

Article

Developing a Crowdsourcing Digital Repository for Natural and Cultural Heritage Preservation and Promotion: A Report on the Experience in Zakynthos Island (Greece)

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Abstract: The present study discusses the design and development of a digital repository for the preservation and dissemination of the cultural and natural heritage of Zakynthos Island (Greece). Following a crowdsourcing approach, the platform allows users to actively contribute to its content while aiming to integrate scattered information from other relative initiatives. The platform is based on a popular Content Management System (CMS) to provide the core functionality, extended with the use of the CMS's API to provide additional, personalized functionality for end-users, such as organizing content into thematic routes. The system also features a web application, mainly targeting users visiting the island of Zakynthos, and is developed exclusively with open web technologies and JavaScript frameworks. The web application is an alternative, map-centered, mobile-optimized front-end for the platform's content featured in the CMS. A RESTful API is also provided, allowing integration with third-party systems and web applications, thereby expanding the repository's reach and capabilities. Content delivery is personalized, based on users' profiles, location, and preferences, enhancing engagement and usability. By integrating these features, the repository effectively preserves and makes accessible the unique cultural and natural heritage of Zakynthos to both local and global audiences.



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Keywords: cultural heritage; natural heritage; biodiversity; content management systems; multimedia digital repositories; web applications; crowdsourcing

1. Introduction

Amid the ever-increasing efforts to promote environmental awareness and preserve cultural heritage and biodiversity, online digital repositories and portals play an increasingly vital role in safeguarding both the cultural heritage and the biodiversity of local communities by registering them and introducing them to a global audience. By incorporating historical narratives, traditional knowledge, ecological data, and information on local species, such repositories can significantly contribute to the preservation of cultural distinctiveness and enhance environmental consciousness. Furthermore, they can support research and educational activities, as well as public campaigns aimed at increasing environmental accountability and cultural appreciation.

In this work, we developed a platform, available online [1,2], that aims to provide useful knowledge, in the form of a repository/portal, regarding the culture and nature of the island of Zakynthos, Greece.

Zakynthos is well known for its Venetian architecture, which reflects its historical ties to Venice. Venetian architecture can be identified in bridges, churches, and houses. The cultural heritage of the island also involves several intangible cultural elements, such as theatre, music, poems, along with a vast collection of paintings and murals that can be found in several museums and churches on the island. The unique landscape, with monumental olive trees, enhances not only the natural but also the cultural heritage of Zakynthos. Some of the olive trees date from more than 2000 years ago. The natural heritage of the island also includes beautiful coastal and marine ecosystems with unique biodiversity, such as the Loggerhead sea turtle.

Modern digital repositories can support heterogeneous types of content, such as historical sources, photographic material, maps, and lists of species, thereby forming a comprehensive representation of the local biodiversity and culture. They also provide advanced search capabilities with multiple criteria and intuitive front ends, allowing users to effectively explore and retrieve relevant information within large-scale collections [3].

Many repositories incorporate interactivity and virtual community tools such as community forums, rating and feedback mechanisms, and educational resources, thereby promoting collaboration and the exchange of knowledge among stakeholders [4]. They also integrate geospatial tools and mapping technologies, enabling the visualization of cultural landmarks, biodiversity hotspots, and conservation areas, thereby enhancing the understanding and appreciation of local ecosystems and traditional sites, while assisting visitors in identifying nearby points of interest [3].

Online archives usually adhere to open access principles or provide Application Programming Interfaces (APIs), allowing for the free exchange and reuse of cultural and biodiversity data among different information systems, thereby promoting transparency, collaboration, and innovation in research and conservation efforts. Effective cultural repositories, additionally utilize standardized metadata schemas like Dublin Core, METS, and EAD, which facilitate interoperability and data exchange between systems [5]. The CIDOC Conceptual Reference Model (CRM) is also significant in structuring complex cultural heritage information [6].

Online archives, as repositories of cultural and natural heritage, provide several benefits. They preserve cultural artifacts, oral histories, and indigenous knowledge, preserving them for future generations and promoting cultural continuity and resilience [7,8].

By documenting species distributions, habitat characteristics, and ecological trends, online archives contribute to the conservation and management of local biodiversity, supporting informed decision-making and conservation planning [9].

Archives also serve as valuable educational resources for schools, universities, and community organizations, raising awareness regarding the importance of cultural heritage and ecological conservation among diverse audiences. Researchers and practitioners can access a wealth of data to support scientific studies, conservation projects, and policy development initiatives, driving innovation and evidence-based decision-making [7].

Finally, online archives can engage and motivate local communities to actively participate in the documentation, management, and promotion of their cultural and natural heritage, promoting a sense of ownership and pride in their heritage and environment [10].

Despite the significant role and advantages described above that online digital repositories can offer, the deployment of such a custom information system from scratch requires considerable development effort and cost. Modern Content Management Systems (CMS) can provide a cost-effective alternative.

Having evolved from simple static content tools to dynamic platforms, CMS now offer robust management of metadata, expendability by custom plugins and Application Programming Interfaces (APIs), and scalable cloud integration to handle diverse content—from

text and historical documents to multimedia and geospatial data. These features enable rapid development with built-in search capabilities, adaptable user and programming interfaces, and solid security and user management mechanisms. Overall, modern CMS can provide significant benefits in terms of cost efficiency, scalability, community support, interoperability, and usability, making them ideal platforms for preserving and sharing cultural, historical, and ecological data globally.

Additionally, the integration of community and crowdsourcing features, such as discussion forums, commenting, rating and feedback mechanisms, can significantly enhance the value of a digital repository and ensure the quality and relevance of the included material. Such functionality encourages users to actively participate, promoting the sharing of knowledge, experiences, and perspectives, and enriching the repository's content.

Crowdsourcing techniques enhance the collection of diverse content and can help to create a comprehensive, accurate, and up-to-date archive, reflecting the evolving nature of heritage. User contributions, including multimedia material, storytelling, and ecological observations, provide valuable content that otherwise would be inaccessible and unregistered, making the repository a dynamic and evolving resource for education and preservation.

Thematic routes are structured routes connecting related content based on specific themes such as historical periods, cultural traditions, or natural ecosystems. They can provide a guided tour through relevant artifacts, documents, and multimedia content, providing enhanced understanding and contextualized storytelling. Integrating thematic routes into a digital repository improves accessibility, engagement, and learning, encouraging both casual visitors and researchers to explore the repository's content more deeply, getting meaningful insights into cultural and natural heritage.

The preservation and dissemination of cultural and natural heritage in the digital era require robust, scalable, and cost-effective solutions. This research aims to develop a modern digital repository that integrates essential contemporary features and functionality, while minimizing development and maintenance costs. By leveraging the capabilities of modern Content Management Systems (CMS), the proposed repository will provide an efficient, scalable framework with built-in security, metadata management, advanced searching functionality, and seamless interoperability with external systems.

To enhance user experience and engagement, the proposed repository incorporates thematic routes, offering structured and curated content navigation based on historical, cultural, or ecological themes. Additionally, a personalization mechanism is integrated, enabling users to tailor their interactions based on personal preferences and interests, ensuring a more intuitive and meaningful exploration of the repository's content.

Another key aspect of this research is to enhance sustainability by integrating crowdsourcing techniques, allowing users to contribute valuable content such as historical narratives, personal accounts, images, and ecological observations. Features such as community forums, rating and feedback mechanisms, and participatory annotation will facilitate knowledge exchange, ensuring continuous enrichment and validation of the repository's content.

By combining the efficiency of modern CMS, user-centric design through thematic routes and personalization, and the participatory potential of crowdsourcing, this research seeks to create a sustainable and engaging digital repository that effectively preserves, shares, and enhances cultural and natural heritage on a global scale.

2. Related Work

Creating a repository/portal for the culture and nature of Zakynthos is based on combining the optimal practices related to both cultural and environmental repositories. Emphasizing interoperability, user-centered design, and community involvement will

ensure the repository is comprehensive, accessible, and sustainable. Integrating cultural and environmental data will provide a richer, more holistic understanding of Zakynthos's heritage, supporting both academic research and public engagement. Some recent studies and articles on digital cultural and environmental repositories are as follows.

At a central level, several recommendations and policies have been issued, and initiatives have been undertaken by the European Union, regarding the digitization of the cultural and natural heritage, aiming to preserve, disseminate, and provide broader accessibility to Europe's rich cultural assets through the use of digital means and state of the art technologies.

The "Recommendation on the digitization and online accessibility of cultural material and digital preservation" (2011/711/EU) [11] focuses on the need to digitize cultural assets, ensuring their online accessibility and long-term preservation, emphasizing the importance of partnerships among private and public stakeholders and suggesting the use of "Europeana" [12] (an EU featured cultural repository) as a digital archive. The European Commission has also set some rather ambitious goals, encouraging member states to digitize all monuments and sites at risk by 2030, and half of the most visited monuments and sites. This initiative is part of a broader "Digital Decade" strategy, aiming to advance Europe's digital transformation by 2030. Artificial intelligence, data analytics, and extended reality (xR) are some of the suggested cutting-edge technologies to enhance both the digitization process and end users' experience [13].

The importance of digitizing cultural and natural heritage has driven the allocation of funds to numerous related initiatives and projects. Two noteworthy ones include Europeana [12] and The Horizon 2020 Programme [14]. The first is a digital platform providing access to millions of cultural assets (e-books, music, artworks, etc.) from European museums, galleries, libraries, and repositories, aiming to create a common data space for cultural heritage, facilitating the sharing and re-use of digitized images and 3D models across Europe. The latter is a research and innovation program framework, financing several projects on the use of digital technologies in cultural heritage.

The increasing importance and funding of heritage digitization has also resulted in rich scientific research activity in the field. The review paper of Zibani et al. [15] explores the state-of-the-art digital repositories managing cultural and environmental content and highlights the importance of digital repositories in preserving and promoting cultural and environmental heritage by offering advanced features that support the management, discovery, and reuse of diverse content types.

"Cultural Heritage Repositories: Digital Archives for Culture and Natural Heritage", by Marta Severo and Alonzo Addison [16], using the UNESCO World Heritage portal as a case study, provides a comprehensive overview of the creation and management processes of digital cultural heritage repositories. It also outlines best practices for planning, designing, and deploying digital archives, emphasizing the importance of standardized approaches and sustainable practices. The study of Ndegwa et al. [17] also emphasizes the importance of organizational preparedness and financial sustainability in digital preservation, which is resource-intensive, requiring significant investment in infrastructure, staffing, and technology monitoring.

Content Management Systems (CMS) can help in the standardization and sustainability of such efforts. Gradually, they have become integral frameworks suitable for developing online digital repositories, offering streamlined content administration, enhanced accessibility, and improved collaboration. "The Role of Content Management Systems in Developing Library Websites" by Patnaik et al. [18], discusses how CMS platforms facilitate easy content administration, enabling librarians and staff to update website materials, add new resources, and adjust layouts without extensive technical expertise.

They also analyze various collaboration models and the use of Web CMS to develop online communities, emphasizing CMS's role in enhancing information dissemination in library settings.

"Utilizing Institutional Repositories and Content Management Systems for Information Preservation and Dissemination: A Focus on D-Space and Drupal" by Bharathkumar [19] provides an overview of digital repositories, discussing their definition, purpose, and the role of CMS in managing, preserving, and disseminating various types of digital content efficiently.

These studies underscore the pivotal role of CMS as a foundational framework in the development and management of online digital repositories across various sectors.

Another important aspect of the present study is the incorporation of crowdsourcing techniques and virtual communities as a means to ensure content contribution and diversity, thus enhancing the sustainability of the digital repository. In this direction, the work by Zhang and Dong [20] provides theoretical insights and practical guidance for optimizing crowdsourcing mechanisms contributing to the broader goals of sustainable cultural heritage preservation and digital humanities development. "Digital Cultural Heritage and Social Sustainability" by Li Liew C. and Chowdhury G. [21] demonstrates how engaging communities in the curation and management of digital heritage strengthens the sense of ownership and relevance, enhancing the social sustainability of digital repositories by ensuring they meet the needs and expectations of their user base. Factors like equity, cultural sensitivity, and literacy are highlighted as vital for achieving sustainability in digital cultural heritage services.

Enhanced user engagement, as another pivotal factor for the sustainability of digital repositories, is also investigated in the present study through the incorporation and integration in the developed system of two strategies: user personalization mechanisms and content organization into thematic routes.

"Digital Topics on Cultural Heritage Investigated", a research paper by Münster et al. [22], identifies current trends and technologies in digital cultural heritage and highlights the prominence of machine learning and extended reality (including virtual, augmented, and mixed reality). It emphasizes the potential of these technologies to transform how cultural heritage is preserved and experienced.

Sodiya et al., in their study "AI-driven personalization in web content delivery: A comparative study of user engagement in the USA and the UK" [23], focus on user engagement in the USA and UK, demonstrating that AI-driven personalization strategies increase metrics such as time spent on site and click-through rates, underscoring the potential of AI to enhance user engagement, by aligning content delivery with user preferences.

The study "Pathways to Discovery: Supporting Exploration and Information Use in Cultural Heritage Collections", by Goodale et al. [24], showcases how the "PATHS" project developed an interface that supports information exploration and discovery through thematic pathways in cultural heritage collections, allowing users to navigate the collections in a manner that aligns with their interests, enhancing engagement and satisfaction.

"Advanced systems and technologies for the enhancement of user experience in cultural spaces: an overview", by Capece et al. [25], provides an overview of the evolution of user experience (UX) applied to personalized enjoyment of cultural places, emphasizing the role of advanced technologies in creating thematic routes that adjust to individual preferences.

The above papers, among many others in the field, collectively illustrate the rapidly evolving landscape of digital cultural and natural heritage preservation, showcasing innovative technologies and methodologies aimed at enhancing accessibility, conservation, and public engagement in heritage management.

On a local level, efforts to create digital archives of cultural and natural heritage, have been gaining momentum in recent years on the island of Zakynthos. The efforts are largely driven by governmental and EU initiatives and local organizations, usually in collaboration with academic institutions.

The development of a digital portal for the cultural and natural heritage of Zakynthos is crucial to consolidate and amplify the diverse local digitization efforts currently in place. Various governmental bodies, local organizations, and academic institutions are actively involved in preserving and showcasing the island's rich heritage, but these efforts remain fragmented and dispersed. A centralized digital portal would serve as a "single entry point", integrating these scattered initiatives into cohesive and accessible resources.

Additionally, it would promote collaboration among stakeholders and public engagement by providing the means for residents and visitors to contribute and explore Zakynthos's heritage through digital experiences. The portal would also benefit education and research activities, offering valuable resources to scholars and educators worldwide.

To conclude, the proposed system is essential for unifying and enhancing the impact of local initiatives, preserving local heritage, and making it widely accessible and appreciated. Being based on open standards and architectures, it can also serve as a prototype for similar initiatives everywhere.

3. Requirements, Design, and Architecture

3.1. Objectives

The main objective is the establishment of an online multimedia digital repository, highlighting the cultural and natural heritage of Zakynthos Island, with the potential to be expanded to other topics and thematic areas. The design incorporates both well-established and cutting-edge technologies, such as Content Management Systems (CMSs), multimedia databases, digital repositories, web development architectures and tools, and modern presentation paradigms, such as Augmented Reality (AR). The primary objectives of the initiative also include:

- **Robust Back-End Infrastructure**

The platform will feature, at the core of its back end, a CMS, integrating a multimedia digital repository along with semantic and classification information [26]. The CMS will also provide content reviewing, approval, and management workflow, along with user management, profiling, personalization, and feedback mechanisms. Users will thus be able to contribute multimedia-rich content, along with classification, semantic, and geospatial metadata, which, once reviewed and approved by the platform's field experts, will be published. All of the platform's content and functionality will be exposed via a RESTful API, enabling third-party applications and systems to leverage its resources.

- **Interactive Web Application**

A mobile-friendly, responsive web application will be developed as an additional/alternative front-end to the one provided by the CMS for users to access the platform's content. It will be particularly useful to on-site visitors, providing location-based information by utilizing geolocation services provided by modern mobile computing devices. The presentation of the information will be map/location-based, featuring modern presentation paradigms such as augmented reality. In order to enhance the user experience and personalization, the web application will organize the content into predesigned thematic routes, allowing users to focus on featured content that better suits their specific interests, such as cultural landmarks, biodiversity hotspots, or historical sites, creating personalized journeys and enriching the on-site exploration. Additionally, the application will gather user-centric metrics to provide

valuable insights into user interactions and preferences and improve the platform's overall functionality and personalization mechanisms.

- **Enhanced User Engagement**
The platform will incorporate interactive user rating, feedback, and digital social features to encourage users' active participation, content contribution, and valuable feedback. By utilizing crowdsourcing techniques, users can contribute their own content, share personal experiences and knowledge, and provide valuable insight, enriching the digital repository. This collaborative approach not only enhances the depth and breadth of the content but also fosters a sense of community among users, something invaluable for the platform's sustainability. These features aim to provide a deeper understanding and appreciation of Zakynthos Island's cultural and ecological significance.
- **Centralizing Information**
One of the main targets is to gather and consolidate the wealth of cultural and ecological information, currently scattered across different sources, initiatives, and institutions, into a unified, central repository. By doing so, the platform seeks to bridge gaps between fragmented data, ensuring accessibility and consistency in the information presentation. Users, researchers, and stakeholders will be able to explore, analyze, and utilize the island's rich cultural and natural heritage more effectively while promoting collaboration among contributors from different disciplines.

Overall, the platform aspires to establish a versatile and comprehensive repository that not only showcases the unique attributes of Zakynthos but also facilitates expansion to other regions. By promoting a deeper connection between visitors and the regional cultural and ecological heritage, it offers a valuable tool for engagement and education.

3.2. System Requirements

The main system requirements of the proposed platform are:

- **Web-Based User Interface**
All of the platform's functionality and content, provided both by the front end of the Content Management System and the Web Application, should be fully accessible by modern web browsers. Additionally, the user interface should adhere to the principles of responsive design, ensuring compatibility with a wide range of popular computing devices, desktop or mobile ones. The User Interface should be intuitive and aligned with modern web design standards, providing a seamless experience across all major operating systems and devices. Accessibility features will be incorporated, especially on the front-end provided by the CMS, in order to achieve at least the minimum expectations of today's standards and level of inclusivity.
- **Modular Design Utilizing Open-Source Technologies**
The system should follow modular and open design architecture by adopting popular and proven open-source tools, frameworks, and web standards. This approach is expected to significantly reduce operational and ownership costs, a vital factor for the platform's sustainability while boosting its flexibility and scalability. By adhering to an open-source approach, the platform is expected to benefit from future community-driven innovations, improvements, and security updates. The platform's content contributors will have access to a collection of robust tools for managing and publishing content, while administrators and supervisors will have intuitive control panels to oversee platform and content administration operations and user engagement. Finally, end users will enjoy an engaging interface, with features like search tools and feedback options.

- **Support for State-of-the-Art Multimedia Content**
The system should be capable of maintaining and presenting diverse multimedia content, including both legacy and modern advanced formats. These include high-resolution images, streaming videos, 360° panoramic images and videos, 3D content, and maps, providing a media-rich, interactive, and immersive experience to end users. Integrated map-based information, along with geolocation services, will provide geographical context, enhancing users' understanding of spatial aspects. The extensive multimedia support will appeal to a variety of users' needs and is expected to be especially valuable for educational, virtual tourism, cultural, and ecological applications. Advanced presentation techniques such as Augmented Reality (AR) can further enhance the overall user experience by overlaying digital content on the user's physical environment, offering on-site visitors an immersive and enhanced experience.
- **User Profiling and Mechanisms**
Users will have the ability to provide feedback, contribute their own content, and evaluate (e.g., content rating and commenting) the available information. Additionally, the system should collect and analyze user behavior and preferences (e.g., articles read, focused content categories, physical visiting of places of interest featured on the platform) in order to gain insight into their engagement patterns. These data can be leveraged by stakeholders to inform decision-making and enhance efforts in cultural preservation and biodiversity conservation. Additionally, they can be used to provide user-tailored suggestions for relative content, allowing them to follow a logical progression of information, and facilitating deeper exploration of a subject without the need to manually search for related content. Through these features, users actively contribute to the platform's mission of safeguarding and promoting cultural and ecological heritage, making them key participants in its ongoing success.
- **Thematic routes mechanism**
Will allow administrators to organize articles with relevant content into thematic routes, especially targeting on-site visitors, using the web application to explore the island's cultural and natural wealth. These guided thematic tours will provide personalized learning journeys, encouraging visitors to engage with the platform's topics that align with their personal interests or informational needs, significantly boosting user satisfaction and retention. The platform's web application will be based on these thematic routes in order to provide, along with digital map and geolocation services, a more focused and guided access to the platform's content.

3.3. System Architecture and Usage Scenarios

Based on the objectives and system requirements described above, the resulting architecture of the proposed system is illustrated in Figure 1, along with the primary usage scenarios.

3.3.1. Content Management System

At the core of its back end, the system relies on a CMS to facilitate all the user and content management functionality, as well as provide the main front end of the system. Contributors can use the CMS's built-in editor to upload content on the system, providing the essential metadata for its classification and geolocation. Once administrators/field experts approve the content, it is incorporated into the digital repository and published.

The CMS will provide the core functionality of the digital repository, specifically:

- Content creation, editing, reviewing, and publishing workflow.
- Content storage, organization, classification, and retrieval.

- User management and permissions, supporting multiple user roles with specific permissions for secure and efficient collaboration.
- Design and layout of the system's main website with custom themes and templates.
- SEO and metadata management for search engine discovery and supporting semantic/metadata information.
- Version control and backup, allowing for content revisions and reverting to previous versions.
- Integration with third-party software and extension plugins to add new functionalities and support interoperability (e.g., social media and analytics tools).

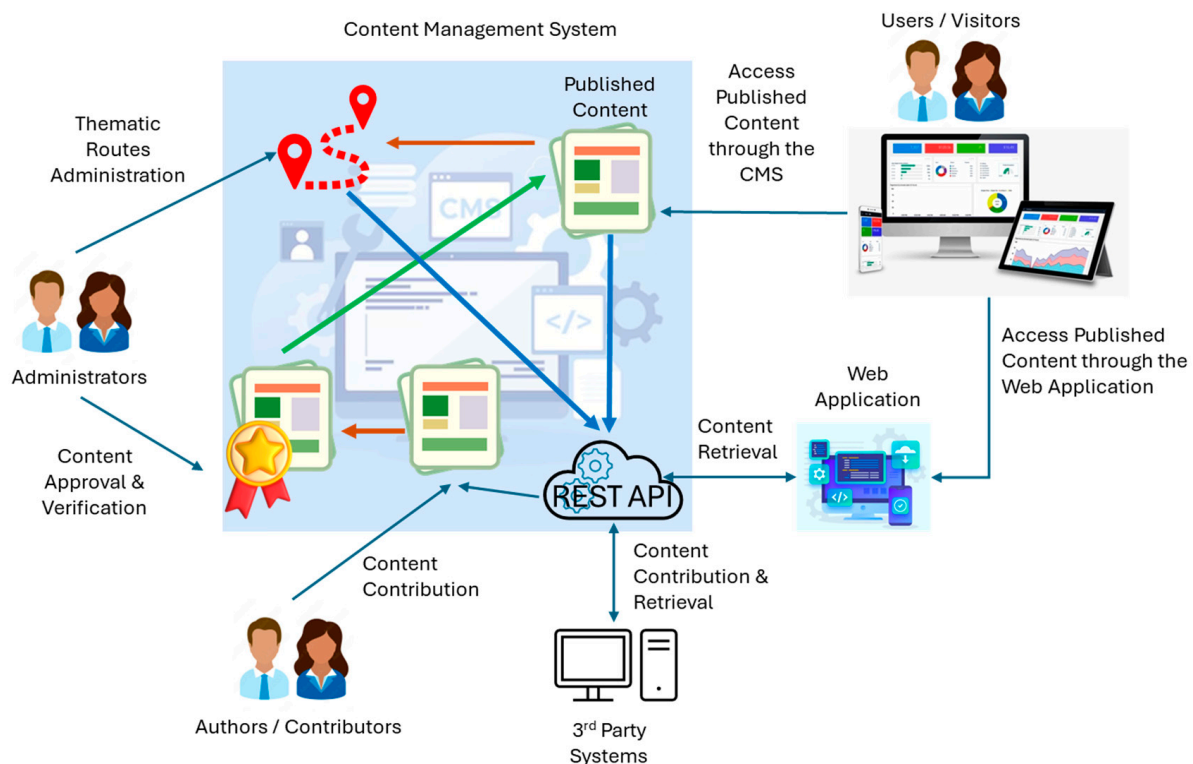


Figure 1. System architecture and components.

3.3.2. Thematic Routes Administration

Using an intuitive interface provided by the thematic routes administration module, the system's administrators will be able to easily define and maintain thematic routes by combining thematically related published articles. Users, especially on-site visitors, can follow the defined routes, enjoying personalized learning journeys through Zakynthos's cultural and natural heritage.

Each route will be accompanied by essential metadata provided by the administrators. Geolocation metadata integrated into the repository's articles will be utilized to present the points of interest in a map-centered way, allowing users to benefit from the navigational services integrated into their mobile computing devices, such as smartphones or tablets.

3.3.3. Web Application

A web application featuring a responsive, mobile-friendly user interface will offer an alternative (to the one provided by the CMS) front-end for accessing the digital repository's content. It will be largely based on the thematic routes subsystem in order to display the content in a responsive and intuitive way, optimized for mobile devices.

By combining map-based presentation, geolocation technologies, and advanced presentation paradigms, such as augmented reality, largely supported by modern mobile devices, it aims to enhance the experience of on-site visitors.

3.3.4. RESTful API

The RESTful API will expose the system's functionalities and content to third-party systems and custom applications [27]. This will enable other digital repositories and websites to seamlessly feature and integrate the platform's content. Additionally, it allows for the development of third-party web applications that can serve as alternative front ends for accessing and interacting with the repository's content, the one provided by the system being one of them.

4. Implementation

In this section, we will discuss the implementation of the system's back-end infrastructure, which provides most of the system's functionality, as well as the implementation of the web application as an alternative, map-based, mobile-friendly, front end to the system's content.

4.1. Implementation of the System's Back-End Services

The back-end infrastructure is built around the WordPress (version 6) CMS [28], a highly versatile, scalable, and user-friendly CMS suitable for a wide range of websites and web applications. The main reasons behind the choice of WordPress as the foundation for the system implementation are the essential features that align with the system's requirements, including:

- Intuitive administration environment and flexibility to accommodate a wide range of needs.
- Extensive library of themes to customize the front-end appearance and plugins to extend the core functionalities and features.
- Search Engine Optimization (SEO) features and plugins.
- Strong community support from users, developers, and designers, with regular updates to improve security, provide new features, and ensure compatibility with the latest web standards.
- Scalability and extensibility: being suitable for anything from a simple blog to a full-fledged e-commerce site. The provided native PHP API and web REST API allow for accessing the provided functionality and content from custom web applications.
- Responsive design supporting all modern computing devices.
- Robust content authoring workflow and user management features.

The modules of the back-end infrastructure are depicted in Figure 2. Each module implements part of the system's functionality, namely:

Multimedia Content Database/Digital Repository: Manages the system's content (mainly articles) and the multimedia repository. All the functionality is inherently provided by the CMS.

User and Content Management: The CMS provides all the functionality required for user management (registration, authorization, management, profiles, roles, and permissions), as well as content management (authoring, editing, metadata classification, reviewing, and approval for publishing by content supervisors/experts).

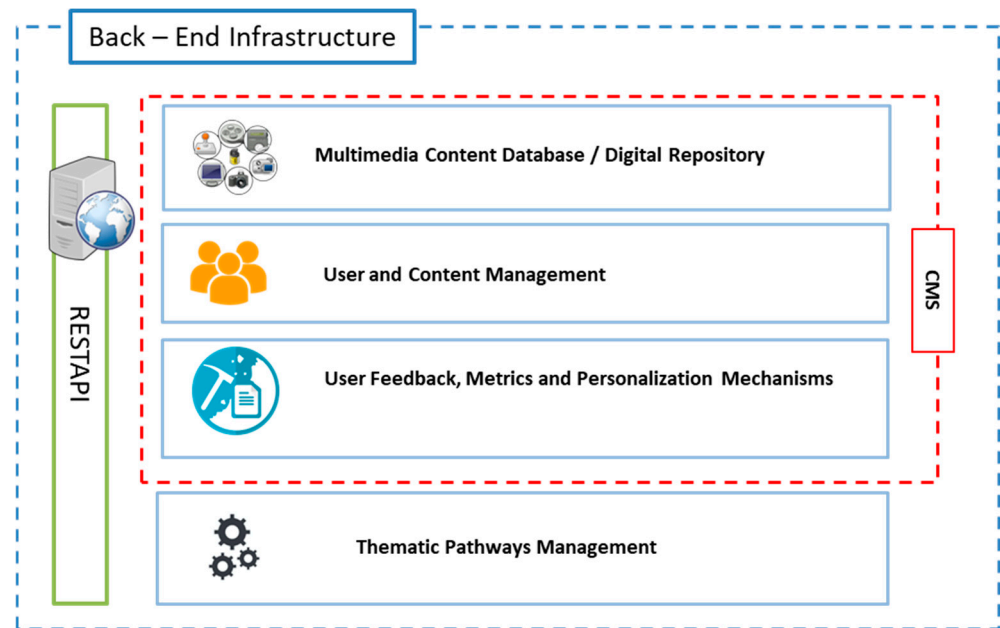


Figure 2. Back-end infrastructure modules.

User Feedback, Metrics, and Personalization: End users can rate the articles they read and provide feedback for improvement. This functionality was added with the WordPress plugin “Rate My Post” by FeedbackWP (V. 4.3.1) [29]. Additionally, the system keeps track of the articles a user has read (and the categories in which they are classified by their authors), in order to provide relevant/suggested articles, as well as relevant thematic routes on the web application. This functionality was implemented with the development of a custom WordPress plugin, written in PHP programming language in combination with the WordPress provided PHP functions [30] and the REST API [31].

Platform Front-End: The “ZON” Theme (V 1.0.6) [32] by THEMEDREESIA was installed to provide an appealing and intuitive “magazine-like” look and feel for the main platform front end. The homepage is split into thematic areas, highlighting important content categories and subcategories.

Thematic Routes Management: By using this custom administration application, content managers and administrators of the system can define new and edit existing thematic routes (e.g., museums of the city). For each defined route, the system maintains:

- Essential information and metadata (duration, distance, thematic categories, optimal seasons, a small description, etc.)
- A list of points of interest, for which the platform features detailed articles, which form the thematic route.

Once the thematic routes are defined, they become accessible to end users via the platform’s web application.

This module was developed as a custom web application, integrated with the CMS, written in PHP programming language, and utilizing the API provided by WordPress.

4.2. Implementation of the Web Application

In addition to the main front end of the system, which typically is provided by the underlying CMS, a web application was implemented to serve as an alternative, map-centered, front end to the system, better suited to on-site visitors accessing the system with mobile devices. The web application utilizes the REST API to exchange data with the back-end services and access the functionalities provided by each back-end module.

The web application highlights thematic routes and activities curated by the system's content managers. Users can explore these featured routes and identify those that best align with their preferences. Upon selecting a route, the application displays relevant information and offers the option to view the featured points of interest on a map. For each point of interest, the application provides basic details along with a link to access the full related article featured on the platform's CMS. Thematic routes ranked by the platform as most relevant to the user's profile are specially marked as recommended.

The mobile application was developed as a web-based, responsive application, relying solely on web technologies, notably HTML5, CSS, and JavaScript. JavaScript frameworks were used to provide the basis and essential functionality to build upon, during the development of the various modules (Figure 3). In the following, we describe briefly the utilized components:

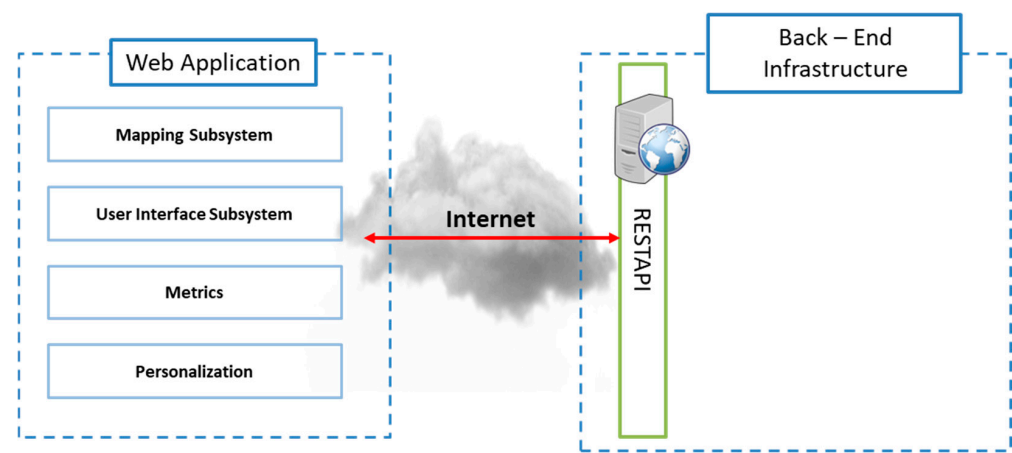


Figure 3. Web application modules.

Mapping Subsystem: Handles the map-based presentation of the points of interest involved in a selected thematic route, along with the user's current position given by the mobile device's geolocation sensors. It was implemented with LeafletJS (V. 1.9.4) [33] and OpenStreetMap [34] mapping service. LeafletJS provides a JavaScript programming interface for the development of interactive maps, while OpenStreetMap provides open-source GIS/mapping services.

User Interface Subsystem: The OnsenUI (V2.0) [35] JavaScript framework was used for the implementation of the user interface of the web application. OnsenUI provides a JavaScript framework for the development of web and hybrid mobile applications, with the look and feel of native Android and iOS mobile apps.

Metrics Subsystem: Implemented in JavaScript, this subsystem regularly tracks the user's location using the geolocation services of their mobile device and sends important metrics to the system's back end via a REST API. These metrics help the system maintain statistics, such as the number of physical visits to points of interest highlighted by the system. Furthermore, when the user is located close to a featured point of interest, the system triggers the display of related content from the digital repository.

Personalization Subsystem: In order to provide an adequate level of personalization, the web application rates the thematic routes according to the user's interests as those are registered by the user metrics integrated into the system.

Whenever a registered user reads an article on the platform, it is added to the maintained user metadata, in order to gradually build a personal profile of interests. Additionally, whenever a new thematic route is defined, the related content categories are assigned to it by the creators. The personalization subsystem combines these metadata to calculate

two (2) suggestion ratings for each featured thematic route according to the user's profile and interests (Figure 4):

- A rating indicating the matching of the categories of the articles the user has been reading on the platform with the thematic route's categories.
- A rating indicating the percentage of the points of interest featured in the route that the user has shown interest in by reading their corresponding articles on the platform's website in the past.

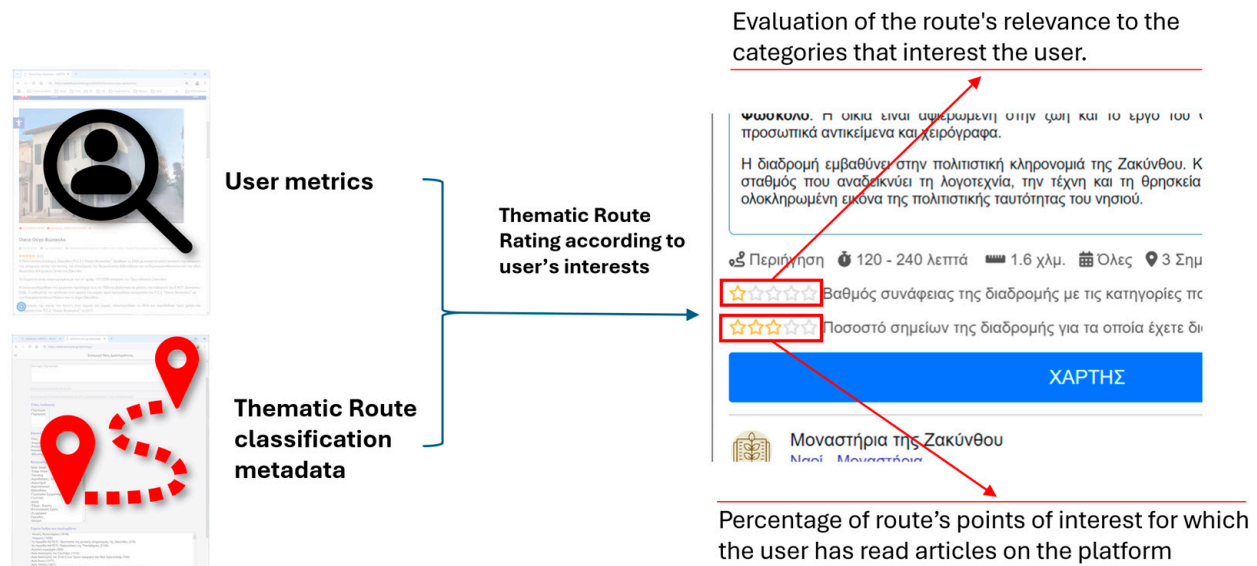


Figure 4. Personalization Subsystem.

5. Evaluation

The evaluation assessment of the previously presented web portal focuses on a three-fold perspective, including its functionality, performance, and user experience, based on real-life data obtained from e-questionnaires. The particular study highlighted critical findings, as well as some recommendations for improvement, with the ultimate goal of providing improved service experience to the general public.

The evaluation of the ANTETI website's functionality was conducted through a structured experiment involving real users to assess usability, navigation, content quality, loading speed, and aesthetics. Key performance indicators (KPIs) such as navigation time, user satisfaction, and task success rates were measured. A representative sample of users was selected based on demographics and familiarity with technology. Participants completed specific tasks like searching for information and downloading documents, while analytical tools tracked interactions and completion times. Statistical and qualitative analysis provided insights into website performance. Real-time user support was offered, and procedures ensured data accuracy, particularly for entries related to Zakynthos' physical and cultural environment. This methodology enabled a comprehensive and reliable evaluation of the ANTETI platform.

It is worth mentioning that compared to think-aloud protocols (where users verbally express their thoughts while navigating the site), e-questionnaires were less intrusive and required fewer resources, making them more practical for a larger study. While think-aloud protocols provide rich qualitative insights, they often suffer from observer bias and demand significant time for analysis.

Regarding the usability evaluation of the ANTETI website, two primary measurement tools were used, the Likert scale and the System Usability Scale (SUS) test. The Likert

scale was employed for a wide range of questions related to user experience, allowing participants to express their level of agreement or satisfaction on a five-point scale (e.g., from “Strongly Disagree” to “Strongly Agree” or from “Very Unsatisfied” to “Very Satisfied”). This method was chosen due to its effectiveness in capturing gradual variations in user perceptions, providing a structured yet flexible way to measure opinions on navigation ease, content quality, aesthetics, and performance.

Additionally, the SUS test was utilized as a standardized usability assessment tool. The SUS consists of ten statements, each rated on a five-point Likert scale, to evaluate overall usability and ease of use. It provides a single score out of 100, which is widely recognized in usability studies. The SUS was chosen because of its simplicity, reliability, and comparability with industry benchmarks, allowing a more standardized interpretation of the website’s usability performance.

Furthermore, e-questionnaires were selected as the primary data collection method for several reasons, particularly efficiency, accessibility, and scalability. Unlike traditional in-person usability studies, which require scheduling participants and observing their behavior in real time, e-questionnaires allow users to provide feedback remotely, at their own pace, and from any location. This enabled a larger and more diverse sample, reducing geographic and time-related constraints.

5.1. Experiment Design

For the design of the experiment evaluating the functionality of the ANTETI website of Ionian University, the following steps were followed. The experiment needed to be well-structured to gather measurable and useful qualitative data that would contribute to the overall evaluation of user experience, functionality, and effectiveness of the website.

To ensure the systematic and reliable collection of data from the evaluation experiment of the ANTETI website of Ionian University, a framework was designed based on scientific methods and analytical techniques. The aim of the design was to identify the strengths and weaknesses of the website so that specific improvement proposals can be made based on objective measurements and observations from user experience.

The entire process was designed in a clear and detailed manner, allowing for easy replication of steps and accurate recording of results. The following steps provide guidelines for the preparation, execution, and analysis of the data collected from the participants in the experiment, representing different user categories of the platform.

5.2. Participants

The study participants represented a diverse range of ages, internet proficiency levels, and connections to the website’s subject matter. Age groups ranged from 18–24 to 55+, reflecting broad interest, while internet expertise varied from basic to professional, reflecting a mix of beginners and advanced users. Some participants were Ionian University students, academics, or researchers, while others had no specific affiliation, suggesting the website attracts both academic and general audiences. Overall, the participant profile highlights the website’s wide appeal across different demographics and user backgrounds.

5.3. Evaluation Tool

The questionnaire used in the evaluation was structured into several sections, covering key aspects of user experience. It began with demographic questions, including age and internet proficiency, followed by users’ relationship with the website’s subject matter. The next sections assessed navigation ease, usability, and the ability to locate information efficiently. Users then evaluated loading speed and reported technical issues, providing insights into the website’s performance. Content quality, clarity, and relevance were also examined, alongside aesthetics and design, to determine their impact on functionality. Finally,

overall satisfaction and feedback were gathered, allowing users to suggest improvements. This comprehensive structure ensured a thorough evaluation of the website's strengths and weaknesses.

5.4. Data Collection Process

The questionnaire (Appendix A) was distributed electronically via email and platforms connected to the website, targeting various user groups, including students, researchers, and the general public. Invitations were sent to both frequent and new visitors to ensure a diverse sample, allowing for a comprehensive evaluation of user experiences across different audience segments.

Responses were collected through an online platform that stored data in a Microsoft Excel table, ensuring secure connections and easy analysis. The data were centrally stored and categorized by question and user, maintaining accuracy and accessibility for evaluation. These methods facilitated efficient data collection, protected user information, and contributed to reliable insights into the website's performance.

5.5. Question Categories

The evaluation of the ANTETI website included various question categories to assess user experience and satisfaction. The questionnaire collected demographic data, such as age group, internet proficiency, and users' relationship with the website's subject matter. It also evaluated website usability by measuring ease of navigation, information retrieval, and satisfaction with its structure and organization.

Additionally, the questionnaire examined performance aspects, including page loading speed and technical issues encountered. Content quality was assessed in terms of clarity, relevance, and the role of design in functionality. Finally, users provided feedback on overall satisfaction, the likelihood of recommending the website, and suggestions for improvement, such as adding a blog. These insights highlighted key areas for enhancement to improve the website's user experience.

5.6. Sampling and Demographics

The evaluation sample for the ANTETI website included a diverse range of users, providing a comprehensive understanding of their experiences. Responses varied in terms of usability, with some users finding navigation smooth while others faced challenges. Most participants had a positive experience regarding performance, but some reported technical difficulties. Opinions on content quality also differed, with varying views on clarity and usefulness. Overall satisfaction levels were mixed, with some users highly satisfied and others expressing concerns and suggesting improvements.

Demographically, the largest group of participants was aged 18–24, followed by an equal representation of users in the 35–44, 45–54, and 55+ age groups. The 25–34 age group had fewer participants, but all age categories were included, ensuring a balanced and inclusive evaluation sample.

5.7. Evaluation Results

According to the conducted evaluation results, there seem to be mixed opinions about the ease of navigation on the website. As shown in Figure 5a, a significant number of users marked navigation as "difficult" or "very difficult", while others found it less difficult, thus highlighting opportunities to further improve the design and structure of the platform's website.

Page loading time was another technical priority from the construction point of view. The data analysis depicted in Figure 5b revealed that, while the majority of users expressed significant satisfaction, there is also an opportunity to enhance the technical aspects of the

platform to address occasional delays and further elevate the overall browsing experience for all users.

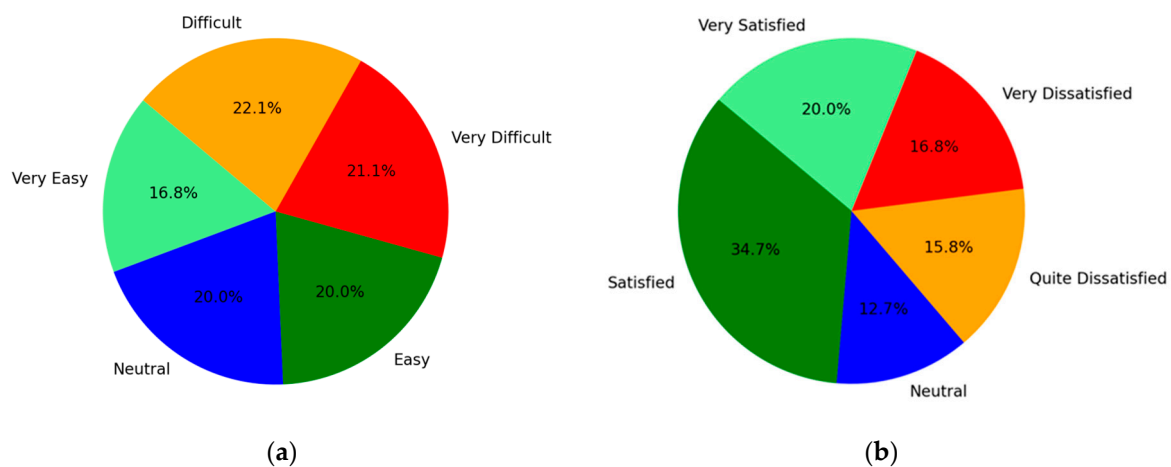


Figure 5. (a) Ease of browsing the website; (b) Page loading speed satisfaction.

Analysis of content clarity is also another significant evaluation aspect, as Figure 6a indicates. Most users find the content “clear” or “very clear”, but there is a minority for whom the information is rather not clear. This observation highlights an opportunity to refine and tailor the content to better accommodate the diverse needs and familiarity levels of all end-users.

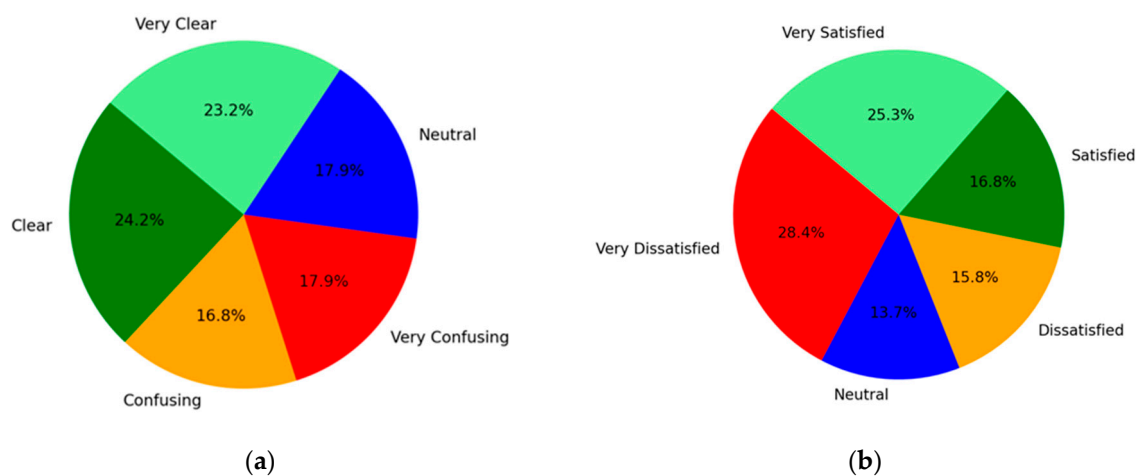


Figure 6. (a) The clarity of the content of the website; (b) Overall satisfaction level with the website's usability.

As far as the overall satisfaction level with the platform's usability is concerned, Figure 6b offers an overall picture of the perceptions of real-life end users. Although some users reported being “very satisfied”, a significant percentage expressed “dissatisfaction”, suggesting that certain issues are negatively impacting the overall user experience. On the other hand, the intention to recommend the platform shows mixed patterns, with some users responding with “maybe”, thus reflecting a positive yet cautious outlook. The latter indicates that while the website has strengths that resonate with a portion of users, there are areas requiring improvement to address the concerns of those who are dissatisfied. The cautious responses regarding recommendations may stem from users recognizing potential but feeling hesitant due to existing shortcomings that hinder a consistently positive experience.

The aforementioned results were implemented by integrating both quantitative and qualitative methods. To ensure the validity and reliability of the collected data, descriptive statistics and t-tests for SUS Score Comparison were applied. The initial method provided an overview of user satisfaction and usability perceptions, while the latter was employed to determine if usability perceptions varied significantly based on user experience, by comparing usability scores across different user groups.

The overall assessment indicates that the website has successfully appealed to a wide-ranging audience, encompassing researchers, students, and the general public. However, there is potential for improvement in areas such as navigation, content clarity, and technical performance to more effectively address the varied needs of its users. By implementing targeted enhancements, the website can significantly improve its usability and establish itself as a valuable resource for education and information within the field of environmental research.

6. Discussion

The current study explores the design and implementation of a web-based platform aimed at promoting the cultural and natural heritage of Zakynthos Island, incorporating features to facilitate user contributions and feedback.

The database of the system contains various types of cultural heritage to ensure comprehensive documentation and classification. For this purpose, it contains both tangible and intangible cultural heritage, as well as natural cultural heritage.

As far as tangible cultural heritage is concerned, paintings, sculptures, and archaeological artifacts are included in the database, together with historical buildings and sites, monuments and statues, as well as bridges and Venetian aqueducts and roads. For each item of tangible cultural heritage stored in the repository, we have collected text, metadata (such as classification and geospatial information), as well as related multimedia content (e.g., legacy and 360° panoramic photos and videos). Regarding intangible cultural heritage, traditional music, theater, manners, and customs are documented alongside their respective authors and artists.

The natural cultural heritage of Zakynthos is also documented in the system, including NATURA and protected areas, caves, olive groves, and other points of interest.

Information for the above-mentioned heritage content was collected after conducting research from international and national bibliographies and scientific journals, while the rest of the items were collected in situ and elaborated afterward. The collection of information about the cultural and natural heritage, initially featured in the platform's repository, lasted four years and is the result of various academic and local stakeholders' initiatives and projects.

From a technical standpoint, built around a popular CMS, the system relies solely on open-source tools and technologies, employing a modular, open architecture to offer a versatile solution for creating digital repositories across various themes. A key goal was to streamline the deployment process and reduce ownership, maintenance, and support costs.

The system's core back-end services leverage the CMS's inherent functionality, with its API used to enhance the CMS's capabilities as needed. A REST API functions as the "bridge" between the back-end services and the web application. Additionally, JSON has been adopted as an effective method for data exchange between the web application and the system's back-end services.

The development approach for the mobile web application illustrates how intricate, location-based, multimedia applications can now be effectively built using solely web technologies like HTML, CSS, and JavaScript, alongside advanced browser features like WebGL. While such sophisticated mobile apps used to require custom SDKs and platform-

specific tools, these applications can now be deployed as cross-platform, web or progressive web apps, while still offering platform-specific functionalities and user interfaces.

Modern JavaScript frameworks provide the foundation for creating advanced mobile apps with technologies such as location-based services, interactive maps, AR, 360° videos, and 3D content. However, a major consideration in choosing a framework is its longevity and lifecycle, community support, popularity, and backing from major companies.

6.1. Challenges and Considerations

Ensuring the accuracy and reliability of the cultural and biodiversity data provided, especially due to the crowdsourcing and user-oriented content contribution strategy of the platform, requires solid validation processes and quality control measures. The proposed system incorporates a panel of field experts, supervising, reviewing, and administering the contributed content before publishing. The content management functionality and workflow provided by the CMS proved adequate for the task.

Respecting the rights and privacy of indigenous communities and individuals on the featured data is paramount, necessitating ethical guidelines and informed consent protocols [36].

Additionally, adequate technological infrastructure, including internet connectivity, digital storage, and data management information systems, is necessary for maintaining and accessing online archives. Securing funding and support in the long term for the maintenance and expansion of online archives can be challenging. The design of the proposed platform, based exclusively on open technologies and architecture, minimizes the ownership, maintenance, updating, and support costs. Collaborative partnerships among stakeholders can also help in this direction.

Further engaging diverse communities and stakeholders in the development, maintenance, and management of online archives requires approaches that respect local knowledge systems, cultural practices, and values.

Finally, some aspects of the system, such as streaming multimedia content over the internet, necessitate an active connection and involve transferring significant amounts of data, which may incur charges for users from their service providers. However, as mobile internet becomes more accessible and affordable, and with the growing availability of free public Wi-Fi in urban areas, this concern is expected to decrease over time.

6.2. Future Prospects

The future of online archives for local cultural and biodiversity heritage holds promising opportunities for innovation and collaboration.

The integration of more advanced content personalization mechanisms based on artificial intelligence and machine learning technologies can further improve the analysis of user behavior, preferences, and search patterns, providing more accurate, custom-tailored content suggestions. Natural language processing (NLP) and computer vision techniques can enhance and automate metadata generation and semantic labeling, making digital archives more accessible and user-oriented [22,25].

Furthermore, machine learning-driven clustering and classification algorithms can improve the organization of the repository's content into thematic routes, allowing the users of the platform to explore its content in a more intuitive and engaging manner, offering even more personalized experiences and ensuring accessibility for diverse audiences with different needs and expectations.

On the front-end information presentation level, the further incorporation of state-of-the-art technologies, such as augmented and virtual reality, can offer novel and intuitive ways to enhance the accessibility, interactivity, and immersive experiences offered by online

archives. Combined with suitable content, such as 360° panoramic and stereoscopic images and videos, virtual reality can create immersive 3D environments where users can explore historical sites, artifacts, and ecosystems with a sense of physical presence. Augmented reality can superimpose digital content onto the real world, especially for on-site visitors, providing contextualized and interactive content, thereby enriching the understanding of cultural and natural heritage [13].

Additionally, partnerships between cultural institutions, conservation organizations, academic institutions, and indigenous communities can facilitate the co-creation, sharing, and stewardship of cultural and biodiversity data, ensuring their preservation and relevance for the future.

7. Conclusions

Online archives can play an increasingly crucial role in bridging the areas of cultural heritage and biodiversity conservation, serving as dynamic platforms for documenting, preserving, and sharing the narratives and ecological treasures of local communities. Utilizing the power of digital technology, online repositories can contribute to and promote cultural diversity, ecological resilience, and sustainability. Addressing challenges such as data quality, privacy concerns, technological infrastructure, and community engagement will be essential in realizing the full potential of online archives for local cultural and biodiversity information.

By utilizing open-source software, architectures, and standards, the portal will not only be cost-effective but also highly adaptable and scalable. This approach allows for community involvement, and continuous improvement and contribution by a broad network of developers and users. The proposed digital repository can serve as a paradigm for similar efforts globally. Other regions and communities can replicate this model, benefiting from the shared tools and methodologies, thus fostering a collaborative environment for heritage preservation.

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Data Availability Statement: The platform is available at <https://anteti.envi.ionio.gr> and currently hosts approximately 200 articles related to the cultural and natural heritage of the island of Zakynthos, Greece. Its content is currently available exclusively in Greek. The data from the platform’s evaluation process is not publicly available, as the consent provided by the participating users applies solely to their use within the framework of this research for the extraction of aggregated statistical data and conclusions, and not for their public disclosure for any other purpose.

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Appendix A

Table A1. The platform evaluation questionnaire.

Question	Available Answers
User Information	
1. Age	"18–24", "25–34", "35–44", "45–54", "55+"
2. Internet usage experience	"Basic", "Moderate", "Advanced", "Professional"
3. Relevance—Relationship with the website's subject	"Tonian University student", "Researcher/Academic", "General Public", "Other (please specify)"
User Experience and Usability	
4. How easy was it to navigate the website?	"Very easy", "Easy", "Neutral", "Difficult", "Very difficult"
5. Did you find the information you were looking for easily?	"Yes, very easily", "Yes, fairly easily", "Neutral", "No, with difficulty", "No, I couldn't find the information"
6. How satisfied are you with the structure and organization of the website?	"Very satisfied", "Satisfied", "Neutral", "Somewhat dissatisfied", "Very dissatisfied"
Speed and Technical Issues	
7. How satisfied are you with the page loading speed?	"Very satisfied", "Satisfied", "Neutral", "Somewhat dissatisfied", "Very dissatisfied"
8. Did you encounter technical issues while navigating?	"No, not at all", "Yes, very few", "Yes, several", "Yes, many"
9. If you encountered technical issues, please describe them (optional)	
Content and Information	
10. How clear and understandable did you find the website's content?	"Very clear", "Clear", "Neutral", "Confusing", "Very confusing"
11. How satisfied are you with the quality of the provided information?	"Very satisfied", "Satisfied", "Neutral", "Somewhat dissatisfied", "Very dissatisfied"
12. Would you like to see additional information or features on the website? If yes, which ones?	
Aesthetics and Design	
13. How attractive do you find the website's aesthetics?	"Very attractive", "Attractive", "Neutral", "Unattractive", "Not attractive at all"
14. Do you think the website's aesthetics support its functionality?	"Yes, absolutely", "Yes, quite a lot", "Neutral", "Not really", "Not at all"
General Satisfaction and Comments	
15. How satisfied are you overall with your experience on the website?	"Very satisfied", "Satisfied", "Neutral", "Somewhat dissatisfied", "Very dissatisfied"
16. Would you recommend the website to someone else?	"Yes", "Maybe", "No"
17. Please add any comments or suggestions for improvement (optional)	

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