Engineering and Technology Journal e-ISSN: 2456-3358

Volume 11 Issue 04 April-2026, Page No.-9615-9629

DOI: 10.47191/etj/v11i04.35, I.F. – 8.595

Development of an Online Cemetery Management Web Application with Integrated Mapping System Using Dijkstra's Algorithm for Path Selection

Monica Maraine G. De Jesus[1], Byron O. Malana[2], John Haeron B. Millena[3], Josiah Emmanuel G. Reyes[4], Eliza B. Ayo[5]

[1,2,3,4,5]School of Science and Technology, Centro Escolar University – Manila, Philippines

ABSTRACT: This study presents the design, development, and evaluation of an Online Cemetery Management System (OCMS) with an integrated mapping module that uses Dijkstra's Algorithm for path selection, implemented at Holy Gardens Memorial Park in Taytay, Rizal, Philippines. Traditional cemetery operations continue to rely on paper-based records, informal reservation channels, and static physical maps, resulting in inefficiencies, data inconsistencies, and navigational difficulties, particularly during peak visitation periods such as *Undas*. To address these challenges, the system integrates Geographic Information Systems (GIS) via Leaflet.js with PostGIS-enabled spatial databases, real-time GPS navigation, augmented-reality wayfinding, and an online burial-plot reservation module within a unified web-based platform. The system was developed using an Agile methodology with a Node.js and Express.js backend, PostgreSQL with PostGIS for spatial data management, and EJS for server-side rendering. Evaluation followed ISO/IEC 25010 quality standards across seven domains: Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, and Portability. Quality assurance testing employed Cypress, Postman, Google Lighthouse, OWASP ZAP, and BrowserStack, yielding scores between 8/10 and 9/10. User evaluation data collected from 63 respondents produced mean scores ranging from 3.66 to 3.90 on a 4-point Likert scale, with all domains rated as Excellent. The findings demonstrate that integrating GIS, algorithmic pathfinding, and web-based administrative tools within a single platform effectively addresses the operational gaps identified in both the literature and existing cemetery management applications. The study contributes to the growing body of research on digital cemetery management by providing an empirically validated, open-source implementation model applicable to resource-constrained cemetery administrations in Southeast Asia and comparable contexts.

KEYWORDS: Cemetery Management System, Geographic Information Systems, Dijkstra's Algorithm, Web-Based Application, Spatial Database, ISO/IEC 25010, Digital Wayfinding, Burial Plot Reservation

INTRODUCTION

Digital solutions are increasingly being developed to address operational inefficiencies across a range of public service sectors, including cemetery management. Conventional cemetery systems depend heavily on manual record-keeping and static physical maps, which frequently lead to misplaced information, delayed retrieval, and difficulty locating burial sites (Sultana et al., 2021; Abdullah et al., 2022). These limitations become especially apparent during peak visitation periods such as *Undas* in the Philippines when large numbers of visitors require fast and accurate navigation. As cemeteries expand over time, the complexity of managing burial plots through paper-based systems grows, underscoring the need for digital alternatives that improve accessibility, accuracy, and organizational efficiency.

Geographic Information Systems (GIS) have contributed substantially to the transformation of spatial data management in cemetery contexts. GIS platforms enable the conversion of traditional cemetery layouts into interactive digital maps capable of representing burial plots, pathways, and sections with geographic precision. By linking burial records to spatial coordinates, cemetery data becomes easier to access, update, and analyze. Studies have demonstrated that GIS-based systems improve land-use planning and optimize spatial organization in cemetery environments (Noor et al., 2023; Crisanto-Perrazo et al., 2022; Pál & Hajdú, 2024). Furthermore, digital mapping allows administrators to monitor plot availability and manage cemetery expansion more effectively, thereby supporting long-term operational planning.

Complementing GIS, Global Positioning System (GPS) technology plays an important role in enhancing navigation within spatially complex environments. GPS-enabled systems allow users to determine their real-time location and receive directional guidance to specific destinations. In cemetery settings, this technology addresses the persistent challenge of locating graves in large, densely populated areas where traditional methods such as verbal directions or physical signage prove inadequate. Research indicates that digital navigation systems improve the user experience by providing accurate and efficient wayfinding (Klingemann et al., 2024; Horbiński & Smaczyński, 2023). Integrating GPS with digital maps enables visitors to follow guided paths directly to burial sites, reducing the time and effort required for grave location.

The adoption of web-based platforms further strengthens cemetery management by enabling remote access to services and information. Through online systems, users can search for burial records, check plot availability, and submit reservation requests without physically visiting the cemetery office. Digital platforms standardize administrative processes, ensuring that transactions are recorded consistently and reducing the likelihood of errors. Studies suggest that web-based systems enhance service delivery by minimizing delays and improving communication between stakeholders (Sultana et al., 2021; Abdullah et al., 2022). This accessibility is particularly beneficial for individuals unable to visit the cemetery in person, contributing to a more user-centered management process.

Despite these technological advances, significant gaps persist in existing cemetery management solutions. The literature reveals limited implementation of real-time navigation with algorithmic pathfinding, insufficient integration between spatial mapping and administrative reservation systems, continued reliance on technically demanding tools that restrict accessibility for smaller institutions, and inadequate attention to data security in platforms handling sensitive personal and burial information (Noor et al., 2023; Klingemann et al., 2024; Allison et al., 2023; Katapally et al., 2024; Wall et al., 2023). Commercial platforms such as PlotBox and CIMS address some of these needs but typically require substantial licensing investments and cloud-dependent architectures that raise data sovereignty concerns (Abdullah et al., 2022; Engel & Rubinstein, 2023). Meanwhile, open-source academic initiatives like OpenAtlas and THANADOS prioritize research applications over operational cemetery management (Aspöck et al., 2023).

This study addresses these gaps through the development and evaluation of an Online Cemetery Management System (OCMS) with an integrated mapping module and Dijkstra's Algorithm-based path selection, implemented at Holy Gardens Memorial Park in Taytay, Rizal, Philippines. The system combines GIS-based spatial mapping via Leaflet.js, real-time GPS navigation with augmented reality guidance, an online burial plot reservation module, and centralized administrative record management within a single web-based platform built on open-source technologies. By leveraging Node.js, PostgreSQL with PostGIS, and standard web APIs, the system is designed to be accessible to resource-constrained cemetery administrations while maintaining the functional depth required for comprehensive cemetery operations.

The system was evaluated using ISO/IEC 25010 quality standards across seven domains Functional Suitability, Performance Efficiency, Compatibility, Usability, Reliability, Security, and Portability through both quality assurance software testing and user evaluation surveys administered to 63 respondents. This dual evaluation approach ensures that the system's technical performance aligns with actual user experiences and needs.

The study contributes to the field of digital cemetery management in several ways. First, it provides an empirically tested implementation of Dijkstra's Algorithm for cemetery-specific pathfinding, an area where existing literature identifies a notable absence of algorithmic approaches. Second, it demonstrates the feasibility of Post GIS integration for Southeast Asian cemetery contexts, addressing a geographic gap in the spatial database literature. Third, it offers a local-deployment model using open-source technologies as an alternative to cloud-dependent commercial solutions, directly responding to infrastructure constraints documented in developing regions (Chibuye & Phiri, 2022). Finally, the comprehensive evaluation framework provides reproducible benchmarks for future cemetery management system research.

LITERATURE REVIEW

2.1 Geospatial Technologies in Cemetery Management

The integration of geospatial technologies has fundamentally reshaped how cemeteries document burial sites, manage land use, and facilitate administrative operations. GIS platforms including ArcGIS, QGIS, and MapInfo have enabled cemetery managers to digitally track available burial plots, conduct spatial assessments, and predict future space requirements (Crisanto-Perrazo et al., 2022; Noor et al., 2023; Długoński et al., 2022; Sarigai et al., 2024). The integration of GIS with centralized database systems has improved the accuracy and accessibility of burial records, facilitating efficient data retrieval and cross-referencing (Saraf et al., 2024).

Methodological innovations have expanded the scalability of these tools. Pál and Hajdú (2024) developed a UAV-based workflow for creating cemetery spatial databases using computer vision to vectorize grave contours, specifically addressing the needs of small communities that lack standardized mapping infrastructure. Remote sensing technologies, including unmanned aerial vehicles and LiDAR-based Digital Terrain Models, provide high-resolution imagery that enhances cemetery mapping and documentation (Pál & Hajdú, 2023; Colleter & Barreau, 2021). Ground-Penetrating Radar has also proven effective in locating unmarked or historical graves without site disturbance, serving both administrative and cultural heritage preservation purposes (Seramur et al., 2023; Wall et al., 2023).

2.2 Web Mapping and Interactive Visualization

Leaflet.js has emerged as a widely adopted open-source JavaScript library for creating interactive web maps in cultural heritage and small-scale spatial documentation contexts. Horbiński and Smaczyński (2023) demonstrated its use in combination with Three.js for documenting cultural heritage objects through integrated attribute records, photographs, and 3D models. The library's lightweight footprint makes it suitable for academic and community projects with limited resources, although performance analyses recommend caution with very large GeoJSON vector datasets, where optimized vector tiling may be required (Balla & Gede, 2025). Sarigai et al. (2024)

developed idwMapper, an interactive framework for visualizing high-dimensional geospatial data, while Horbiński et al. (2021) established design principles for web map effectiveness across responsive graphical user interfaces.

2.3 Artificial Intelligence and Data Management

Artificial intelligence and machine learning have introduced new capabilities in cemetery data management, including automated burial documentation, genealogical research, and predictive analytics (Bai et al., 2023; Lo Duca et al., 2024). Named Entity Recognition and Large Language Models are now employed to extract, categorize, and link burial data, enabling interactive family tree visualization (Lo Duca et al., 2024). Agostini et al. (2024) proposed intelligent cemetery systems integrating IoT, AI, and sustainability principles. Database management frameworks such as CIDOC CRM modeling and platforms like OpenAtlas and THANADOS have improved the organization of historical, spatial, and ownership records (Aspöck et al., 2023), while commercial solutions including PlotBox, Chronicle, CIMS, CemeteryFind, and Cemify offer integrated platforms spanning record-keeping, spatial management, and public access (Abdullah et al., 2022; Engel & Rubinstein, 2023).

2.4 Digital Wayfinding and Cemetery Navigation

The concept of digital wayfinding in cemetery contexts has gained increasing scholarly attention. Klingemann et al. (2024) identified the "journey to the grave" as a distinct user experience requiring thoughtful navigation support, particularly in spatially complex or congested cemeteries. Allison et al. (2024) developed a comprehensive typology of cemetery technologies (CemTech) organized across five themes: Wayfinding, Narrativizing, Presencing, Emplacing, and Repurposing. Häkkilä et al. (2024) explored virtual and augmented reality applications for cemetery heritage sites, highlighting user experience considerations unique to memorial environments. Despite this growing body of work, the literature reveals limited research on comprehensive navigation systems that combine real-time pathfinding algorithms with device orientation APIs for turn-by-turn cemetery directions.

2.5 Web-Based Service Automation and Reservation Systems

Web-based platforms have facilitated the transition from manual to automated cemetery administration, enabling users to search for graves, reserve plots, and access records remotely (Sultana et al., 2021; Klingemann et al., 2024). Interactive mobile applications supporting QR code-based information retrieval have been documented (Teo et al., 2023; Wall et al., 2023), and automated reservation systems have streamlined plot booking by reducing administrative delays (May et al., 2021; Sabir & Noor, 2024). However, reservation functionality in most existing systems represents an ancillary feature rather than a core component addressing informal booking practices through social media and email channels (Sultana et al., 2021).

2.6 Data Security and Privacy Considerations

Data security concerns have intensified as cemetery records increasingly migrate to cloud-based platforms. Multi-factor authentication, encryption, and blockchain technology have been proposed to safeguard digital cemetery databases (Teo et al., 2023; Katapally et al., 2024). Wall et al. (2023) emphasized that historical burial records require protection not only from unauthorized access but also from data loss through inadequate backup procedures. Research predominantly focuses on theoretical security measures rather than practical, deployable architectures, leaving cemetery administrators without comprehensive frameworks that balance protection requirements with implementation feasibility (Katapally et al., 2024; Wall et al., 2023).

2.7 Environmental and Social Dimensions

Cemeteries are increasingly recognized as important components of urban green infrastructure, with documented ecological benefits including carbon sequestration, biodiversity conservation, and urban cooling (McClymont & Sinnett, 2021; Nordh et al., 2022; Säumel et al., 2023). However, tensions persist between advocates for dual-use cemetery parks and those arguing for preservation of burial spaces as sacred sites (Mathijssen, 2025; Klingemann, 2022). Social inclusivity remains a critical gap, as marginalized communities frequently face barriers in accessing burial spaces due to restrictive zoning, financial constraints, and discriminatory land policies (Maddrell et al., 2021; Vargas et al., 2022). Digital platforms, while improving accessibility, risk introducing new forms of exclusion for elderly populations and communities with limited internet access (May et al., 2021; Milewska et al., 2024).

2.8 Identified Gaps

The review of existing literature and similar applications reveals several persistent gaps that the present study seeks to address. First, no published research implements Dijkstra's Algorithm or comparable pathfinding approaches for comprehensive cemetery navigation with turn-by-turn guidance. Second, PostGIS has been primarily utilized in Western contexts, with no published studies addressing its integration for Philippine cemetery management. Third, academic literature lacks empirical performance benchmarks for Leaflet.js at typical cemetery-scale datasets. Fourth, existing systems offer limited integration between spatial mapping, administrative reservation management, and real-time navigation within a single platform. Fifth, cloud-dependent architectures dominate commercial offerings, while limited research examines local deployment models that provide data sovereignty alongside flexible remote access. Finally, notification architecture, analytics dashboard design, and multi-stakeholder role-based interfaces remain underexplored in cemetery-specific contexts. These gaps collectively establish the rationale for the present study's integrated system design and comprehensive evaluation approach.

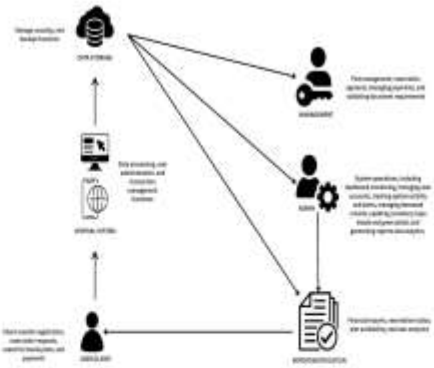

Figure 1. Conceptual Framework

METHODOLOGY

3.1 Research Design

This study employs a descriptive developmental research design to analyze, develop, and evaluate the Online Cemetery Management System. The descriptive component examines existing cemetery management challenges through literature review and stakeholder consultation, while the developmental component focuses on iterative system design, implementation, and testing. Data collection methods include structured questionnaires, user testing sessions, semi-structured interviews, and automated system performance logging. The evaluation framework follows ISO/IEC 25010 quality standards to ensure comprehensive assessment across multiple quality domains.

3.2 Research Approach

A pragmatic mixed-methods approach guides the study, emphasizing practical solutions to real-world cemetery management challenges. Quantitative data were collected through system performance metrics (response time, accuracy, error rates) and Likert-scale survey instruments. Qualitative data were gathered from open-ended questionnaire responses and semi-structured interviews with cemetery administrators. This dual-method approach ensures both technical performance validation and user experience assessment.

3.3 Study Site and Participants

The system was developed and evaluated at Holy Gardens Memorial Park, located in Taytay, Rizal, Philippines (Region IV-A, Southern Tagalog). The site was selected as it represents a mid-sized cemetery facing the operational challenges typical of Philippine memorial parks, including manual record-keeping practices, informal reservation processes conducted through social media, and navigational difficulties during peak visitation periods.

Purposive sampling was employed to select 50 respondents distributed across three stakeholder categories: 10 cemetery administrative staff from Holy Gardens Memorial Park who currently use manual management methods; 5 municipal IT personnel who assessed technical robustness, system integration, and security features; and 35 Centro Escolar University students who served as representative cemetery visitors testing user-facing functionalities. An additional 13 respondents participated during extended evaluation, bringing the total user evaluation sample to 63. This distribution ensured comprehensive assessment from administrative, technical, and end-user perspectives.

3.4 Data Sources

Primary data were gathered directly from the research site. Holy Gardens Memorial Park provided the cemetery floor plan, which served as the reference for identifying plot boundaries, pathways, sections, and landmark locations. Additional primary data were collected through structured questionnaires, user testing sessions, and semi-structured interviews. Secondary data were sourced from peer-reviewed journals, technical documentation, and published studies covering cemetery management systems, GIS, pathfinding algorithms, and web application development.

3.5 System Architecture and Technology Stack

The OCMS architecture comprises four integrated layers. The Web Client Interface (Frontend Layer) provides role-specific dashboards for clients, management, administrators, and owners, with an interactive cemetery map built using Leaflet.js for real-time visualization of plot locations, occupancy status, and section layouts. The API Gateway (Middle Layer) manages authentication, authorization, rate limiting, and request routing between frontend and backend components. The Application Services Layer implements focused microservices for user management, plot management, reservations, payments, notifications, administrative functions, and reporting. The Database Layer utilizes PostgreSQL with PostGIS for spatial data storage, supporting all write operations with optional read replicas for performance optimization.

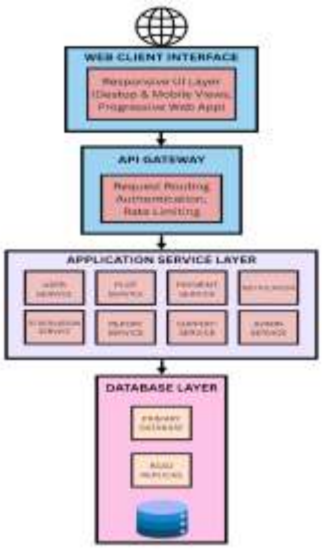

Figure 2. Software Requirements

The technology stack includes Node.js (LTS) with Express.js (v5.1.0) for backend processing; PostgreSQL with PostGIS for spatial database operations; EJS (v3.1.10) with Express EJS Layouts for server-side rendering; Leaflet.js (v1.9.4) with

Leaflet Draw (v1.0.4) and OpenStreetMap tiles for mapping; Dijkstra.js (v1.0.1) for pathfinding with Haversine distance calculations; Chart.js for analytics dashboards; bcrypt, JWT, and express-session for authentication and security; and Nodemailer with Gmail SMTP for automated notifications. Browser APIs (Geolocation, MediaDevices, Canvas, Device Orientation) support GPS tracking, augmented reality navigation, and real-time positioning.

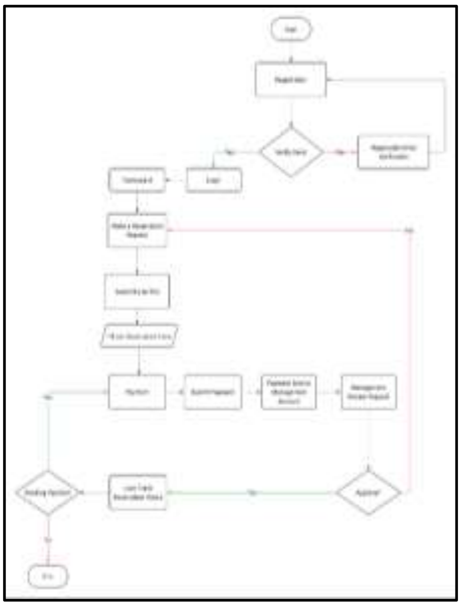

Figure 3. ***User***

Figure 4. ***Admin***

Figure 5. ***Management***

3.6 Development Methodology

Development followed an Agile methodology supporting incremental delivery, continuous stakeholder feedback, and iterative refinement. The process comprised seven phases: Planning (requirements elicitation through stakeholder interviews, data dictionary development, and entity-relationship modeling); Design (UI/UX layout development, system architecture definition, and component interaction planning); Development (feature implementation including mapping, record management, and reservation modules); Testing (functional, integration, usability, security, compatibility, performance, and stress testing); Deployment (local hosting with Ngrok tunneling for secure external access); Review (structured evaluation using predetermined metrics including response time, usability, and user satisfaction); and Launch (formal introduction to target users with post-launch performance monitoring).

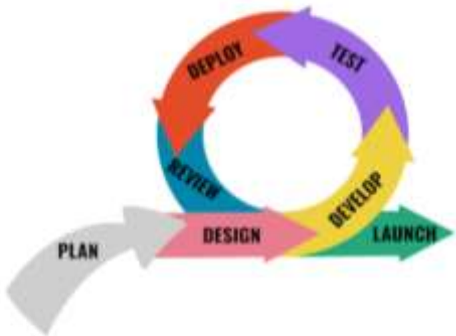

Figure 6. Software Methodology

Dijkstra's Algorithm

```
//Dijkstra's Algorithm Implementation (Road Network Pathfinding)
//Core Functions:
//1. calculateShortestPath(startId, endId)
//Builds a graph from the road network and returns the shortest path between two locations using real geographic distances.

function calculateShortestPath(startId, endId) {
  const graph = {};

  for (const nodeId in roadNetwork.nodes) {
    graph[nodeId] = {};
  }

  roadNetwork.edges.forEach(([a, b]) => {
    const nodeA = roadNetwork.nodes[a];
    const nodeB = roadNetwork.nodes[b];
    const dist = L.latLng(nodeA.lat, nodeA.lng).distanceTo(L.latLng(nodeB.lat, nodeB.lng));
    graph[a][b] = dist;
```

3.7 Evaluation Framework

System evaluation employed a two-tiered approach comprising quality assurance (QA) software testing and user evaluation.

```
    graph[b][a] = dist;
  });

  try {
    return dijkstra.find_path(graph, startId, endId);
  } catch (error) {
    console.error('Pathfinding error:', error);
    return null;
  }
}


//2. Candidate Node Evaluation Loop
//Candidate Node Evaluation Loop Finds the best entry point to the road network by selecting the candidate node with the lowest combined walking and road distance to the destination.

candidateNodes.forEach(candidate => {
  try {
    // Calculate path from this candidate node to destination
    const path = dijkstra.find_path(graph, candidate.nodeId, destinationNodeId);

    if (path && path.length > 0) {
      // Calculate road network distance
      let roadDistance = 0;
      for (let i = 0; i < path.length - 1; i++) {
        const nodeA = roadNetwork.nodes[path[i]];
        const nodeB = roadNetwork.nodes[path[i + 1]];
        roadDistance += L.latLng(nodeA.lat, nodeA.lng).distanceTo(L.latLng(nodeB.lat, nodeB.lng));
      }

      // Total distance = distance from user to node + road network distance
      const totalDistance = candidate.distFromUser + roadDistance;

      if (totalDistance < shortestTotalDistance) {
        shortestTotalDistance = totalDistance;
        bestNode = {
          nodeId: candidate.nodeId,
          coords: candidate.coords,
          distanceFromUser: candidate.distFromUser,
          roadDistance: roadDistance,
          totalDistance: totalDistance
        };
      }
    }
  } catch (error) {
    // Skip nodes where pathfinding fails
    console.warn('⚠ Pathfinding failed for node', candidate.nodeId);
  }
});


//calcPath(startId, endId)
//A simplified version of calculateShortestPath that reads from a local state object and returns the shortest path or null if none is found.

function calcPath(startId, endId) {
  const graph = {};
  for (const id in state.roadNetwork.nodes) {
    graph[id] = {};
  }

  state.roadNetwork.edges.forEach(([a, b]) => {
    const nA = state.roadNetwork.nodes[a];
    const nB = state.roadNetwork.nodes[b];
    if (nA && nB) {
      const d = L.latLng(nA.lat, nA.lng).distanceTo(L.latLng(nB.lat, nB.lng));
      graph[a][b] = d;
      graph[b][a] = d;
    }
  });

  try {
    return dijkstra.find_path(graph, startId, endId);
  } catch (e) {
    console.error('Path error', e);
    return null;
  }
}
```

3.7.1 Quality Assurance Testing

QA testing assessed seven ISO/IEC 25010 domains using established tools: Cypress for end-to-end workflow testing (Functionality, Reliability); Postman for API endpoint testing (Functionality, Security); Google Lighthouse and Chrome DevTools for performance and network analysis (Performance); BrowserStack and Chrome DevTools for cross-browser and responsive design testing (Compatibility); Figma-based heuristic evaluation for interface assessment (Usability); OWASP ZAP for vulnerability scanning (Security); Jest for backend logic validation (Reliability); and Ngrok with multi-environment browser testing (Portability).

3.7.2 User Evaluation

Following testing sessions of 30–45 minutes, participants completed a structured questionnaire organized according to ISO/IEC 25010 quality domains. Each domain included three to five items rated on a 4-point Likert scale (1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent), supplemented by open-ended questions. Semi-structured interviews with cemetery administrators explored management workflows, security concerns, and recommendations. Quantitative data were analyzed using mean scores, standard deviations, and frequency distributions. Qualitative data underwent thematic analysis to identify patterns and improvement areas. Technical log data were cross-referenced with user feedback to validate performance perceptions.

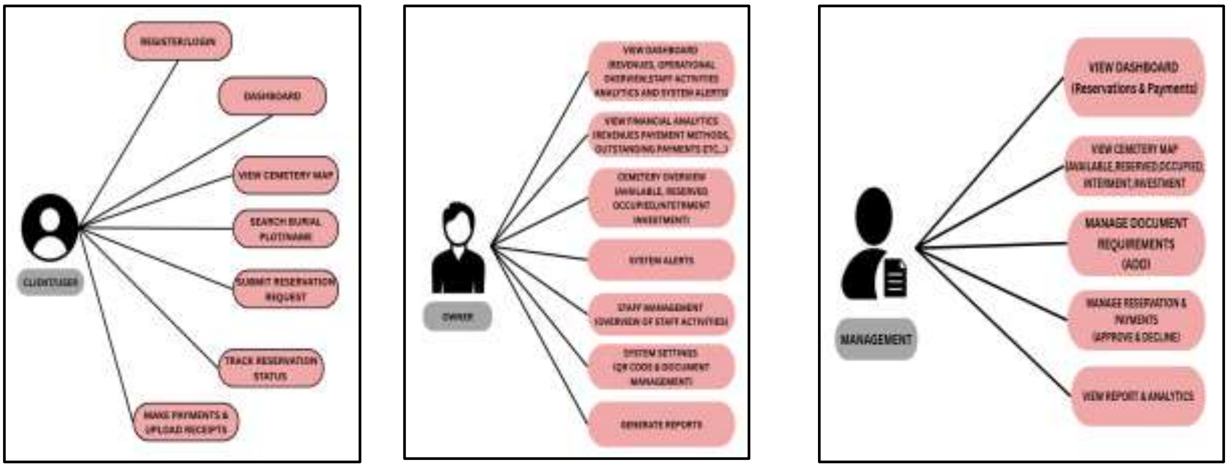

Figure 7. ***Use Cases***

3.8 Statistical Measures

Four primary metrics guided quantitative evaluation. Search accuracy was calculated as the ratio of correct results returned to total queries submitted, expressed as a percentage. System response time measured the average duration for processing standard queries, calculated as the sum of individual response times divided by the total number of queries. The System Usability Scale (SUS) provided a standardized composite usability score derived from participant responses to navigation, accessibility, and system responsiveness items. Standard deviation was computed to assess consistency across search accuracy, directional guidance, and response time measurements, with lower values indicating more stable and predictable system behavior.

3.9 Ethical Considerations

Ethical protocols were observed throughout the study, including obtaining informed consent from all participants, protecting privacy through data anonymization, ensuring voluntary participation, and reporting findings only in aggregate form. The system was developed in compliance with the Data Privacy Act of 2012 (Republic Act No. 10173) of the Philippines, incorporating user authentication, role-based access control, and secure data storage to ensure responsible handling of sensitive burial and personal information.

3.10 Scope and Delimitations

The system was designed specifically for Holy Gardens Memorial Park and does not extend to other cemetery sites. The mapping and pathfinding features are confined to roads and pathways within cemetery boundaries using spatial data provided by cemetery management. While the system detects user location globally through GPS, Dijkstra-based routing operates exclusively within the mapped cemetery infrastructure. The online reservation system includes payment verification and receipt upload functionality, but does not process real-time payments through third-party gateways; users submit proof of payment for manual verification. System accuracy depends on the completeness of records maintained by cemetery management. The system is optimized primarily for mobile devices, so some GPS-dependent navigation features may perform more slowly on non-mobile platforms.

RESULTS

4.1 Identified Gaps in Literature and Similar Applications

The systematic review of existing literature and comparable applications identified five principal gaps that informed the system design. Table 1 summarizes the gaps identified in the scholarly literature, while Table 2 presents limitations found in existing applications.

Table 1: **Gaps Identified in the Literature**

Source	Gap Identified	Citation
Geospatial Technologies for Cemetery Management	Limited implementation of real-time navigation for guiding users within cemetery environments	Noor et al. (2023)

Environmental Indices for Cemetery Location	Lack of integration between spatial systems and reservation/administrative management processes	Crisanto-Perrazo et al. (2022)
Visualization for Collaborative Cemetery Digitization	Absence of efficient pathfinding algorithms to support navigation within mapped systems	Engel & Rubinstein (2023)
UAV-Based Cemetery Spatial Databases	High dependency on advanced technical expertise, limiting accessibility for smaller institutions	Pál & Hajdú (2024)
Geospatial Investigation of African-American Cemetery	Limited emphasis on data security and privacy in handling sensitive cemetery records	Wall et al. (2023)

Table 3. Gaps Identified in Similar Applications

Application	Gap Identified	Citation
CemoMemo	Limited support for real-time navigation and interactive wayfinding	May et al. (2021)
CemTech Typology	Focus on visualization and memorialization rather than functional navigation and administration	Allison et al. (2023)
Genealogical Data-Driven Cemetery Visits	Absence of integrated reservation and user transaction features	Lo Duca et al. (2024)
Web Map GUI Effectiveness	Limited usability for non-technical users due to complex interface design	Horbiński et al. (2021)
DiScO Systems Mapping	Insufficient implementation of structured data security and privacy mechanisms	Katapally et al. (2024)

These findings reveal consistent deficiencies across both research and practice. Most existing systems prioritize geospatial visualization without incorporating real-time navigation with algorithmic pathfinding. Administrative functions such as reservation management remain disconnected from mapping modules. Usability for non-technical users and robust data security mechanisms are frequently overlooked. The OCMS was designed to address each of these gaps through integrated system architecture.

4.2 Quality Assurance Testing Results

Comprehensive QA testing was conducted across all seven ISO/IEC 25010 domains. Tables 3 through 9 present the results for each domain.

Table 4. Functionality Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
Cypress	End-to-end testing of login, map navigation, reservation, payment	9/10	Excellent	All major workflows functioned correctly without critical failures
Postman	API endpoint testing for login, reservations, payments, data retrieval	9/10	Excellent	All API requests returned correct responses with minimal latency

Functionality testing confirmed that all core system features including user authentication, cemetery map navigation, reservation submission, and payment processing operated correctly and consistently. Both end-to-end workflow testing and API endpoint validation returned scores of 9/10, indicating that the system reliably performs its intended functions.

Table 5. Performance Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
Google Lighthouse	Page load speed, performance scoring, responsiveness	9/10	Excellent	Minor delays in map rendering; no significant impact on user experience
Chrome DevTools	Runtime performance and network activity analysis	9/10	Good	Stable performance under normal usage conditions

Performance testing demonstrated stable system behavior under normal usage conditions. Minor delays were observed during map rendering and route computation operations, which is expected given the computational demands of spatial data processing. These delays did not significantly affect the overall user experience.

Table 6. Compatibility Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
BrowserStack	Cross-browser testing (Chrome, Edge, Safari)	8/10	Good	Consistent operation with minor UI differences across browsers
Chrome DevTools	Responsive design across screen sizes	8/10	Good	Layout adapts well across device types

Compatibility testing confirmed that the system operates consistently across multiple browsers and device types. Minor interface variations were observed between browser environments, but these did not impair functionality or usability.

Table 7. Usability Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
Figma (Heuristic Evaluation)	Layout, color consistency, navigation flow, user experience	9/10	Excellent	Intuitive and consistent interface for first-time users
Chrome DevTools	Layout rendering, responsiveness, element behavior	8/10	Good	Minor alignment adjustments needed on smaller screens

Usability evaluation indicated that the system provides an intuitive and navigable interface. Heuristic evaluation rated the design highly for consistency and clarity, though minor alignment refinements were recommended for smaller screen sizes.

Table 8. Reliability Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
Cypress	Repeated end-to-end workflow testing	9/10	Excellent	No failures across multiple test iterations
Jest	Backend logic and data consistency validation	9/10	Excellent	Consistent and accurate results

Reliability testing confirmed consistent system behavior under repeated use. No failures were observed across multiple test cycles, and backend logic produced consistent, accurate outputs throughout validation procedures.

Table 9. Security Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
OWASP ZAP	Vulnerability scanning (XSS, SQL injection)	9/10	Excellent	No major vulnerabilities detected

Postman	Authentication and API security testing	9/10	Excellent	Secure data handling confirmed

Security testing using OWASP ZAP detected no major vulnerabilities, and API security validation confirmed proper authentication enforcement and data protection. The system's security stack comprising bcrypt password hashing, JWT authentication, and CSRF protection performed as intended.

Table 10. Portability Testing Results

Tool	Test Conducted	Score	Interpretation	Remarks
Ngrok	System accessibility across devices and networks	8/10	Good	Accessible across devices during testing
Browser Testing	Multi-environment compatibility	8/10	Good	Minimal configuration required for access

Portability testing demonstrated that the system can be accessed across different devices, operating systems, and network environments with minimal configuration, confirming the viability of the web-based deployment approach.

4.3 User Evaluation Results

User evaluation data were collected from 63 respondents using a 4-point Likert scale. Tables 10 through 16 present the results for each ISO/IEC 25010 quality domain.

Table 11. User Evaluation: Functional Suitability

Criterion	Mean	SD	Interpretation
System features work as intended	3.78	0.41	Excellent
Grave search and mapping provide accurate results	3.86	0.35	Excellent
Tasks can be completed without errors	3.84	0.37	Excellent

Functional suitability received uniformly high ratings (M = 3.78–3.86), confirming that users perceive the system as accurate and reliable in performing grave search, mapping, and task completion functions. Low standard deviations (0.35–0.41) indicate strong consensus among respondents.

Table 12. User Evaluation: Performance Efficiency

Criterion	Mean	SD	Interpretation
System responds quickly during actions	3.72	0.45	Excellent
Pages and features load smoothly	3.66	0.47	Excellent
System remains responsive during continuous use	3.80	0.40	Excellent

Performance efficiency ratings ranged from 3.66 to 3.80, all interpreted as Excellent. The slightly higher standard deviations in this domain (0.40–0.47) suggest that while most users experienced smooth performance, a small subset encountered occasional loading delays, particularly during map-intensive operations.

Table 13. User Evaluation: Compatibility

Criterion	Mean	SD	Interpretation
System works properly on the device used	3.84	0.46	Excellent
Interface displays correctly across screen sizes	3.74	0.44	Excellent
System functions properly in the browser used	3.88	0.32	Excellent

Compatibility received some of the highest ratings in the evaluation (M = 3.74–3.88), with browser functionality scoring 3.88 and the lowest standard deviation (0.32) across all items. No respondents rated any compatibility criterion as Poor or Fair, confirming effective cross-platform operation.

Table 14. User Evaluation: Usability

Criterion	Mean	SD	Interpretation
Instructions and labels are clear and understandable	3.88	0.38	Excellent
Layout and design are user-friendly	3.84	0.42	Excellent
System is easy to navigate	3.84	0.37	Excellent

Usability ratings (M = 3.84–3.88) indicate that users found the interface clear, well-organized, and easy to navigate. Notably, instruction clarity received the highest mean score in this domain, suggesting that the system's labeling and guidance effectively support user task completio

Table 15. User Evaluation: Reliability

Criterion	Mean	SD	Interpretation
System works consistently without crashing	3.72	0.45	Excellent
No errors prevented task completion	3.68	0.47	Excellent
System consistently provides accurate information	3.80	0.40	Excellent

Reliability scores ranged from 3.68 to 3.80, with information accuracy receiving the highest mean in this domain. While all criteria were rated Excellent, the error-free task completion item received the lowest score (3.68), suggesting occasional minor issues that did not prevent successful system use.

Table 16. User Evaluation: Security

Criterion	Mean	SD	Interpretation
Prevents unauthorized viewing of sensitive records	3.68	0.51	Excellent
Prevents unauthorized modification of records	3.72	0.49	Excellent
Prevents anonymous actions without authentication	3.68	0.51	Excellent
Verifies identities through secure login credentials	3.86	0.35	Excellent
Maintains verifiable proof of transactions	3.90	0.30	Excellent

Security evaluation produced mean scores from 3.68 to 3.90, with transaction verifiability receiving the highest rating (3.90) and lowest variability (SD = 0.30) across the entire evaluation. These results demonstrate strong user confidence in the system's ability to protect sensitive data and maintain accountability for all recorded transactions.

Table 17. User Evaluation: Portability

Criterion	Mean	SD	Interpretation
Works well from different locations	3.80	0.40	Excellent
Functions across operating systems without adjustments	3.82	0.38	Excellent
Easily accessible without complex installation	3.84	0.37	Excellent

Portability ratings (M = 3.80–3.84) confirm that the web-based architecture effectively supports access across locations, operating systems, and devices without requiring installation or special configuration. This validates the design decision to implement a browser-based platform over native applications.

DISCUSSION

The results of this study provide empirical support for the effectiveness of integrating GIS, algorithmic pathfinding, and web-based administrative tools within a unified cemetery management platform. The consistently high ratings across all ISO/IEC 25010 quality domainswith mean scores between 3.66 and 3.90indicate that the OCMS meets user expectations and performs reliably in its intended operational context.

The system's implementation of Dijkstra's Algorithm for cemetery-specific navigation addresses a gap explicitly identified in the literature. While Klingemann et al. (2024) discussed wayfinding challenges and Allison et al. (2024) categorized wayfinding as a CemTech theme, neither provided technical implementation details for algorithmic route optimization. The OCMS demonstrates that shortest-path computation, combined with Haversine distance calculations and device orientation APIs, can deliver practical turn-by-turn navigation in cemetery environments. The high functionality scores (9/10 in QA; M = 3.78–3.86 in user evaluation) validate this approach.

The integration of PostGIS for spatial data management in a Philippine cemetery context represents a geographic contribution to the literature. Previous PostGIS implementations in cemetery management have been documented primarily in Western contexts such as Hungary and the United States (Pál & Hajdú, 2024; Wall et al., 2023). The successful deployment at Holy Gardens Memorial Park demonstrates the feasibility of PostGIS-enabled spatial databases for Southeast Asian cemetery operations, where cemetery layouts, cultural practices, and infrastructure conditions differ meaningfully from those in Western contexts.

The web-based architecture using open-source technologies (Node.js, PostgreSQL, Leaflet.js) directly addresses the cost and infrastructure barriers documented in the literature. Długoński et al. (2022) and Amoah et al. (2024) identified financial and technical barriers as persistent obstacles to cemetery digitalization, while Chibuye and Phiri (2022) noted infrastructure constraints in developing regions. The OCMS's local deployment model accessible through standard web browsers on consumer-grade hardware provides an alternative to cloud-dependent commercial solutions that require substantial licensing investments and continuous internet connectivity. The portability scores (8/10 QA; M = 3.80–3.84 user evaluation) confirm that this approach effectively reduces technical barriers to adoption.

Compatibility emerged as a particular strength, reflecting the system's responsive web design. The finding that no respondents rated any compatibility item as Poor or Fair aligns with the design objective of universal browser-based access. This outcome addresses the digital divide concerns raised by May et al. (2021) and supports the argument that web-based architectures can serve diverse user populations more effectively than platform-specific applications requiring installation and updates.

The security evaluation merits attention both for its strengths and limitations. QA testing using OWASP ZAP detected no major vulnerabilities, and user confidence in security measures was high (M = 3.68–3.90). Transaction verifiability received the highest single-item score in the entire evaluation (M = 3.90, SD = 0.30), suggesting that users particularly value the system's capacity to maintain auditable records. These results align with the emphasis placed on security in the cemetery management literature (Katapally et al., 2024; Wall et al., 2023), though the current implementation addresses practical security needs rather than advanced measures such as blockchain-based record protection.

The observation that usability, while rated Excellent, produced the lowest mean among evaluation domains warrants consideration. Although scores remained high (M = 3.84–3.88), this pattern suggests that interface refinement represents the most productive area for system improvement. The qualitative feedback indicated that some first-time users encountered minor difficulties with navigation flow and button placement, consistent with the general finding in the HCI literature that even well-designed systems benefit from iterative usability refinement (Horbiński et al., 2021).

Several limitations should be acknowledged. The study was conducted at a single cemetery site, which constrains the generalizability of findings to cemeteries with different layouts, scales, or management practices. The purposive sampling strategy, while appropriate for the evaluation objectives, does not produce statistically representative results for the broader population of potential cemetery system users. The reliance on Ngrok for deployment introduces temporary URL limitations that differ from production hosting environments. Additionally, the 4-point Likert scale, while sufficient for the evaluation objectives, may have produced ceiling effects given the consistently high ratings, potentially obscuring more nuanced differences in user experience across domains.

The study contributes to the theoretical discourse on digital transformation in cemetery management by demonstrating that geospatial logic, wayfinding theory, web-based service automation, information management principles, human-centered design, and secure digital governance can be operationalized within a single system architecture. The successful integration of these theoretical perspectives into a functioning platform supports the view articulated by Sultana et al. (2021) and Abdullah et al. (2022) that effective cemetery modernization requires unifying navigation, documentation, reservation, and reporting within a coherent management environment.

CONCLUSION

This study developed and evaluated an Online Cemetery Management System with integrated GIS mapping and Dijkstra’s
Algorithm-based path selection for Holy Gardens Memorial Park. The system was assessed through comprehensive quality assurance testing and user evaluation involving 63 respondents across ISO/IEC 25010 quality domains. The findings demonstrate that the OCMS is an effective digital platform that successfully automates cemetery navigation, reduces errors in grave location, provides real-time GPS-guided wayfinding, and streamlines burial plot reservation and administrative processes. The consistently positive evaluation results with all domain means between 3.66 and 3.90 and all interpretations rated Excellent confirm that the system meets its design objectives. The integration of Dijkstra’s Algorithm with GIS-based spatial data provides accurate pathfinding within the cemetery environment, addressing a documented gap in the literature. The PostGIS-enabled spatial database demonstrates feasibility for Southeast Asian cemetery contexts, and the open-source, locally deployable architecture offers a practical alternative to commercial cloud-dependent solutions for resource-constrained cemetery administrations.

Despite strong overall performance, the study identifies areas for continued development. Usability refinement particularly navigation flow optimization and interface element positioning represents the most impactful near-term improvement opportunity. Performance optimization through caching mechanisms and database query refinement would benefit users experiencing occasional loading delays. Enhanced security measures, including multi-factor authentication and end-to-end encryption for payment data, would strengthen data protection for administrative accounts.

Future research should extend system evaluation to multiple cemetery sites with varying scales and management structures to assess generalizability. Longitudinal studies examining sustained adoption patterns and operational impact over extended periods would provide deeper insight into the system’s practical value. Investigation of advanced features such as predictive burial space modeling, multilingual interfaces, and offline navigation capabilities would expand the system’s applicability. Additionally, formal performance benchmarking of Leaflet.js at various cemetery-scale datasets would contribute empirical data to an area where the current literature lacks cemetery-specific optimization research.

The study establishes that modern web technologies, spatial databases, and algorithmic pathfinding can be combined effectively to address the persistent challenges of cemetery management transforming cemeteries from manually administered sites into digitally navigable, administratively efficient, and publicly accessible information environments while maintaining respect for their cultural significance as memorial spaces.

Link for Software Presentation:

REFERENCES

1. Abdullah, S., Hussain, N. H. M., Talib, N., Hashim, I. C., Hashim, H., & Osoman, M. A. (2022). Development of Muslim Graveyard Management System (MGMS) using Geospatial Technology applications. International Journal of Academic Research in Progressive Education and Development, 11(4). https://doi.org/10.6007/ijarped/v11-i4/15035
2. Agostini, A. L. C., Manfroi, C., Pereira, R., Da Costa, E. M., & Santos, N. D. (2024). Cemetery: More Human, Intelligent, and Sustainable. 2024 International Conference on Intelligent Environments (IE), 132–138. https://doi.org/10.1109/ie61493.2024.10599898
3. Allison, F., Nansen, B., Gibbs, M., Arnold, M., Holleran, S., & Kohn, T. (2023). Reimagining memorial spaces through digital technologies: A typology of CemTech. Death Studies, 48(8), 790–800. https://doi.org/10.1080/07481187.2023.2276308
4. Amoah, E. G., Forkuor, D., & Opoku, F. (2024). The last cityscapes: Public cemetery management in Kumasi’s urban terrain. Mortality, 1–20. https://doi.org/10.1080/13576275.2024.2390468
5. Aspöck, E., Eichert, S., Theodoridou, M., Felicetti, A., & Richards, N. (2023). Integrating data on early medieval graves: Mapping the THANADOS database to the ARIADNE infrastructure with the Mortuary Data Application Profile. Internet Archaeology, 64. https://doi.org/10.11141/ia.64.11
6. Bai, N., Ducci, M., Mirzikashvili, R., Nourian, P., & Roders, A. P. (2023). Mapping urban heritage images with social media data and artificial intelligence. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, XLVIII-M-2–2023, 139–146. https://doi.org/10.5194/isprs-archives-xlviii-m-2-2023-139-2023
7. Balla, D., & Gede, M. (2025). Vector data rendering performance analysis of open-source web mapping libraries. ISPRS International Journal of Geo-Information, 14(9), 336. https://doi.org/10.3390/ijgi14090336
8. Chibuye, B., & Phiri, J. (2022). An assessment for record keeping and cemetery management: A case of Lusaka City Council, Zambia based on Technology

Acceptance Model (TAM). Open Journal of Business and Management, 10(2), 577–590. https://doi.org/10.4236/ojbm.2022.102032

9. Colleter, R., & Barreau, J. (2021). 3D reconstruction and geostatic analysis of an early medieval cemetery. Remote Sensing, 13(9), 1688. https://doi.org/10.3390/rs13091688
10. Crisanto-Perrazo, T., Guayasamín-Vergara, J., Mayorga-Llerena, E., Sinde-Gonzalez, I., Vizuete-Freire, D., Toulkeridis, T., Gomez, G. F., & Fierro-Naranjo, G. (2022). Determination of empirical environmental indices for the location of cemeteriesAn innovative proposal for worldwide use. Sustainability, 14(10), 6284. https://doi.org/10.3390/su14106284
11. Da Silva, F. C., De Assis Cavallaro, F., Aquino, W. F., & Tonello, P. S. (2022). Use of geophysical techniques for analysis of trace metals in a cemetery unsaturated soil zone. Geociências, 41(2), 517–525. https://doi.org/10.5016/geociencias.v41i02.16227
12. Długoński, A., Dushkova, D., & Haase, D. (2022). Urban cemeteriesPlaces of multiple diversity and challenges. Land, 11(5), 677. https://doi.org/10.3390/land11050677
13. Długozima, A. (2022). How to find a suitable location for a cemetery? Application of multi-criteria evaluation for identifying potential sites. Moravian Geographical Reports, 30(1), 34–53. https://doi.org/10.2478/mgr-2022-0003
14. Engel, D., & Rubinstein, J. (2023). Drones, phones, and stones: Visualization for collaborative digitization of historic cemeteries. Practice and Experience in Advanced Research Computing, 413–416. https://doi.org/10.1145/3569951.3603633
15. Gonçalves, V., Albuquerque, A., Carvalho, P., Almeida, P., & Cavaleiro, V. (2023). Groundwater vulnerability assessment to cemeteries pollution through GIS-based DRASTIC index. Water, 15(4), 812. https://doi.org/10.3390/w15040812
16. Grabalov, P., & Nordh, H. (2021). The future of urban cemeteries as public spaces: Insights from Oslo and Copenhagen. Planning Theory & Practice, 23(1), 81–98. https://doi.org/10.1080/14649357.2021.1993973
17. Häkkilä, J., et al. (2024). Virtual reality and augmented reality applications for cemetery heritage sites. [Conference proceedings].
18. Horbiński, T., Cybulski, P., & Medyńska-Gulij, B. (2021). Web map effectiveness in the responsive context of the graphical user interface. ISPRS International Journal of Geo-Information, 10(3), 134. https://doi.org/10.3390/ijgi10030134
19. Horbiński, T., & Smaczyński, M. (2023). Interactive thematic map as a means of documenting and visualizing information about cultural heritage objects. ISPRS International Journal of Geo-Information, 12(7), 257. https://doi.org/10.3390/ijgi12070257
20. Katapally, T. R., Elsahli, N., & Bhawra, J. (2024). DiScO: Novel rapid systems mapping to inform digital transformation of health systems. Frontiers in Public Health, 12. https://doi.org/10.3389/fpubh.2024.1441328
21. Klingemann, H. (2022). Cemeteries in transformationA Swiss community conflict study. Urban Forestry & Urban Greening, 76, 127729. https://doi.org/10.1016/j.ufug.2022.127729
22. Klingemann, H., Schmid, J., Umbricht, A., Rota, D., & Hametner, N. (2024). Journey to the grave. Interdisciplinary Journal of Signage and Wayfinding, 8(1), 35–50. https://doi.org/10.15763/issn.2470-9670.2024.v8.i1.a147
23. Larentis, O., et al. (2024). An interdisciplinary analysis of the late Islamic cemeteries within the Cathedral and the ruins of Adulis, Massawa, Eritrea. Heritage, 8(1), 1. https://doi.org/10.3390/heritage8010001
24. Lo Duca, A., Abrate, M., Marchetti, A., & Moretti, M. (2024). Genealogical data-driven visits of historical cemeteries. Informatics, 11(1), 9. https://doi.org/10.3390/informatics11010009
25. Loffreda, G., Chikovani, I., Mocumbi, A. O., Asmar, M. K., Blanco, L. C., Grant, L., & Ager, A. (2023). Informing adaptation strategy through mapping the dynamics linking climate change, health, and other human systems. PLOS Climate, 2(4), e0000184. https://doi.org/10.1371/journal.pclm.0000184
26. Maddrell, A., McNally, D., Beebeejaun, Y., McClymont, K., & Mathijssen, B. (2021). Intersections of (infra)structural violence and cultural inclusion: The geopolitics of minority cemeteries and crematoria provision. Transactions of the Institute of British Geographers, 46(3), 675–688. https://doi.org/10.1111/tran.12437
27. Mathijssen, B. (2025). Mapping nature burial in the Netherlands (2003–2023). Mortality, 1–32. https://doi.org/10.1080/13576275.2025.2449904
28. May, M. J., Kantor, E., & Zror, N. (2021). CemoMemo. Journal on Computing and Cultural Heritage, 14(4), 1–22. https://doi.org/10.1145/3467888
29. McClymont, K., & Sinnett, D. (2021). Planning cemeteries: Their potential contribution to green infrastructure and ecosystem services. Frontiers in Sustainable Cities, 3. https://doi.org/10.3389/frsc.2021.789925
30. Milewska, A., Kacprzak, M., Wielewska, I., Dabrowski, P., & Chrzaszcz, A. (2024). The specificity and costs of public services in cemetery maintenance:

A case study of Bydgoszcz City. European Research Studies Journal, XXVII(2), 101–117. https://doi.org/10.35808/ersj/3373

31. Noor, N. B. M., Sabir, N. S. K., Ibrahim, I. B., & Azhari, A. W. B. (2023). Geospatial technologies approach for cemetery management solutions: A review. Jurnal Planologi, 20(2), 105. https://doi.org/10.30659/jpsa.v20i2.30226
32. Nordh, H., Olafsson, A. S., Kajosaari, A., Præstholm, S., Liu, Y., Rossi, S., & Gentin, S. (2022). Similar spaces, different usage: A comparative study on how residents in the capitals of Finland and Denmark use cemeteries as recreational landscapes. Urban Forestry & Urban Greening, 73, 127598. https://doi.org/10.1016/j.ufug.2022.127598
33. Ocón, D., & Young, W. P. (2024). Bridging the nature–cultural heritage gap: Evaluating sustainable entanglements through cemeteries in urban Asia. Sustainability Science, 19(5), 1641–1660. https://doi.org/10.1007/s11625-024-01533-2
34. Oyeleke, O. O., & Oloukoi, G. (2024). Sustainability practices in urban cemetery management. Path of Science, 10(4), 4001–4007. https://doi.org/10.22178/pos.103-5
35. Pál, M., & Hajdú, E. (2023). Setting standards for cemetery spatial databasesA case study. Abstracts of the ICA, 6, 1–2. https://doi.org/10.5194/ica-abs-6-195-2023
36. Pál, M., & Hajdú, E. (2024). Methodological innovations for establishing cemetery spatial databasesA UAV-based workflow helping small communities. ISPRS International Journal of Geo-Information, 13(2), 57. https://doi.org/10.3390/ijgi13020057
37. Sabir, N. S. K., & Noor, N. M. (2024). Object-oriented classification approach (OBIA) in extracting burial plot for Muslim cemeteries management. IOP Conference Series: Earth and Environmental Science, 1412(1), 012017. https://doi.org/10.1088/1755-1315/1412/1/012017
38. Sallay, Á., Tar, I. G., Mikházi, Z., Takács, K., Furlan, C., & Krippner, U. (2023). The role of urban cemeteries in ecosystem services and habitat protection. Plants, 12(6), 1269. https://doi.org/10.3390/plants12061269
39. Saraf, M. H. M., Ridzuan, N. I., & Mustaffa, M. F. (2024). The use of geospatial information system for an enhanced property valuation process. Journal of Computing Research and Innovation, 9(2). https://doi.org/10.24191/jcrinn.v9i2.457
40. Sarigai, S., Yang, L., Slack, K., Lane, K. M. D., Buenemann, M., Wu, Q., Woodhull, G., & Driscol, J. (2024). idwMapper: An interactive and data-driven web mapping framework for visualizing and sensing high-dimensional geospatial (big) data. arXiv. https://doi.org/10.48550/arxiv.2402.11001
41. Säumel, I., Butenschön, S., & Kreibig, N. (2023). Gardens of life: Multifunctional and ecosystem services of urban cemeteries in Central Europe and beyond. Frontiers in Environmental Science, 10. https://doi.org/10.3389/fenvs.2022.1077565
42. Seramur, K. C., Campbell, K. B., Anderson, J. B., & Cowan, E. A. (2023). On Cemetery Hill: The legacy of burials at Clemson University. Archaeological Prospection. https://doi.org/10.1002/arp.1916
43. Spera, S. A., Franklin, M. S., Zizzamia, E. A., & Smith, R. K. (2022). Recovering a Black cemetery: Automated mapping of hidden gravesites using an SUAV and GIS. International Journal of Historical Archaeology, 26(4), 1110–1131. https://doi.org/10.1007/s10761-021-00642-3
44. Sultana, M., Khandaker, N., Anannya, T. T., & Islam, M. N. (2021). Requirements elicitation and development of a graveyard management system in the context of Bangladesh. 2021 International Conference on Science & Contemporary Technologies (ICSCT), 1–6. https://doi.org/10.1109/icsct53883.2021.9642654
45. Teo, C., Wang, X., Tan, S. C., & Lee, J. W. Y. (2023). Enhancing critical thinking in operations management education. Higher Education Pedagogies, 8(1). https://doi.org/10.1080/23752696.2023.2216388
46. Vargas, T. M., Uribe, C. L., Bedoya, S. V., Zapata, M. L. Q., & Cardona-Gallo, S. A. (2022). Cemetery relocations in Hidroituango: An interdisciplinary study. Anais Da Academia Brasileira De Ciências, 94(1). https://doi.org/10.1590/0001-3765202220201098
47. Wall, J., Bohnenstiehl, D. R., Levine, N. S., Millhauser, J. K., McGill, D. E., Wegmann, K. W., & Melomo, V. (2023). A geospatial and archaeological investigation of an African–American cemetery in Raleigh, North Carolina, USA. Archaeological Prospection. https://doi.org/10.1002/arp.1921