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PAPER

# Design and Implementation of a Web GIS Application for Heritage Documentation Using Drones, Lidar, and Laser Scanning: The Case of Lubonja, Korçë, Albania

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## ABSTRACT

Cultural legacy is an integral part of a country's identity and its historical and social development. This heritage must be preserved and protected through modern documentation, monitoring, and management technologies. In this context, information and communication technologies (ICT), specifically geographic information systems (GIS), have emerged as transformative tools. Recently, Web GIS applications have expanded opportunities for collaboration and real-time information sharing by offering accessible and interactive platforms for geospatial data integration. Web GIS empowers heritage experts to create precise maps, 3D models, and real-time heritage experts by allowing them to create precise maps, 3D models, and real-time representations of cultural assets. Despite its potential, a significant challenge lies in effectively disseminating information to attract tourists and promote heritage sites. This study explores the application of Web GIS in addressing these challenges in Lubonja, a prehistoric village in Korçë, Albania. It discusses the benefits and limitations of this technology in preserving and promoting cultural heritage and how advanced geospatial technologies can enhance accessibility, public participation, and heritage management.

## KEYWORDS

web geographic information systems (GIS), cultural heritage, geospatial analysis, drones, laser scanning, data visualization, Lubonja

## 1 INTRODUCTION

As technology plays a crucial role in the preservation, documentation, and promotion of cultural assets, cultural heritage management has increasingly embraced digital transformation. The integration of digital technologies in this field has paved the way for innovative solutions to challenges arising from resource limitations, urbanization, and climate change.

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In cultural heritage management, geographic information ystems (GIS), particularly Web GIS, have become powerful tools. They provide cutting-edge features for collaborative decision-making, real-time data sharing, 3D visualization, and spatial data processing. GIS enables high-precision mapping and interactive exploration of cultural sites, especially when combined with modern data collection techniques like drones, Lidar, and laser scanning [1], [2]. These technologies support advanced spatial analysis, including the identification of degradation patterns, environmental risk assessment, and planning of restoration efforts [3]. For example, geographical analysis tools can identify clusters of endangered heritage sites, simulate environmental impacts, and predict risks using simulation techniques. These capabilities are vital for prioritizing conservation efforts and optimizing resource allocation. Furthermore, GIS enhances heritage data visualization through immersive 3D models and interactive maps, which support planning and monitoring while also engaging the public through virtual tours and educational content [4].

Technological advancements in Web GIS have significantly broadened its potential. Unlike traditional GIS, Web GIS provides real-time data access, interactive interfaces, and collaborative capabilities, making it a valuable tool for public engagement and heritage promotion. Tools such as ArcGIS Online and StoryMaps allow users to explore cultural sites through dynamic maps and multimedia content, enabling global access and interaction [5]–[7].

Despite the promise of Web GIS, its application in regions such as Albania remains limited, particularly in integrating high-resolution spatial data and providing public access to cultural heritage information. A key challenge is the effective use of digital platforms to engage communities, attract visitors, and protect vulnerable heritage sites [3].

This paper presents the design and implementation of a Web GIS application developed for the documentation and promotion of the Lubonja village's culture in Korçë, Albania. It demonstrates how the integration of drones, lidar, laser scanning, and GIS technologies can produce a scalable, interactive, and immersive platform for both experts and the public. The project offers a replicable model that bridges advanced geospatial data collection and web-based visualization to support heritage management, spatial analysis, and educational outreach [7].

The paper is structured as follows. Section 2 reviews background and related works. Section 3 outlines the technique employed for data gathering, processing, and platform development. Section 4 describes the implementation of the Web GIS platform, including visualization tools and user interface design. Section 5 discusses the platform's performance and evaluation. Section 6 concludes with key findings, future directions, and recommendations for enhancing the platform's functionalities.

## 2 BACKGROUND AND RELATED WORKS

The integration of GIS into web platforms has transformed cultural heritage management by enabling real-time access to geographical data and expanding audience interaction. Unlike traditional GIS systems, Web GIS platforms allow for the dissemination of interactive, user-friendly content to a global audience [8]. These systems are especially valuable for documenting, monitoring, and promoting cultural and natural assets. They support real-time data exchange, multimedia integration, and spatial analysis, which are vital for public involvement, academic research, and historical tourism [9].

Numerous programs throughout the world have demonstrated the effectiveness of Web GIS in managing cultural heritage. For example, UNESCO utilizes high-resolution satellite imagery and geospatial analysis to monitor and conserve

World Heritage Sites [10]. Similarly, the European Union's "OpenHeritage" initiative uses Web GIS to document and promote cultural assets, encouraging public participation and development of sustainable tourism. In Asia, Web GIS is employed in projects such as the digital mapping of Angkor Wat, combining 3D modeling and satellite data to manage and allow virtual exploration of the monument. These examples highlight how Web GIS empowers both local and international stakeholders to contribute to heritage protection while overcoming site-specific challenges [11].

In a regional context, GIS applications have been adapted to address local cultural landscapes and archeological needs. In Albania, GIS has been used to map and monitor heritage sites threatened by urbanization and climate change. However, the adoption of advanced data collection technologies such as drones, Lidar, and laser scanning remains limited. This study builds upon earlier efforts by incorporating these technologies to protect 3D models and geospatial data for the prehistoric village of Lubonja, Korçë. The integration of high-resolution spatial data with Web GIS provides a scalable model for cultural heritage documentation and promotion [12].

The use of Web GIS for educational and tourism purposes has also been widely explored. For instance, recent studies [13] have examined how mobile GIS applications enhance cultural tourism by giving interactive, location-based content for users. One study highlights the effectiveness of mobile Web GIS in creating virtual historical tours, enabling remote exploration of heritage sites through multimedia-rich interfaces. Another emphasizes the pedagogical value of GIS in increasing public and student awareness of historical conservation practices [14].

### 2.1 Case study: Lubonja

Lubonja village, located in southeastern Albania, serves as a compelling case study for the integration of Web GIS into cultural heritage management. The area is characterized by mountainous terrain, including notable peaks such as Malingelo (1,766.8 m), Rungaja (1,945 m), and Mali i Zi (1,703 m). Situated at an elevation of 950 to 1,200 meters, the village holds significant archaeological value, featuring sites ranging from ancient settlements to historical churches and fortresses [15]. Significant archaeological areas include:

1. **Current Settlement of Lubonja:** This area features important cultural assets such as the Church of the "Dormition of St. Mary," classified as a First Category Cultural Monument, established in 1015, alongside other churches and ancient oak trees.
2. **Kuqeshi:** An earlier settlement above modern Lubonja, containing the remnants of churches and a monastery.
3. **Mëhalla e Sipërme:** A site with ruins of ancient settlements and the Church of "St. Marina."
4. **Lubonja Castle:** A strategic site located at 1,234 meters with rich historical and archaeological significance.
5. **Guri i Shqipes (Eagle's Rock):** A hill with ruins believed to be the remains of an ancient fortress.
6. **Rrobas and Kisha "Fuçinë":** An area featuring additional ruins, a church, and several archeological findings.

This study leverages Web GIS to document and visualize these heritage areas comprehensively. By incorporating drone imagery, Lidar, and laser scanning, high-resolution 3D models and interactive maps have been developed, making

Lubonja's heritage more accessible to both specialists and the public. The Web GIS platform facilitates collaboration among researchers, local authorities, and communities, while also promoting sustainable development through cultural tourism [16]. Table 1 shows the highlights of Lubonja's terrain and peaks.

**Table 1.** Highlights Lubonja's terrain and peaks

| Peak Name | Elevation (m) | Key Description |
|---|---|---|
| Malingelo | 1,766.8 | Part of the mountainous terrain |
| Rungaja | 1,945 | Prominent peak |
| Mali i Zi | 1,703 | Alpine terrain, legends of historical sites |
| Fusha e Shqerrave | 1,900 | Alpine plateau |
| Mali i Stërmollit | 1,500 | Alpine terrain |

By situating the Lubonja project within the broader context of global and regional GIS applications, this study demonstrates the transformative potential of Web GIS in preserving cultural heritage. It contributes meaningfully to the body of knowledge on GIS-driven heritage management and offers a scalable approach for similar initiatives worldwide.

## 3 METHODOLOGY

A systematic and data-driven methodology was employed to develop the Web GIS platform for Lubonja's cultural and natural heritage. This approach combined fieldwork, spatial analysis, geospatial modeling, and web-based visualization to ensure the platform's accuracy, reliability, and usability. Figure 1 illustrates the workflow employed in the platform development, highlighting the integration of data acquisition, geodatabase structuring, cloud-based sharing, and interactive storytelling through ArcGIS Story Maps.

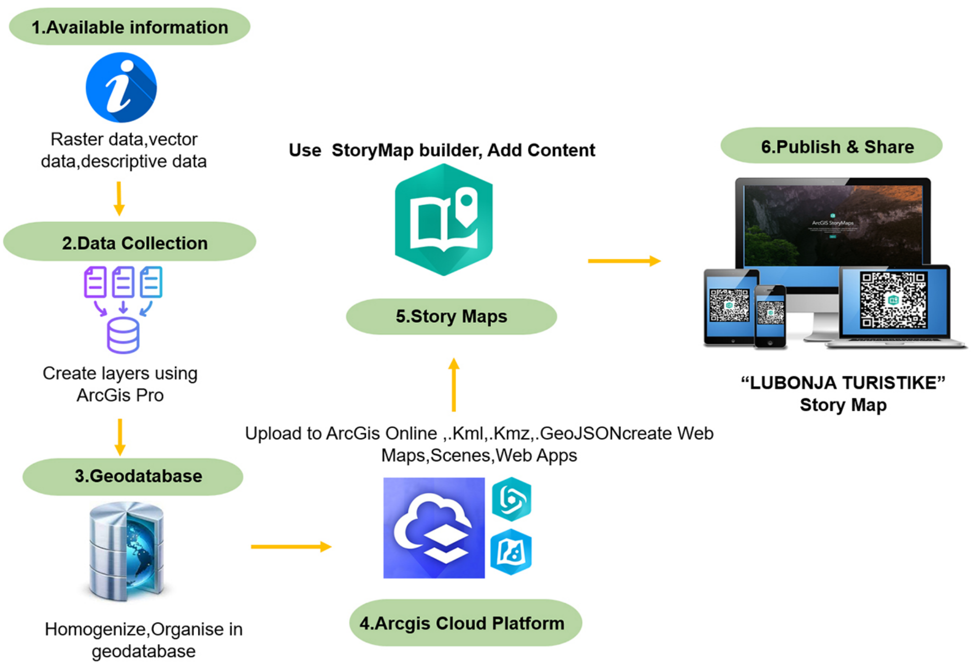


**Fig. 1.** The workflow used in the application

The following steps outline the development process:

a) **Data Acquisition and Field Surveying:** Field surveys were conducted to gather primary data on Lubonja's cultural and natural heritage assets. High-precision GPS devices were used to record coordinates, descriptive metadata, and photographic evidence for each site, ensuring spatial accuracy.
b) **Secondary Data Integration:** Supplementary materials, including historical records, architectural studies, and archived topographic maps, were collected from municipal and archival resource sources. These datasets were standardized and pre-processed to ensure compatibility within the GIS environment.
c) **Data Processing and Homogenization:** All spatial data were converted to the WGS 1984 Web Mercator projection to maintain consistency. Attribute data were categorized by features such as architectural style, historical period, and preservation status. A relational geodatabase was developed in ArcGIS Pro to structure and store both geographical and non-spatial data, supporting complex queries and ensuring data integrity.
d) **3D Visualization of Heritage Sites:** The ArcGIS Pro 3D Analyst extension, detailed digital models of key heritage sites were created to reflect their spatial and structural dimensions. A Digital Elevation Model (DEM) of the region provided topographic context, enabling assessment of accessibility, visibility, and environmental risks. These immersive 3D visualizations enhanced interpretability for both researchers and the public.
e) **Web GIS Development and Story Map Creation:** To increase accessibility and engagement, a narrative Web GIS platform was developed using ArcGIS Online and Story Maps. The platform enables sequential and interactive exploration of Lubonja's heritage, integrating multimedia elements for an engaging user experience.

The result is a seamless and dynamic user interface optimized for both desktop and mobile devices [17]. Navigation tools such as zoom, pan, and rotate were incorporated to facilitate exploration of spatial relationships between cultural features. These tools enrich the user experience and deepen understanding for both general users and domain experts.

An example of using GeoJSON format to express geographic data is presented in Figure 2. The "Castle" layer highlights the flexibility and efficiency of GeoJSON in processing multi-polygonal spatial data for viewing and interaction purposes within ArcGIS Online.


```
{
  "type" : "FeatureCollection",
  "features" : [{"type":"Feature","id":0,"geometry":{"type":"MultiPolygon"
    ,"coordinates":[[[[20.601354606332972,40.450081904848261],[20
    .601406913168418,40.450097335088458],[20.601453571676171,40.450118463353292]
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    .450165458328478],[20.601581018305851,40.450191337051635],[20.60161707092777
    ,40.450212905059317],[20.601667988824463,40.450252156900994],[20
    .601692215303181,40.450269395733081],[20.601739397443502,40.450307680990278]
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    .450364096333104],[20.601814993934564,40.450393241699075],[20
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    .450431622364817],[20.6017927062606,40.45040698457759],[20.601772281470449
    ,40.450379752062076],[20.601749597084098,40.450355084598591],[20
```


**Fig. 2.** Example of the "Castle" layer, in GeoJSON format

The platform currently includes around 100 thematic layers, each visualized based on attributes such as type, historical period, and preservation status. Pop-up windows were configured for each feature, providing detailed information alongside multimedia content (photos, videos, and descriptions). This enhanced user experience and provided a comprehensive understanding of each heritage site.

## 4 IMPLEMENTATION

The implementation phase of the Web GIS platform combined advanced geospatial technologies and user-centric design to create an interactive and informative tool for heritage documentation and promotion [18]. This section details the stages involved in building the platform, including data visualization, interface development, and digital modeling.

### 4.1 Information sharing (Web GIS platform)

Given the extensive information available about Lubonja's village, a Web GIS platform was developed to organize and present thematic knowledge effectively. The platform leverages ArcGIS Story Maps to provide users with an intuitive and interactive experience. The narrative begins with a photograph and an interactive 3D web application powered by ArcGIS. Users can navigate the platform, select bookmarks to focus on specific areas, take measurements, and plan exploration activities. This application also supports local authorities in shaping strategic development initiatives. Figure 3 provides an overview of the 3D application and related contextual information.


**Fig. 3.** The view of the 3D application and accompanying information

As users scroll through the story map, they encounter detailed descriptions of 11 archaeological zones. Each area includes interpretive content, and users are able to search Google Maps for directions. Figure 4 illustrates this narrative approach, highlighting multimedia elements designed to foster user engagement.

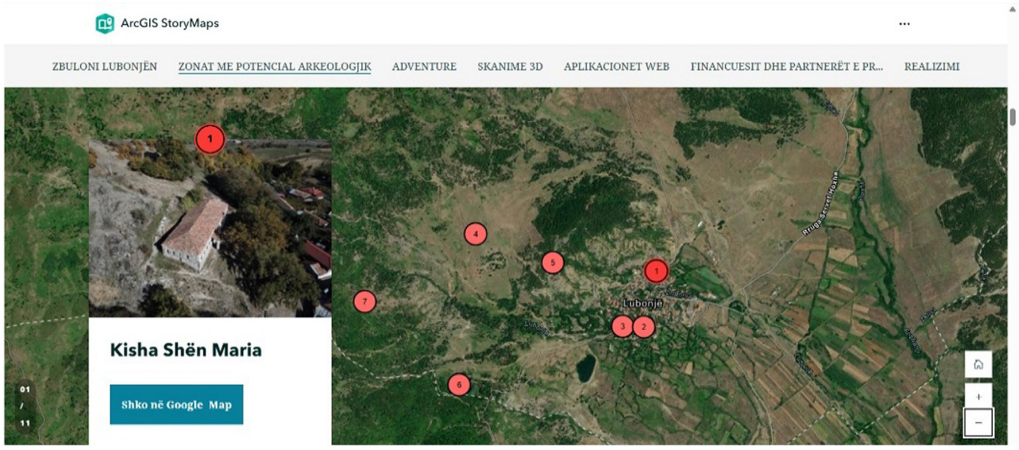


**Fig. 4.** The view of storytelling

In addition to textual descriptions, the platform incorporates video showcasing activities available to visitors, further enhancing interactivity and appeal.

## 4.2 Modeling of historical monuments

Three-dimensional digital modeling plays a vital role in documenting and preserving historical monuments. These models not only capture the present condition of structures but also serve as foundational tools for restoration, conservation, and public awareness initiatives [19]. Techniques such as photogrammetry, laser scanning, and digital visualization were employed in this project, ensuring the accurate and detailed representation of heritage sites. By integrating these technologies, the project supports continuous spatial-temporal monitoring, aiding in the identification of structural vulnerabilities and the planning of preservation strategies [20].

Beyond restoration, 3D modeling also enhances accessibility by allowing users to explore cultural landmarks virtually. These models can be integrated into virtual and augmented reality platforms, providing immersive experiences for both educational purposes and cultural tourism. The ability to simulate heritage sites in high detail encourages broader public appreciation and fosters global interest in preservation efforts [21].

**3D modeling.** Preparatory steps for photogrammetric evaluations included field surveys, detailed imaging, and the processing of three-dimensional models [22]. Two monuments, the Church of "Sleep of Saint Mary" and the Illyrian Prehistoric Castle, were selected for modeling using advanced photogrammetry techniques. The tools employed for data collection included high-precision GPS devices, Total Stations, Drones equipped with high-resolution cameras, Lidar, and Laser scanners. The combination of these technologies ensured accurate spatial data collection and comprehensive documentation [23].

Post-fieldwork, the data were processed using specialized software such as Pix4D, Global Mapper, and Faro Scene to generate high-fidelity textured models. Figure 5 displays the 3D model of the Church of "Sleep of Saint Mary," created using laser scanning via Faro Scene. These models were evaluated for accuracy and integrated into the Web GIS platform, enabling researchers and the public to interact with these digital reconstructions. Additionally, the models serve as benchmarks for assessing future structural changes, ensuring the long-term monitoring of these cultural assets.

Preparatory steps for photogrammetric evaluations included field surveys and the creation of three-dimensional models. Two monuments, the Church of the "Sleep of Saint Mary" and the Illyrian Prehistoric Castle, were modeled using photogrammetry.

The tools used for data collection included GPS, Total Station, drones, Lidar, and laser scanners. Figure 4 displays the 3D model of the Church of "Sleep of Saint Mary" created with a Faro Scene Laser Scanner.

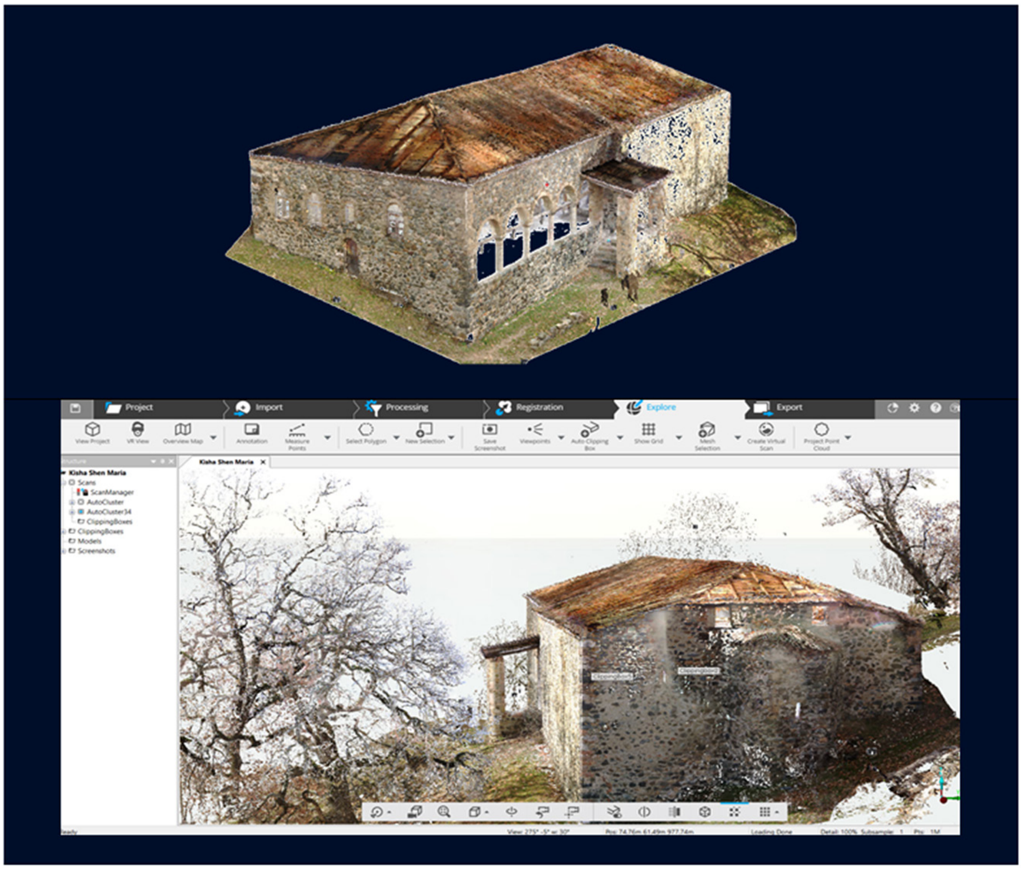


**Fig. 5.** View of 3D buildings, Laser Scanner scanning

**2D maps.** Two-dimensional maps complement the 3D models by introducing the archaeological elements discovered in Lubonja, also possibilities for direct measures and calculations such as distance, area, elevation, profiles, etc., very useful for archaeologists, other scientists, and the public, as presented in Figure 6.

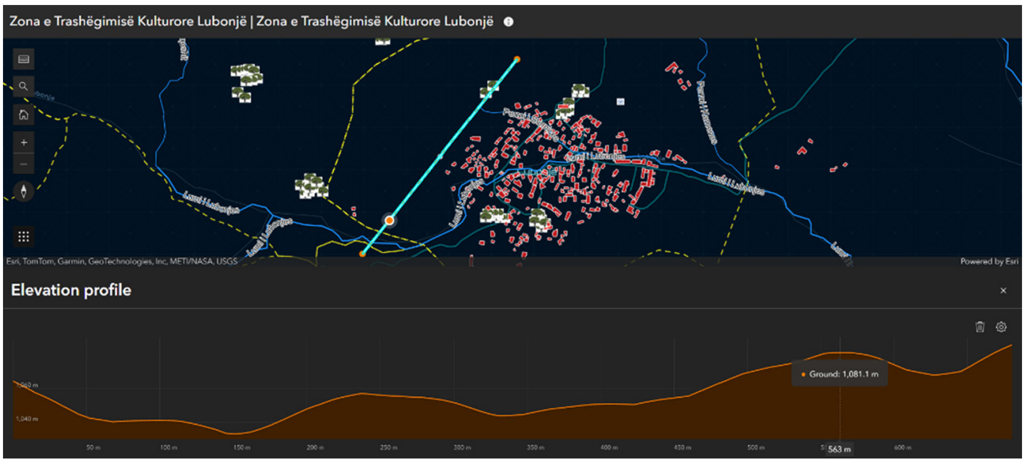


**Fig. 6.** The Web 2D map, which presents the 11 areas with archaeological potential

Each layer is interactive, allowing users to click on elements and to view detailed descriptions and media content. This web map displays the 11 archaeological areas, as well as gives a broader picture of the application's user interface for exploring these features. The project highlights the ability of Web GIS in cultural heritage preservation, enabling tools for visualization, data sharing, and public involvement, paving the path for similar initiatives in other countries.

## 5 DISCUSSION AND EVALUATION

The development of the "Touristic Lubonja" Web GIS platform marks a significant advancement in the digital documentation and promotion of cultural heritage in Albania. Through the integration of cutting-edge technologies such as drones, Lidar, laser scanning, and interactive web mapping, the platform delivers a multidimensional approach to heritage visualization, spatial analysis, and public engagement. Its effectiveness was assessed based on several key criteria: usability, data richness, interactivity, accuracy, accessibility, and impact on heritage promotion. The evaluation criteria are described in Table 2.

**Table 2.** Evaluation criteria

| Criteria | Evaluation |
|---|---|
| **Usability** | The use of ArcGIS Story Maps provided an intuitive and user-friendly interface, allowing users from both academic and non-technical backgrounds to navigate the application easily. Multimedia integration (images, videos, and 3D models) enhanced the storytelling experience. |
| **Data Richness and Accuracy** | The combination of field surveys, high-resolution drone imagery, and laser scanning ensured the generation of accurate and detailed spatial datasets. The use of ArcGIS Pro for 3D modeling and DEM analysis contributed to precise topographic and structural representations. |
| **Interactivity and Engagement** | Interactive maps and pop-up features facilitated user engagement by allowing the public to explore heritage elements dynamically. The mobile compatibility further broadened the platform's accessibility. |
| **Accessibility and public impact** | By being web-based, the platform eliminates physical and geographical access barriers. It has the potential to be integrated into educational curricula, tourism campaigns, and local government planning tools. |

### 5.1 Challenges and limitations

Despite the project's success, several challenges should be considered as presented in Table 3.

**Table 3.** Challenges and limitations

| Challenges | Description | Strategic Recommendation |
|---|---|---|
| **Digital Literacy** [24], [25] | Limited digital skills among local communities may hinder content creation and engagement. Sociotechnical inequalities also limit equitable participation. | Run training workshops; develop local partnerships to build digital capacity. |
| **Infrastructure Dependence** [26], [27] | Continuous internet and server access are essential but may be unreliable in remote areas. | Collaborate with national institutions for infrastructure and hosting support. |
| **Data Maintenance** [28] | The platform's long-term value relies on frequent updates, community input, and consistent digital preservation. | Use standardized metadata and open formats; implement sustainable content workflows. |
| **Scalability & User Validation** [29] | Although designed for a rural context, the platform has potential for broader application. Initial user feedback is promising. | Conduct pilot testing with broader audiences; Refine features based on usability, accessibility, and engagement. |

### 5.2 Comparative study with other implementations

To contextualize the Lubonja platform in a broader context, a comparison with other Web GIS-based heritage projects was conducted, focusing on aspects like scale, technology, community engagement, and innovation. This comparison is presented in Table 4.

**Table 4.** Comparative study with other implementations

| Project | Region | Technologies Used | Scale & Focus | Unique Feature | Comparison to Lubonja App |
|---|---|---|---|---|---|
| **Open-Heritage Eu** [11] | Europe (Multiple Countries) | Web GIS, BIM, Crowd Sourcing | Large-scale, urban heritage | Citizen participation and adaptive reuse | Lubonja's platform is smaller in scale but introduces high-resolution 3D modeling, which is less common in community-driven EU projects. |
| **Angkor Wat Virtual GIS** [13] | Cambodia | 3D GIS, Satellite Imagery, VR | Single major heritage site | Virtual reconstruction and remote exploration | Both projects emphasize 3D visualization, but Lubonja incorporates multi-source spatial data and story mapping tailored to rural contexts. |
| **Palenque 3D Atlas** [16] | Mexico | Cloud-based 3D GIS, Remote Sensing | Archeological focus | Integration with open data and scholarly networks | Lubonja matches in terms of 3D fidelity and scholarly depth but is distinguished by its real-time web accessibility and mobile readiness. |
| **Digital Heritage-scape Albania (Pilot)** | Albania | Basic GIS Mapping | Urban Cultural sites | Geo-tagging and photo integration | Lubonja's project is more advanced, utilizing laser scanning, drone imagery, and Story Maps for a more immersive and analytical platform. |

This comparative analysis highlights that while Lubonja's Web GIS application is localized in scale, it excels in technological integration, data resolution, and platform usability, setting a new standard for digital heritage projects in rural and developing regions.

Additionally, the application could be enhanced in the future by incorporating *augmented reality (AR)* [30], [31] components to offer immersive, on-site educational experiences; *Enabling crowd-sourced* [32] contributions, thus locals and tourists may upload photos, videos, or comments, diversify the database, and enhance real-time updates; *implementing machine learning (ML)* algorithms [33]–[35] and developing predictive models as a powerful tool to identify degradation risks or prioritize conservation efforts based on spatial data patterns. The integration of deep learning techniques [36] and AR [37] in mobile applications, showcase the potential of AI and innovative methods for promoting cultural heritage, aligning with the objectives of our Web GIS application.

## 6 CONCLUSIONS AND RECOMMENDATIONS

The "Touristic Lubonja" Web GIS platform represents a meaningful advancement in the field of cultural heritage management. By integrating Geographic Information Systems (GIS), 3D modeling, and web-based technologies, it provides a comprehensive tool for documentation, preservation, and sharing cultural heritage. The project's scientific contributions include detailed spatial analysis of heritage sites, proactive identification of environmental risks, and the creation of an interactive digital platform for real-time monitoring and educational outreach. These achievements underscore the transformative potential of modern technologies in making cultural heritage more accessible and engaging for diverse audiences.

Looking ahead, several opportunities exist to extend the platform capabilities. A central recommendation is to incorporate crowd-sourced data collection, enabling local community members and visitors to contribute real-time updates, photos, and multimedia content. This participatory approach not only enhances the database but also fosters local engagement and shared responsibility in preservation efforts.

The integration of AR technologies can further enrich user experiences by offering immersive, site-specific educational content that blends physical and digital environments. This would be particularly impactful for younger audiences and cultural tourism. Additionally, incorporating ML algorithms would allow for the analysis of spatial and structural data to predict vulnerabilities and optimize conservation strategies.

Despite its potential, the implementation of Web GIS in cultural heritage preservation also presents challenges. The digital divide remains a barrier, as many rural areas lack the infrastructure and digital literacy necessary to access and contribute to such systems. To overcome this, investments in digital infrastructure and targeted capacity-building initiatives to ensure inclusiveness. Equally important is ensuring the long-term preservation of digital heritage data through standardized formats, sustainable storage solutions, and regular updates. Moreover, enhancing the platform's scalability and interoperability are also essential considerations for future development. Integrating with other national and international heritage systems could enhance collaboration, facilitate data sharing, and amplify its impact.

In conclusion, the benefits of Web GIS significantly outweigh its limitations. As technologies such as AR and AI continue to evolve, they offer new possibilities for improving heritage visualization, analysis, and engagement. The Lubonja project serves as a valuable benchmark for future initiatives, demonstrating how digital tools can support cultural heritage conservation, promote community participation, and make historical knowledge accessible to broader audiences worldwide.

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