based management strategies. As a significant cultural heritage site, Tour Hassan draws a considerable number of visitors. The study involves a comprehensive assessment of the site's carrying capacity, encompassing visitor flow analysis, infrastructure evaluation, and spatial limitations. Informed management strategies are then devised based on these findings. Leveraging Geographic Information Systems (GIS), data-driven decision-making processes are employed to optimize visitor experiences while safeguarding the historical building's integrity. This case study provides valuable insights into the effective management of tourism in historic sites, ensuring their long-term conservation and sustainable development.

## Introduction

Historic buildings and sites are invaluable cultural assets that not only showcase a region's rich heritage but also attract a significant number of tourists [11]. These visitors contribute to the local economy and foster cultural exchange. However, managing tourism in historic buildings presents unique challenges. Striking a balance between accommodating visitors, maintaining the integrity of the historic fabric, and ensuring sustainable practices requires careful planning and effective management strategies [8,17].

Historic buildings serve as cultural touchstones, embodying the identity and history of a place. Their architectural beauty and historical significance attract a steady stream of visitors who seek to experience the past firsthand. However, the preservation of these structures while accommodating tourism poses several challenges. Excessive visitor numbers can lead to overcrowding, wear and tear, and damage to the fragile historic fabric [4,7]. Furthermore, inadequate infrastructure and poor management can undermine the visitor experience and detract from the authenticity of the site. Therefore, it becomes essential to evaluate the carrying capacity of these sites to strike a balance between tourism and conservation [2].

In recent years, Geographic Information Systems (GIS) have emerged as a valuable tool for assessing the carrying capacity of tourist destinations and facilitating informed decision-making processes [1,21]. GIS has revolutionized the field of tourism management by providing a spatial framework to analyze, visualize, and manage various aspects of a destination. By incorporating geospatial data, GIS enables the assessment of visitor flow patterns, infrastructure requirements, and the impacts of tourism on the historic building and its surroundings [13]. Through spatial analysis and modeling, GIS-based management strategies can be developed to optimize visitor experiences while preserving the integrity of the site [6]. This research examines the application of GIS-based management strategies in evaluating the carrying capacity of historic buildings for

sustainable tourism, with a focus on the case study of Tour Hassan, a significant cultural landmark in Morocco.

Tour Hassan, located in Rabat, Morocco, represents an ideal case study for examining the application of GIS-based management strategies in the context of historic buildings. Tour Hassan is a historic tower and minaret that forms part of an incomplete mosque dating back to the 12th century. It holds great cultural and historical significance, attracting a substantial number of visitors each year [24]. However, the management of tourism in Tour Hassan poses several challenges, including maintaining visitor safety, ensuring sustainable access, and preserving the fragile historic fabric.

By applying GIS techniques, the carrying capacity and the density of tourist in Tour Hassan can be assessed. GIS allows for the analysis of visitor flow patterns, identifying areas of congestion, and potential bottlenecks. This information can guide the development of strategies to manage visitor numbers, such as implementing timed entry systems, controlling access to sensitive areas [19,20], and optimizing visitor routes [25]. GIS can also aid in infrastructure planning, ensuring that facilities such as visitor centers, parking areas, and amenities are strategically located to enhance the visitor experience while minimizing the impact on the historic building [23].

Furthermore, GIS-based management strategies can help in monitoring and preserving the historic fabric of Tour Hassan. By mapping the site's condition and vulnerability, GIS can provide insights into areas that require immediate attention and conservation efforts. It can assist in identifying potential risks and developing mitigation measures to protect the site from natural disasters or human-induced threats. Additionally, GIS can aid in the documentation and visualization of the site's historical evolution, enhancing interpretive experiences for visitors.

## **Materials and methods**

### *GIS-data preparation*

Geographic Information Systems (GIS) provide us with powerful tools for the storage, manipulation, analysis, and production of geographic information. These systems offer two key capabilities. Firstly, GIS allows us to model reality by organizing information into multiple layers, enabling autonomous analysis or the exploration of various dimensions and aspects of a given territory. This layered approach allows for a comprehensive understanding of spatial relationships and patterns. Secondly, GIS enables the incorporation of geographic information and its associated attributes, allowing us to link diverse data sets to specific locations on the map [10]. This integration of geographical information and its attributes enhances the depth and richness of analysis, facilitating a more comprehensive assessment of the characteristics, dynamics, and complexities of a particular area or region. Through these capabilities, GIS serves as a valuable tool in spatial analysis, planning, and decision-making processes across various fields and industries.

The present study follows the concept introduced by Glasson [9], which suggests that the impact of visitors on a site is site-specific rather than uniform throughout the entire area. The carrying capacity of the historic building, Hassan Tour, is currently a concern due to the significant number of tourists it attracts each year, leading to irreversible and ongoing damage to its architectural features. Evaluating the carrying capacity requires considering spatial and temporal variations and adjusting it mathematically based on the distribution of activities on the site.



Figure 1: Realistic photos (a) and virtual view (b) of the Hassan Tour site located in Rabat city (Morocco)

The number of annual visitors to Hassan Tour is sourced from the Directorate of Heritage in Rabat, Morocco. Hassan Tour is one of the most historically significant monuments. To estimate the number of potential visitors, formulas 1 and 2 [15] are employed, utilizing known sample averages ( $\bar{x}$  and  $\bar{y}$ ) and expected averages ( $\bar{x}$  and  $\bar{y}$ ).

$$(1) a = \bar{y} - b\bar{x} \quad \text{and} \quad (2) \frac{\sum(x-\bar{x})(y-\bar{y})}{\sum(x-\bar{x})}$$

The capacity of different areas and the rotation coefficient for daily visits are calculated using modified formulas from Boullon [5]. Formula (3) establishes an adjusted average individual standard (AVIS) by considering the area of each monument and its relation to the largest area (2177.49), with a psychological comfort standard of 8m<sup>2</sup>. The visitors' area is calculated in ArcGIS 10.4.1 by mapping each monument as a polygon. The psychological comfort of visitors is taken into account, considering factors such as restroom availability, ticket office location, and the presence of only one entrance. This study adopts an average individual standard of 8m<sup>2</sup>, aligning with psychological comfort limitations.

$$(3) \text{ Adjusted average individual standard (AVIS)} = \left( \frac{\text{area of a monument}}{2177,49} \times 100 \right) / 8\text{m}^2$$

The next step involves calculating the potential carrying capacity (PCC) by multiplying the Basic Carrying Capacity (BCC) by the adjusted Rotation Coefficient (ARC). The PCC represents the maximum number of tourists that can be accommodated in a specific tourist area within a day. BCC is determined by dividing the monument's area by AVIS, while ARC is calculated as the area of monuments divided by the total area of monuments, multiplied by 5, representing the number of daily hours the site is open divided by the duration of a tour (2 hours) [21,22].

(4) Potential Carrying Capacity (PCC) = Basic Carrying Capacity (BCC) X Adjusted Rotation Coefficient (ARC)

Which ARC is:

$$(4.1) \text{ Adjusted rotation coefficient (ARC)} = \frac{\text{Area of monuments}}{\text{Total area of monuments}} * 5$$

Where 5 is the number of daily hours the site is open to visitors (10 h) divided by the time of the tour (2 h).

And BCC is:

$$(4.2) \text{ Basic carrying capacity (BCC)} = \frac{\text{Area of monuments}}{\text{AVIS}}$$

The density of visitors on the site is estimated using Kernel Density, a statistical method that generates a density surface based on the spatial coordinates of visitors, highlighting areas of

concentration [15]. The density at a given point  $x$  is determined using formula (5), where  $k$  represents the nuclear function,  $h$  is the bandwidth, and  $(x - x_i)$  refers to the distance between the evaluation point and the event.

$$(5) \quad \mathbf{fn}(x) = \frac{1}{nh} \sum_{i=1}^n \left[ \mathbf{k} \left( \frac{x-x_i}{h} \right) \right]$$

Where  $k$  is the nuclear function;  $h > 0$ , for the bandwidth; and  $(x - x_i)$  refers to the distance between the evaluation point  $x$  and the event  $x_i$ .

In study, we utilize GIS and mathematical modeling techniques to assess the carrying capacity of the historic building, Hassan Tour. It considers site-specific impacts, estimates potential visitor numbers, calculates carrying capacities, and evaluates visitor density using Kernel Density estimation.

*Management strategy development*

Based on the findings from data analysis, spatial modeling, and risk assessment, informed management strategies were developed. These strategies aimed to optimize visitor experiences, protect the historic fabric, and ensure the sustainable management of tourism in Tour Hassan. Strategies included timed entry systems, visitor route optimization, targeted conservation efforts, and infrastructure improvements.

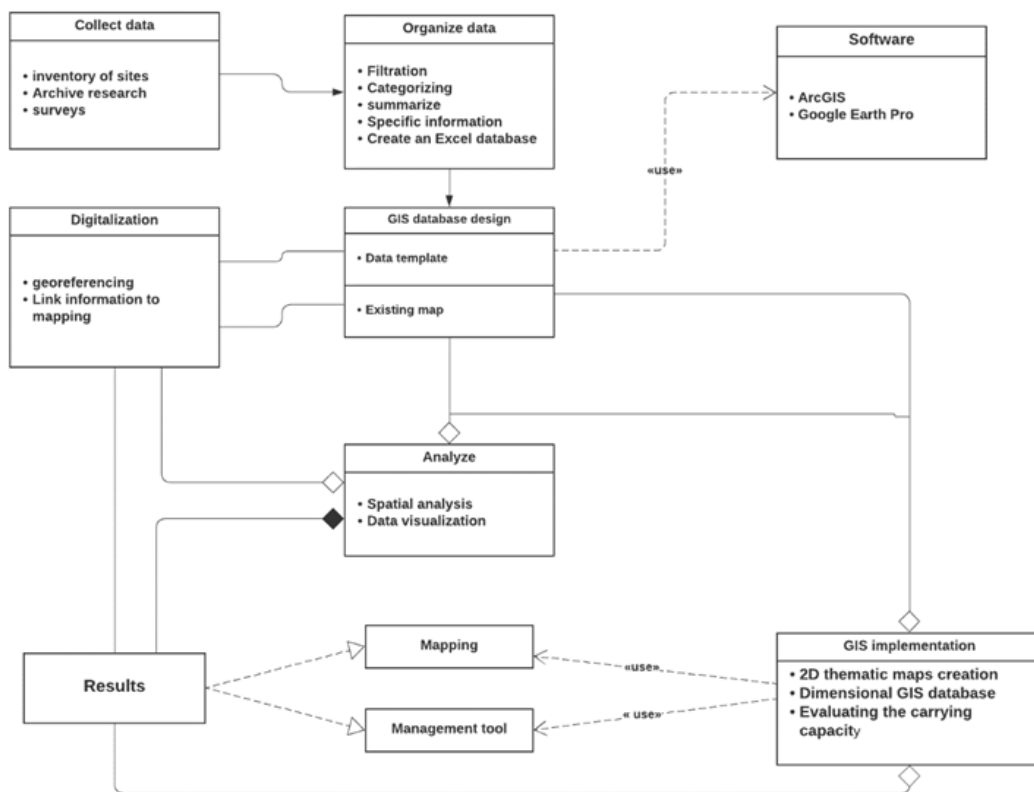


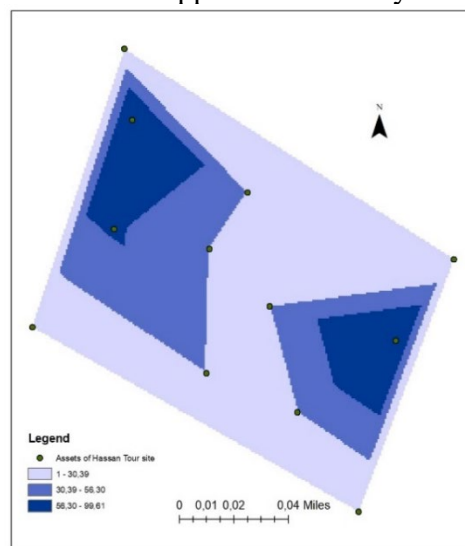
Figure 2: Diagram illustrating the construction of a historical heritage management database

**Results and discussions**

The need to address tourist activities as a management concern arises due to the potential cultural and environmental pressures exerted on the Hassan Tour. However, the application of methods and tools for assessing carrying capacity in such contexts is limited. This poses a significant challenge for planning and decision-making in sustainable tourism. Destinations that attract mass tourism, particularly historic and heritage sites like Hassan Tour, require policies and practices to

monitor carrying capacity. Establishing a scientific foundation and fostering collaborative efforts is essential. In the case of historic and heritage sites, mass tourism often leads to high visitor numbers concentrated around monuments, especially during short visits. The Hassan Tour faces similar concerns. Morocco, in general, has limited experience in implementing carrying capacity management in tourism destinations, likely due to the ambiguities associated with the concept and operational difficulties. The three components of carrying capacity are given varying importance based on the destination's characteristics, the type of tourism, and the interface between tourism and the environment [12,18].

To provide an example, between Mai and September 2019, the Hassan Tour site received a total of 60,550 visitors. The percentage of and density of tourists is relatively consistent across the various areas and historical assets of the Hassan Tour site. **Figure 3** provides a visual representation of the percentage of tourists at the site. From the map, it is evident that visitors tend to congregate around the minaret, mosque, and mausoleum, which are situated within the site. Notably, the courtyard of the site does not appear to be overly crowded with tourists.



*Figure 3: Map of percentage of visitors in Hassan Tour site*

**Figure 4** provides a detailed illustration maps of the density and carrying capacity of tourists visiting the Hassan Tour site during a specific period. The figure highlights that the density of tourists is directly associated with the notable attractions present within the site. The mausoleum and mosque exhibit the highest density of visitors, followed by the minaret then the courtyard. Regarding the carrying capacity, based on the information provided in **Figure 4**, we can infer that the carrying capacity of the Hassan Tour site appears to be influenced by the density of tourists. The figure suggests that the mausoleum and mosque experience a higher number of visitors, indicating that these areas may approach or reach their carrying capacity during the specified period. Meanwhile, the minaret exhibits a relatively lower density, suggesting that it may have a lower impact on the carrying capacity of the site.

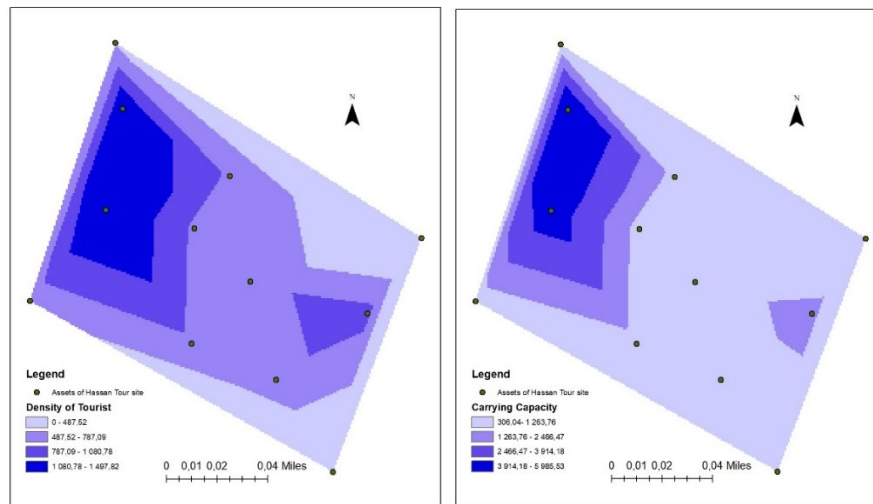


Figure 4: Maps of the density and the carrying capacity of visitors in Hassan Tour site

## Conclusion

This study provided valuable insights into the carrying capacity of the Hassan Tour site and its implications for visitor management. The evaluation of carrying capacity shed light on the distribution of visitors across the site, emphasizing the need for spatial and temporal considerations [14]. By incorporating concepts such as the standard area of visitors, as highlighted by previous research, the study highlighted the importance of adapting carrying capacity calculations to account for the unique characteristics of the site. The study underscored the negative impact of excessive visitor numbers on the historic site, emphasizing the urgency of implementing effective management strategies. The preservation of the site's authenticity and outstanding universal value requires careful planning and control of visitor activities. The findings serve as a wake-up call for authorities and stakeholders to prioritize sustainable tourism practices and strike a balance between visitor satisfaction and the long-term preservation of the site's heritage.

The development of a comprehensive database for managing historic buildings and sites represents a significant step forward [16]. It offers new avenues for future research and facilitates informed decision-making in heritage management. By integrating the results obtained through GIS technology, the study opens up possibilities for creating user-friendly applications that enhance the viewing, modification, and overall management of the historic site. This technological integration will empower authorities to implement adaptive and proactive measures to protect and transmit the heritage to future generations.

Overall, this study highlights the importance of adopting a multidisciplinary approach that combines GIS analysis, carrying capacity assessment, and heritage management principles. The insights gained from this research provide a solid foundation for developing effective policies and practices that ensure the sustainable preservation and enjoyment of historic sites like Chellah. The findings will serve as a valuable resource for authorities, planners, and researchers working towards the preservation and responsible tourism development of similar heritage sites worldwide.

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