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Article

An Open-data Repository for Sustainable Tourism

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Abstract This work outlines the benefits of an open repository of cultural and touristic content for promoting sustainability in tourism. The repository aims at sharing digital content with individuals, local communities, businesses, and tour operators to promote responsible tourism practices. By providing access to cultural and touristic content, the repository can increase awareness of local customs, traditions, and practices. This can promote respect for local culture and help reduce negative impacts on the environment and local communities. The repository also aims to promote off-season travel, which can reduce the strain on local infrastructure and support sustainable tourism practices. Additionally, it can reduce the need for physical souvenirs, which can contribute to waste and pollution. Through the sharing of digital content, the repository can support local communities and businesses by promoting their culture and heritage. This can help generate interest in the destination and support sustainable tourism development. To this end, the design and implementation of the technical infrastructure for such a repository are presented to act as an information system that is available online and contributes to sustainable development. The use case used for its demonstration facilitates cultural material from the region of Crete.

Keywords sustainability; tourism; information systems; open repositories; linked open data

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1. Introduction

Nowadays there is a great discussion regarding the sustainability of tourism [1]. Existing tourism practices may be unsustainable especially when they have negative impacts on the environment, local communities, and cultural heritage [2–4]. For example, tourism may affect the environment through pollution, damage to natural habitats, and depletion of natural resources with potential long-term damage to the ecosystem. Another example is over tourism which can lead to overcrowding, strain on local infrastructure, and damage to cultural heritage sites. In some cases, tourism can also lead to the commercialization of local cultures, resulting in a loss of authenticity and cultural heritage. This can erode local traditions, values, and practices. Last but not least the carbon footprint of long-distance travel, leads to climate change, which has far-reaching impacts on the environment, including changes in temperature, weather patterns, and sea levels [5].

Digital technologies can play an important role in promoting sustainable tourism practices [6]. Sustainable tourism involves minimizing negative impacts on the environment, supporting local communities, and promoting cultural awareness. For example, by providing virtual tours, visitors can experience destinations before their visit and thus enhance their decision-making on a destination. In this way, the sustainability of heritage sites can be also supported since visitors will be able to more accurately design their travel plans by picking the most appropriate for their desired destinations.

From another perspective, online booking systems can help reduce waste by eliminating paper tickets and receipts. Tourists can use mobile apps to explore destinations, learn about local cultures and practices, and find eco-friendly options. Social media can also be used to promote sustainable tourism practices and connect tourists with local communities.

In this work, an open repository of cultural content about a destination is presented. DestinationCrete has the objective of making the provision of various tourism services more sustainable. For example, by making cultural content about a destination openly available, tourists can

learn about local customs, traditions, and practices. This can help them to respect and appreciate the culture of the destination they are visiting, which in turn can foster more responsible and sustainable tourism practices. At the same time through the repository, a destination can be experienced all year long and thus encourage tourists to get in touch with its even during the off-season period thus reducing the strain on the local infrastructure and supporting sustainable tourism practices. At the same time, by providing free cultural content it can reduce the need for physical souvenirs and replace them with digital photos, videos, and other content about the destination that they can use to remember their trip. At the same time, being open to any contribution the open repository can support local communities by promoting their culture and heritage. This can help generate interest in the destination and support local businesses that rely on tourism.

From a technical perspective, we present the design and implementation of an open data platform for the storage, management, and distribution of digital touristic and cultural content. This platform allows both legal entities and individuals to contribute content with appropriate licensing. More specifically, concerning legal entities, the platform aims to address the phenomenon that several public bodies do not have access to the data produced or collected by other public bodies. Due to this huge dispersion and incoherence of the content, it does not efficiently reach the citizens. In addition, as far as natural persons are concerned, the platform enables, through the use of crowd-sourcing techniques from smart mobile devices and the internet, to contribute tourist content to create an open data collection.

In terms of interoperability, the developed system supports open standards and the appropriate APIs to ensure interoperability with existing and new infrastructures and an accreditation subsystem to grant access to digital content. Through an open API, it supports direct interfacing with applications for real-time content extraction.

2. Background and Related Work

2.1. Building Sustainable Tourism Solutions

To build sustainable tourism solutions based on open data, several directions have been proposed in the literature [7–16]. For example, in [7–9] several examples are presented regarding how existing open data repositories can be exploited to create linked-open-data-based applications and services for the tourism sector, thus supporting the main driving force of this research work. In these research cases, emphasis was given to the kind of services that can be built based on openly available information such for example geolocations. At the same time, by expanding this approach, modern mobile-based applications can be built. These could be available before during and after the visit to enhance tourism information provision and experiences. Potential application domains include collaborative e-learning for tourism [11], mobile augmented reality applications for tourism [12], web-based and AR-based digital travels [13], crowdsourcing on Intangible Cultural Heritage [14], etc. At the same time, research on the emerging challenges for the tourism industry as discussed in [15] is a source for innovation in the tourism industry offering new possibilities such as the management of tourism in islands [16]. Among these examples, practical solutions of great interest can be achieved through the usage of open data for dealing with the challenge of over-tourism [17]. For this purpose, tourism-specific service-based APIs are required to support the easier exploitation of tourism data to support innovation and enhance their availability to third parties [18].

2.2. Knowledge Representation for Cultural Heritage

In the Cultural Heritage (CH) domain, the staggering amount of research in 2D/3D digitization technologies resulted in automatic reconstruction methods, good practices, and the democratization of sensors and methods to audiences without technical expertise. In the domain of knowledge representation, Semantic Web technologies and ontologies are today standard tools in CH [19] since the pioneering work of Europeana [20]. In the last decade, event-centric representations have been preferred over object-centric representations [21] because they provide the expressivity to support semantic search, browsing, visualization, and storytelling [22–25]. Event is a basic class in Europeana Data Model (EDM), inherited from the CIDOC-CRM [26]. Thus, more complex, knowledge-driven approaches are building on top of domain standards for the representation of Cultural Heritage such as the CIDOC-CRM [27], and have been explored for the representation of several aspects of tangible and intangible Cultural Heritage such as

traditional craft products, craft processes and recipes thus expanding the traditional artefact-based representation [28–30].

2.3. Open Repositories

Open repositories of cultural and tourist content have become increasingly popular to support sustainable tourism and cultural heritage management [26]. These repositories are typically web-based platforms that store and provide access to digital collections of cultural and touristic content, including images, videos, audio files, and textual information such as historical facts and descriptions of local landmarks.

One of the most widely-used open-source platforms for managing cultural content is Omeka [31], a web-based platform that provides a flexible and extensible system for creating digital collections, and its REST API allows developers to build custom applications that can interact with the repository. Other open-source repositories that can be used to manage cultural and touristic content include DSpace [32], Fedora [33], and Islandora [34]. DSpace is an open-source platform that provides tools for creating, managing, and sharing digital content and has been used in several cultural heritage and museum projects [32]. Fedora is a flexible and extensible digital repository system that can be used to store a variety of digital content types and has been used in several cultural heritage projects [33]. Islandora is a Drupal-based platform that provides tools for creating, managing, and sharing digital content and has been used in several library and archive projects [34].

2.4. Contribution of this Work

This work has the ambition of combining advances in the representation of CH with advances in open repositories to create a new tourism infrastructure that through open data can enhance the sustainability of the tourism industry. In this work, it is argued that open repositories of cultural and touristic content can provide several benefits for both tourists and local communities. For tourists, these repositories can be used to create interactive maps and tours that allow tourists to explore a destination in a more engaging and immersive way. For local communities, these repositories can be used to promote cultural heritage, support local businesses and tour operators, and provide access to digital collections of cultural and touristic content. At the same time by binding these solutions with knowledge representation frameworks for CH the supported solution can take the most out of existing linked open data on represented CH resources.

There are also several potential risks associated with the use of open repositories of cultural and touristic content. One potential risk is the open sharing of data, which can raise privacy concerns and create security risks. Another potential risk is the use of algorithms to personalize recommendations, which can perpetuate bias and discrimination.

3. Methodology

For the design of the platform, a human-centred design [35,36] was followed, in which the design of the system is carried out with a focus on the end-user and the appropriate configuration of the interaction between the two factors—user and system.

3.1. User Requirements Analysis

To capture the requirements of the project, the methodology of analysing the requirements through a bibliographic study was adopted to identify relevant works and requirements and perform competitor analysis [37]. At the same time, to harmonize with the objectives of the project, an additional analysis was carried out using personas and user stories. Personas are descriptions of the end users of the system and their characteristics, intended to bring users to the centre of the design process. User stories are a method used to capture requirements in agile methodologies, describing functionality that the user wants to have in natural language [38], and are of the form: “As <Role> I want/need/desire to <Work with the system> to <Goal>”, often followed by the identification of success criteria, which explain the functional and non-functional characteristics of the system to meet the user story.

3.2. User Interface Design

The platform follows an understandable and easy-to-use mental model, simplifying the interaction processes by providing the features of the system at key points so that they are always

available and visible to the user. In addition, emphasis was placed on minimalist design, removing unnecessary information and following consistency in the design of each function, so that all processes are perceived as a unified and integrated system, which ensures a better user experience. Focusing on the end users and their needs, the design process was iterative [39], starting with requirements analysis, continuing with design and prototyping, and closing each iteration cycle with evaluation. The results of the evaluation led each time to the identification of new requirements and updating of existing ones if necessary, and then to new design and creation of new prototypes. In addition to user requirements, good design principles and best practices, as described in the literature [40,41], were considered for the design of the system, to make the design legible and easy to learn, and at the same time, users know where they are on each page and what they can do there, avoid errors, and provide help and guidance where needed.

3.3. System Architecture

The system architecture can be conceived as a collection of interconnected components. The front-end interface is a user-friendly web interface that allows individuals, communities, local businesses, and tour operators to access and interact with the repository via features for searching, browsing, filtering, and downloading cultural and touristic content. The back-end content management system allows content creators and administrators to upload, manage, and organize cultural and touristic content. This system includes features for tagging, categorizing, and describing content, as well as tools for content curation and moderation. The storage of cultural content is performed by building on a cloud-based storage system that hosts the cultural and touristic content, providing scalability, redundancy, and accessibility for users. The storage system will include features for version control, backup and restore and access control. A content delivery network (CDN) is employed to deliver cultural and touristic content to users with low latency and high availability. The analytics and reporting system provides insights into user behaviour, content performance, and system usage. This system will include features for tracking user interactions, measuring content popularity, and identifying system bottlenecks. A linked open data layer allows the repository to act as a content provision interface for other linked data repositories that enhance the reusability of content and knowledge.

4. Implementation

4.1. User Requirements Analysis

A key issue for the usefulness and usability of data repositories is the "discoverability" of the data, i.e., how easy it is for these data to be easy to locate, access, interpret, and reuse (Findable, Accessible, Interpretable, and Reusable—FAIR). Through the collection and analysis of 79 usage scenarios of open data platforms, recommendations to facilitate data discoverability and data search usage experience on these platforms are [42]: (a) provide query interfaces to support different data search behaviours, (b) provide multiple access points to find data, (c) facilitating users to judge the relevance, accessibility, and reusability of a collection of data from a search summary and (d) Providing statistics on data usage.

Based on the analysis of requirements and supported functionality from existing open data platforms in the research, the following functional requirements are recorded [43]: (a) create collections and logical naming, (b) maintain a history for the data, (c) support for the most common data types, (d) provide an easy-to-use and consistent graphical interface, (e) support for general search, but also advanced search and (f) support the recording and presentation of data quality.

Another important issue in such platforms is how easy it is for users to trust them. After public discussion by multiple participants in such digital repositories' communities, the principles of Transparency, Responsibility, User focus, Sustainability, and Technology (TRUST) [44] emerged, according to which digital repositories must: (a) be transparent about services and data storage, (b) be responsible for ensuring the authenticity and integrity of the data held, (c) ensure data management standards and user expectations are met, (d) maintain services and data in the long term and (e) provide infrastructure and capabilities to support reliable and secure services.

At the same time, for the viability of such repositories based on crowdsourcing techniques, the owners of the data must have the necessary incentives and guarantees to share their data. Analysis of interviews with end users revealed that important factors for sharing data in digital repositories are [45,46]: (a) have the right to share the data themselves, (b) receive appropriate

recognition (attribution) as the source of the data, (c) make it easy to share data, (d) data should not fall under privacy criteria, (e) provide appropriate incentives for data sharing and (f) provide free of charge usage of the platform and services.

In addition, important factors for users wishing to use data from digital repositories are [46]: (a) ability to easily discover data, (b) provision of information on data quality, (c) ability to combine data, (d) clear licensing scheme, (e) security and privacy, and (f) detailed information about the data

In any case, the modern trends of using user-generated content have reshaped the way people traditionally approached pulling content from different sources, now relying on a more open model. However, the approaches so far are aimed at new and tech-savvy users [47]. In the context of using digital repositories, and in particular, a repository that includes cultural and touristic content, the participation of everyone as producers, as well as users of multimedia content, is necessary. For the use of user-generated content in the context of tourism and culture, the aesthetics of the content, the accuracy of the information it provides, and its reliability, as well as the relevance of the content have emerged as important factors [48]. At the same time, it is the quality of the content that has the potential to brand a tourist destination [49], which signals the need to control the content posted to the repository as public, to ensure that the content is not offensive or of low quality, thus protecting content users from using inappropriate or false material, and enhancing trust in the repository by both content owners and users [50].

4.1.1. User Personas and User Stories

For the definition of system requirements, three representative end-user personas (content owners, content users, administrators) were defined, as well as requirements in the form of user stories for each persona [51]. Content owners can be individuals or certified entities that wish to share content through the system. Content users may also be individuals or certified entities wishing to use content available on the platform. For the analysis, two personas for content owners, one for content users, and one for system administrators were used and 19 user stories were produced, typical of all potential users of the system. Examples of user goals and the resulting requirement for the Anna persona that is a multimedia content owner are presented below:

Goal: Anna wants to upload content and become known for her photography skills. The platform should:

- Support posting multimedia content (photos and videos) easily and simply.
- Provide search mechanisms so that other users can easily find its content (search, filters).

Goal: Anna wants to organize content into categories to make it easier for users to find. The platform must:

- Support organizing multimedia content into categories.
- Provide mechanisms for characterizing content in addition to categories (e.g., using tags).

Goal: Anna wants to feel safe about her content to avoid malicious eavesdropping. The platform must:

- Ensure the protection of the intellectual property of the content made available, through licensing.
- Allow content owners to choose how they wish to share their content (Creative Commons licenses, private licensing).
- Offer explanations regarding each different type of licensing so that users can choose the one that best suits their preferences.

Goal: Anna wants to know the popularity of her material to understand users' trends. The platform must:

- Provide detailed statistics for each content post (rating, total views, total licenses).
- Project the evolution of the course of the content in the system through charts by periods (per month, week, year).
- Display statistics on the type of licensing most preferred by users regarding its content.
- Show the content with the highest user ratings, the most licenses, and the most views.

Goal: Anna wants to have management access to her content to remove or edit material. The platform must:

- Allow deletion of content owned by her.

- Allow the editing of her content.
- Allow processing of the disposition of the licenses of her content.

4.1.2. Summary of User Requirements

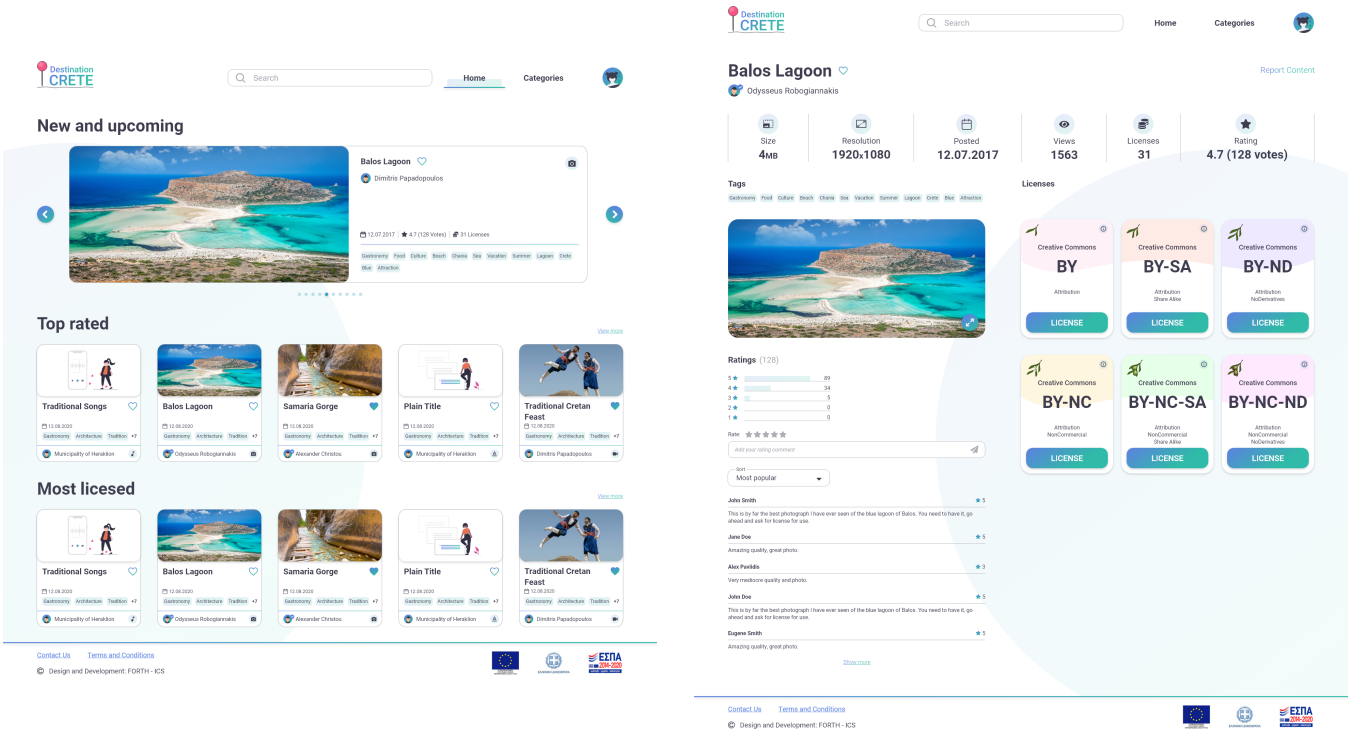
In this section, we provide a summary of the identified user requirements:

- URQ1—Support a user authentication mechanism, through username and password.
- URQ2—Support different ways to discover content through: search, navigation of content categories, and suggested content.
- URQ3—Support content search using keywords.
- URQ4—Support advanced content search using keywords and filters.
- URQ5—Support content categorization to facilitate users' search and location of content. In addition, offer the ability to mark content categories using tags, so that users can improve the discoverability of their content.
- URQ6—Provide a content summary for each content displayed as a search result or as content that falls into a category with the most important elements of the content, such as title, date posted, content categories, content owner, and file type.
- URQ7—Add to favourites functionality for each user.
- URQ8—Content preview for each item displaying the most important content details such as title, date posted, content categories, content owner, file type, licensing, and user rating.
- URQ9—Provide a detailed presentation of content which should include title, content owner, file technical characteristics, number of views and licenses, rating, tags, licenses, and user comments.
- URQ10—Provide content statistics for each content (rating, total views, total licensing, type of licensing most preferred by users).
- URQ11—Provide content history, e.g., new versions, and licensing history, which will be available to the content owner and system administrators.
- URQ12—Support content rating by reporting the average, the number of ratings, and analysing the number of ratings per grade.
- URQ13—Support commenting on content with the possibility of commenting, in conjunction with its rating.
- URQ14—Offer rich content management facilities to content owners and system administrators.
- URQ15—Content licensing management. The administrator will be able to define which licenses will be provided overall as options by the system, from which the content owner will be able to choose which one(s) they wish to apply to the content they post.
- URQ16—Support of different types of licensing. The system will support different types of licensing: all types of creative commons and private licensing, in which the owner will communicate with the user requesting the license.
- URQ17—Content validity and integrity. The administrator will view all content posted by users and approve, reject, or conditionally approve them. Only after content has been approved will it be visible to system users.
- URQ18—Content reporting. The ability to report malicious content will be provided, to ensure high-quality content and user confidence in the system.
- URQ19—User reporting. The ability to report users will be provided, to prevent malicious actions and maintain user trust in the platform.
- URQ20—User Profiles. The system will support different user profiles depending on their role. Content owners will have access to their content statistics and history as well as license requests through their profile, while content users will have access to their favourites, license requests they have made, and files they have obtained a license. The system will support the coexistence of the two roles in one user, through a common account.
- URQ21—User management mechanism to certify the official bodies that post content. In addition, the administrator will be able to register, delete, and edit system users.
- URQ22—Monitoring of authorization history by administrators. The administrator will be able to monitor the history of authorizations. The system will display all new license applications with the ability to rank by period, provide a complete history of past

applications by category (approved or rejected), inform administrators about the progress of license applications (application status), and display statistics of satisfaction of requests.
- URQ23—Support of the most common data types for each content category (images, videos, audio recordings, text).
- URQ24—Easy-to-use and consistent graphical interface.
- URQ25—Easy to understand the system. The system should be easy to understand, even by novice users. Where necessary, explanations will be provided to users about the functionality or use of the platform.

4.2. User Interface Design Rationale

The design rationale was conceptualised following usability guidelines and heuristics for Web-based applications and following design thinking principles [39–41]. As the system can only be used by registered users, an onboarding page was designed, in which the visitor is introduced to the purpose of the platform and the advantages of registering on it. Upon entering the platform, the main functions that a user interacts with have been placed in prominent menus at the top of the page (see Figure 1a). This menu is permanently positioned at the top of each page of the system to facilitate interaction. Specifically, the menu includes redirect links to the home page and content categories, a content search function, and a link to view the user profile. At the bottom of each page of the platform is an extensive footer, which provides information on the design, implementation, and funding authorities, as well as useful links. The home page aims to recommend content to users. Specifically, the home page is split into three parts: new and upcoming, higher rated, and more licensed. In the first category, the user can see a presentation of the 10 newest files uploaded to the platform, to equally support new content, since the content that has the highest rating and the most licenses is usually older content. The second category shows the five files that have received the highest rating from other users, while the third—in the same way of presentation—shows the files that have been licensed more times. When a user posts their material on the platform, the system's home page adjusts accordingly to give more emphasis to the user-posted content. More specifically, the home page displays statistics regarding the user's material, such as rating, licensing, ranking based on popularity, etc. This customization makes it easier for the user to track the progress of their posts. Also, a user can track the content they have posted from their profile. The user profile is accessed from the main menu located on each page of the platform. From the profile, a user can additionally view the material they have favourited and the content licensing applications they have filed. To ensure the ease of use of the system, posted content is classified into one or more of the system's predefined categories. Therefore, the quick and correct search and finding of the content desired by the user is achieved. In addition, each post is accompanied by a series of tags, the selection and creation of which is at the discretion of the creator, to better frame and define the respective content. Also, for the convenience of the user, for each post there is the possibility to show in a preview, to immediately provide the most important information, without the need to redirect to the post details page. Finally, each post comes with several available licenses that each user can apply for, thus ensuring protection from copyright theft (see Figure 1b). Licenses follow the model of Creative Commons or private licensing. In the second case, the user who wishes to use the content must state the way it will be used and make a request. For Creative Commons licenses a brief explanation is provided regarding the license level the user wishes to choose. Therefore, depending on the needs of each applicant, the license is configured and the content is made available. Finally, each user can find the postings and authorizations (according to their role) aggregated in their profile, thus ensuring that they will have constant access to this content, which concerns their activity as a user of the system. The design on all pages of the platform is governed by consistency, both in terms of the position of common interactive elements (menu, footer), but also terms of the appearance of the content (colour schemes and font), as well as in terms of the information provided in the different content overviews (summary, preview, breakdown). So users can easily learn the system.



(**a**) (**b**)

Figure 1. (**a**) Design of the home page; (**b**) Browsing a content item.

4.3. Implementation Technologies

The baseline technology that we used for adhering to the basic system requirements is Omeka [1], a web-based content management system designed specifically for the needs of cultural heritage institutions, museums, libraries, and archives. It is built on top of the LAMP [52] stack (Linux [53], Apache [54], MySQL [55], PHP [56]), and is designed to be easy to use and highly customizable. Omeka is built around the concept of items, which can be thought of as digital representations of physical objects, such as artworks, documents, or artefacts. Each item can include metadata, such as descriptive information, rights statements, and technical details. Items can be organised into collections, exhibits, and other groupings to provide context and meaning. The most important aspect of Omeka which makes it ideal for the work conducted is its ability to integrate a multitude of vocabularies (e.g., CIDOC-CRM) or custom vocabularies (e.g., custom domain-specific ontology representations). This provides flexibility in terms of knowledge compatibility, semantic interoperability and scalability.

This metadata-rich representation allows us to support the representation of a wide range of fundamental, for our case, media types such as images, audio, video, and documents. At the same time, the built-in support for common metadata standards, such as Dublin Core [57] and Metadata Objects Description Schema (MODS) [58] allows us to combine the expressive power of Cultural Heritage standards in the domain of tourism and the same time benefit from the possibility of their delivery in the form of linked open data.

For the User Interface, we benefit from the design of the Omeka which is intuitive and easy to use, with drag-and-drop functionality for uploading files, and a simple editor for creating and editing metadata. Omeka has a solid backend that supports all typical knowledge management tasks supported by a plugin infrastructure to extend the provided functionality. At the time, it supports the implementation of data views on top of the semantic repository compiled in the form of websites and with support for multiple languages translations both on the UI and resource descriptors.

For the Open Linked data API we build upon the robust REST API [59] that enables developers to access and interact with Omeka data programmatically. The API is built on top of the Zend Framework's RESTful module [60] and conforms to the principles of Representational State Transfer (REST). The API supports a wide range of operations, including retrieving resources such as items, collections, exhibits, and files using simple GET requests. Furthermore,

creating and updating resources using POST and PUT requests. Finally searching resources using a powerful search API that supports complex queries and filtering. Currently, on top of the REST API, a mobile version of the repository is being built as discussed in the conclusion section. Regarding user authentication, the API supports user authentication for accessing protected resources using OAuth 1.0a authentication [61]. Generalising this approach, through this API the repository can become available to any software application, web service or agent that wishes to provide tourism data-driven functionality.

5. Use-case for the Region of Crete

Implementing a proof of concept for such an ambitious technical project is not trivial due to the following considerations. Initially, a large pool of data should be available that has a good geographic coverage of the covered area to provide a valid proof of concept. Furthermore, a diversity of supported data and formats is needed to demonstrate the capacity of the system to handle different variation types. Additionally, expressive power, localization features and semantic annotations based on location metadata are required. Finally, the semantic model should be capable of representing the desired information for each content variation.

The aforementioned requirements cover only the part of the repository that regards the representation of information. Further provisions are required to support the interoperability of the represented data with other open-linked data repositories and the possibility of expanding the knowledge base by interlinking and/or importing new content from existing data sources. Another requirement is the exploitation of crowdsourcing techniques for enriching the repository with new information sources. The latest addition provides great incentives to individuals and tourists to complement the repository by contributing their personal experiences and content.

A great issue that should be discussed in approaches such as the one presented in this work regards issues on Intellectual Property Rights (IPR) of existing content and contributions and has two major dimensions. The first regards IPR support for curated content and the second regards IPR transfer from user contributions to the repository. In both cases, a technical solution is required that implements the decided policy.

5.1. Data Sources

For the use case of the region of Crete, we used data sources from major municipalities of the island. These include the Municipality of Heraklion and Chania but also sources provided by the Region of Crete that cover the entire island. The form of the uploaded content includes text, video files, 360 degrees panoramic videos, but also textual information in the form of pdf files that constitute a tour guide for the island and complement the audiovisual material with multimodal text. Furthermore, aspects of the intangible cultural heritage of the island are covered through information on the gastronomic tradition of the island encoded both in the form of recipes and video interviews of living human treasures of the gastronomic tradition of the island.

In terms of metadata, a plethora is supported through integrating Dublin Core terms extending with further information such as localisation features. For each item, semantic information about its location is associated and each location holds its respective metadata. Media objects are also associated with metadata that is (a) extracted automatically from their Exchangeable image file format (Exif) specification and (b) curated by the content curators. In the case of automated extraction Exif properties are assigned to Dublin core metadata automatically when the media object is created.

5.2. Browsing Options

Being able to host and visualise multiple forms of data is essential for an open data repository since part of its usability is dependent on its search and browsing capabilities to support maximum efficiency when searching available content. To this end a simple yet straightforward approach was followed for the main menu of the repository to expose the majority of the browsing functionality through five main selections (a) Contents, (b) Categories, (c) The Island of Crete, (d) Map browse, and (e) Contribute to DCCrete. The first lists all contents of the repository from all item collections and media types. The second offers a categorized view of the content per content category. An example of this view is presented in Figure 2.

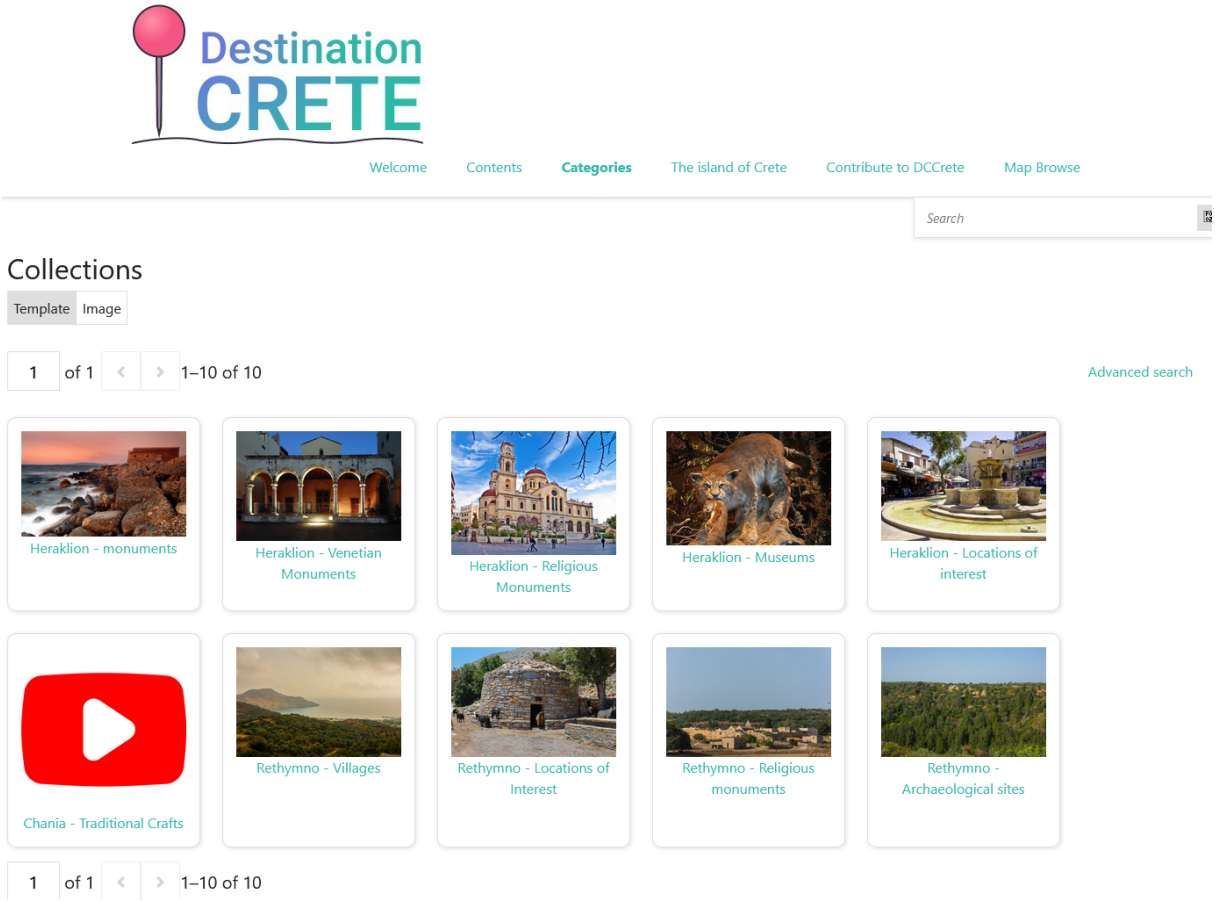


Figure 2. Browsing content based on collection categories

The Island of Crete option allows the filtering of content based on a specific prefecture. In our case, four prefectures are available on the island of Crete. Figure 3 presents the filtering of collections based on the selection of the prefecture of Heraklion while Figure 4 presents the contents of one of these collections.

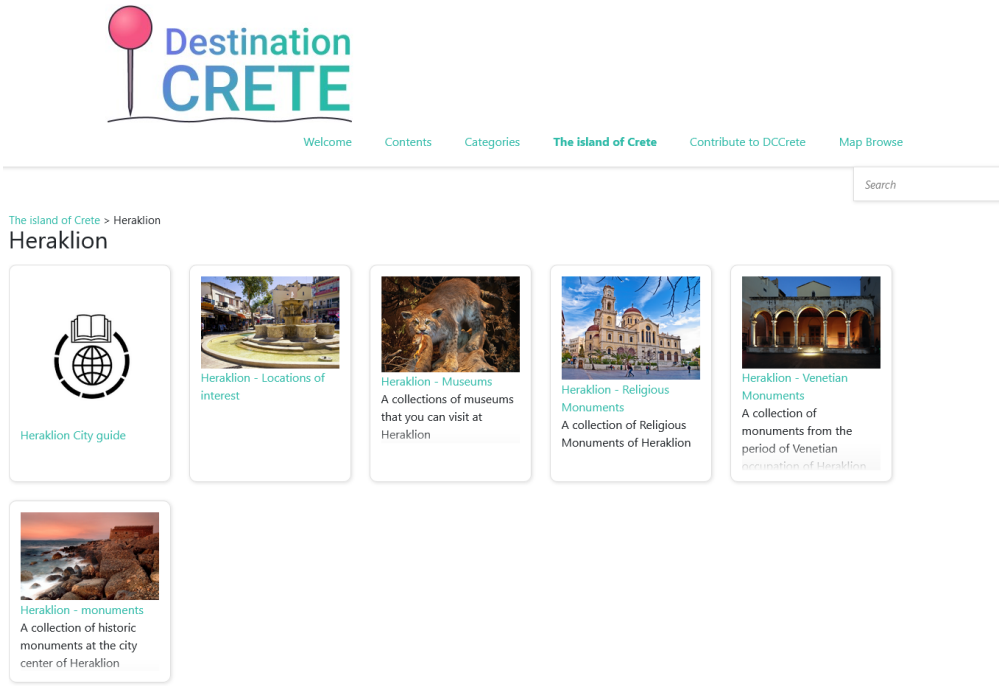


Figure 3. Browsing collections on the prefecture of Heraklion.

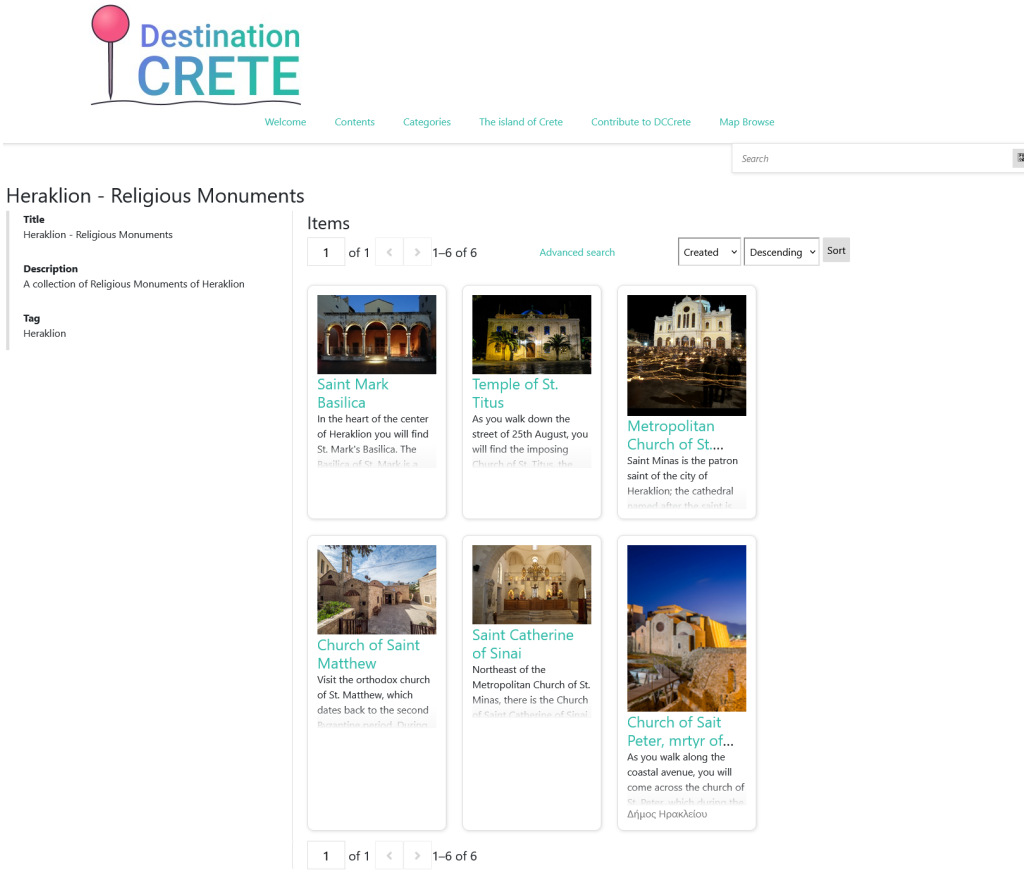


Figure 4. Browsing the contents of a collection.

The Map browse gives access to all the available content based on its geographic location. An example is shown in Figure 5 focusing on the map of Crete. In this example, the map contains points of interest associated with collections or media. Two options are available for browsing. The first is to browse the map by selecting points of interest (pins) to access information on the associated collections or media. The second option is to filter the contents of the map using the advanced search functionality that is available after the map.

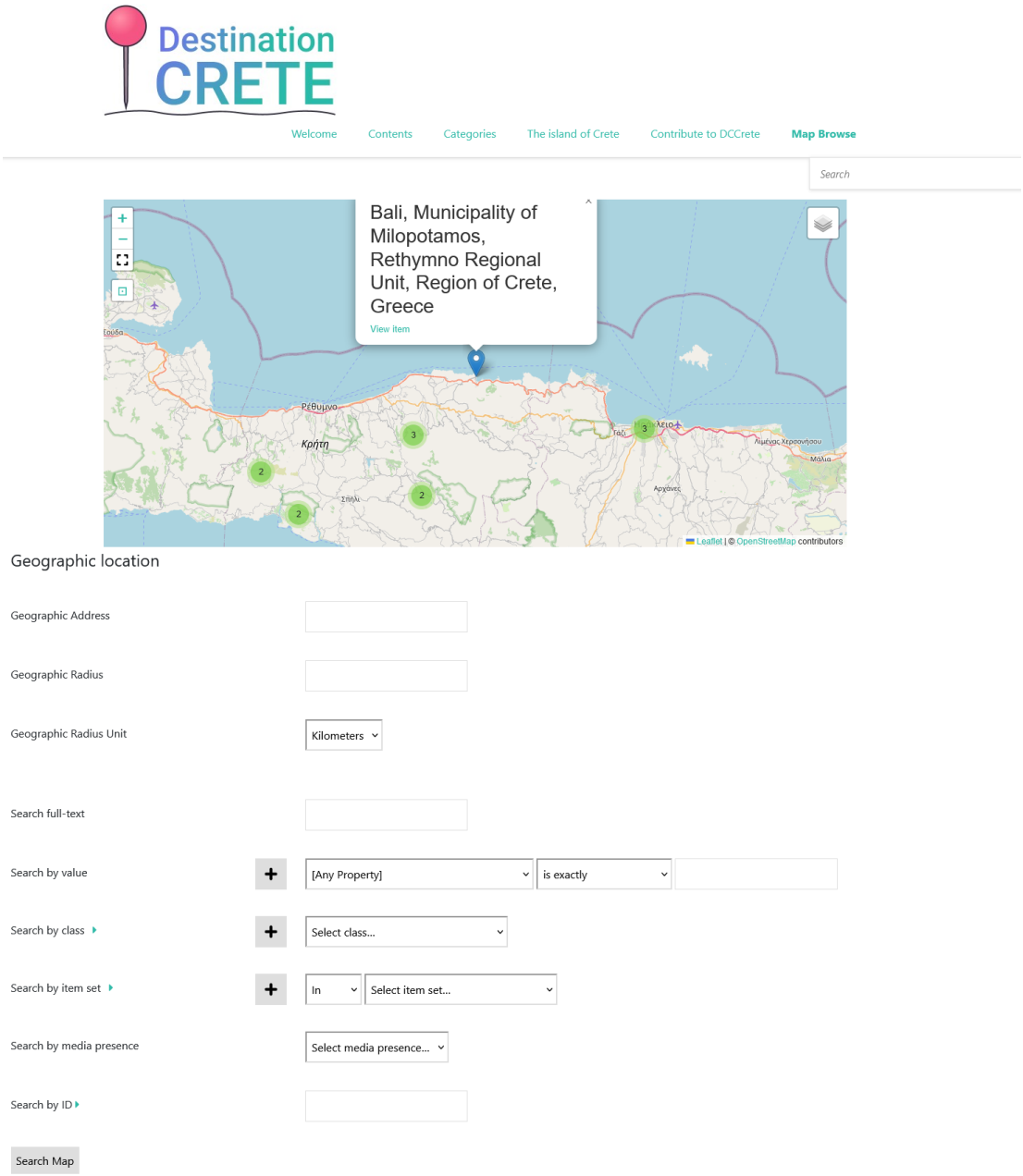
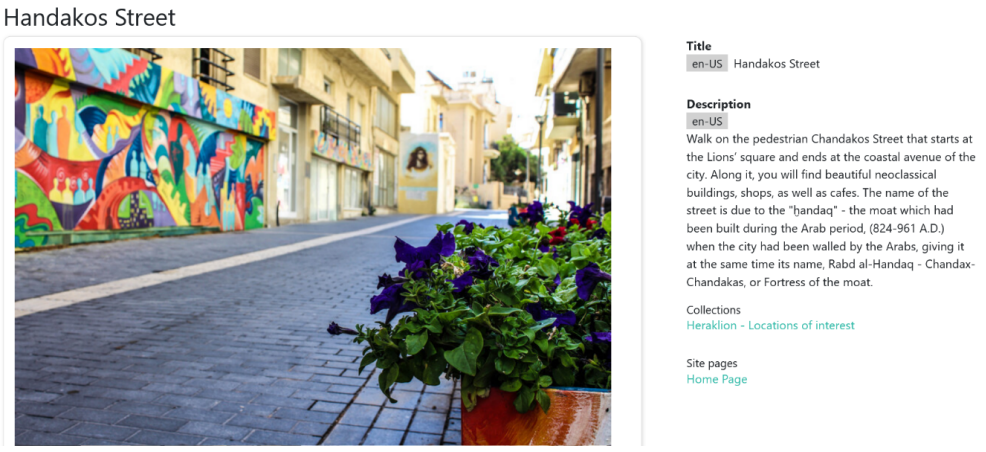


Figure 5. Browsing the contents of a collection.

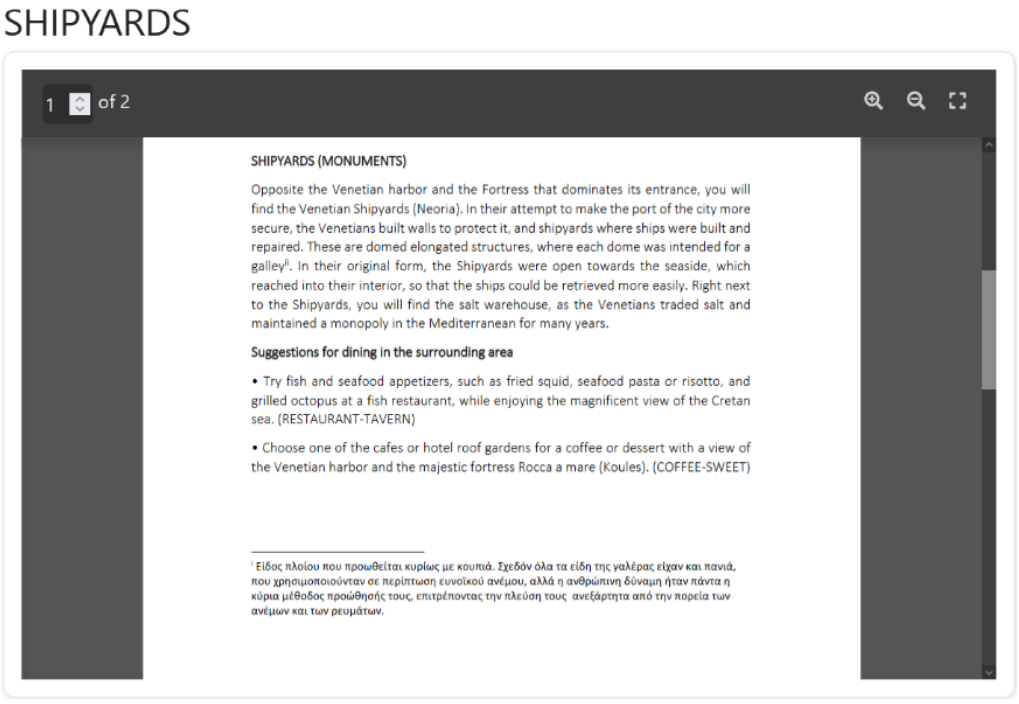
5.3. Data Views

Previewing sever data types online is an essential part of exploring the available content. To this end, several previewing functionalities are supported each of which is associated with a fundamental media type such as images, offline and online videos, pdf documents, etc. Figure 6 presents some examples of how these data types are visualised through the repository.



(**a**)

(**b**)

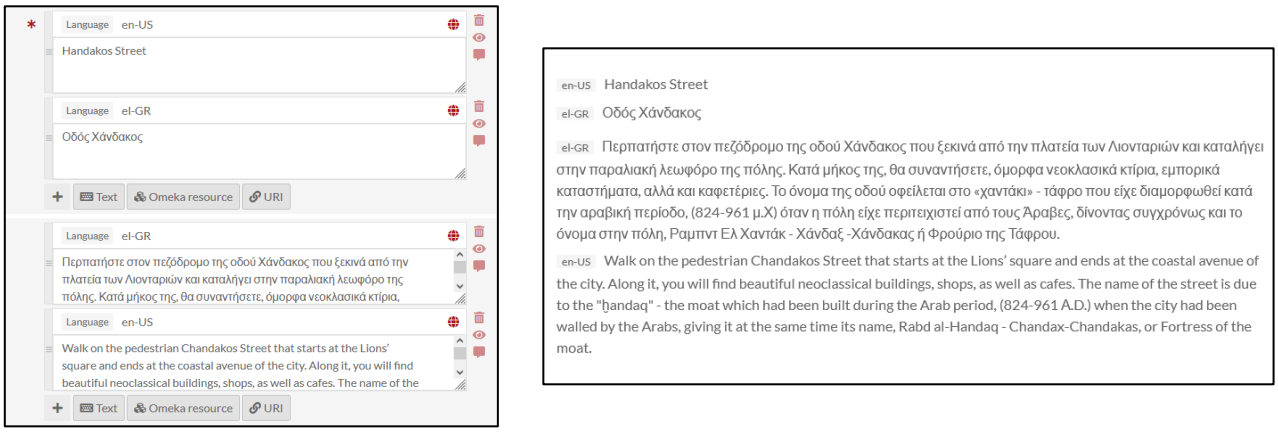


(**c**)

Figure 6. (**a**) image; (**b**) video; (**c**) online pdf.

5.4. Multilingualism

To support multiple languages both in terms of User Interface and content the following features were implemented. Site content is controlled via localisation features of Omeka S. All the assets in the repository are localised initially in two languages with the support for unlimited language translations. Metadata, translations are authored by assigning language codes to each provided text primitive. An example of the multilingual authoring of metadata and their visualisation by the back end is presented in Figure 7.



(**a**) (**b**)

Figure 7. (**a**) Multilingual authoring; (**b**) Visualisation of translations.

Regarding page translations, these are authored individually for each corresponding page and assigned to the site that holds all the translations in a specific language.

5.5. Crowd-sourcing

To further enrich the open data store with advances outlined in research works on user-generated content [49,50] we have created a crowd-sourcing service in the repository that supports user contributions. To provide such contributions the users should be logged into the system and provide requested information on a contribution form (Figure 8). The information requested includes a confirmation of name and email and a collection of multimedia contributions. By submitting content using this service the user must first accept the licence agreement which includes the transfer of ownership for the contributed assets to the repository which in turn has the rights to display, distribute and license the data under non-commercial license types.

All the collected contributions are gathered in an item collection that is invisible to the public to be appropriately reviewed and moderated by the repository curators. The curator can accept, reject or alter a contribution and then select the repository collection, and collections assigned to it. Please note that all end-user contributions are displayed with a reference to the name and email of the user that has performed the contribution to ensure transparency regarding the source of data and make contributors aware that they are propagated with the responsibility of sharing assets that they don't have the IPR on. Furthermore, this provides a further incentive for contributors since their name is bound with their contributions thus allowing them to gain visibility and recognition of their work.

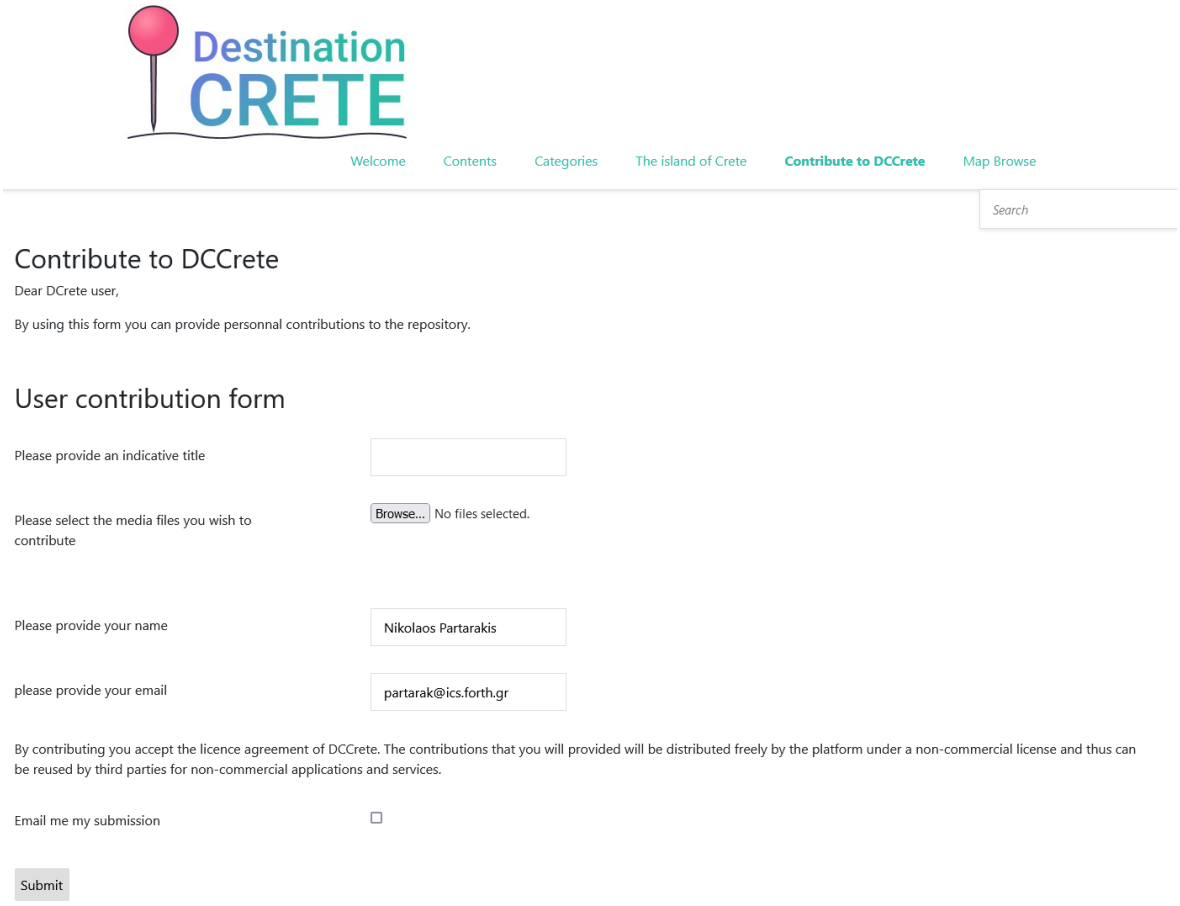


Figure 8. Contributing to DCrete.

5.6. Exposing Linked Data

For making the data contents of the repository openly available for third-party innovation we have implemented a linked data repository that implements an Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH) protocol [62]. The repository allows items, item sets, and media to be harvested by OAI-PMH harvesters. The repository maps non-Dublin Core properties to Dublin Core properties to expose all values of all items. An example of the OAI-PMH harvesting API is presented in Figure 9.

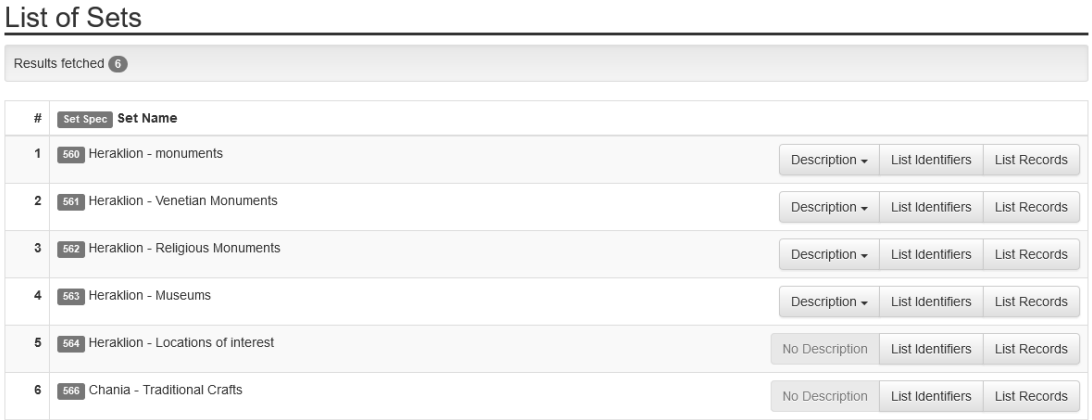


Figure 9. Example of OAI-PMH harvesting API for DCrete.

5.7. Importing for Existing Data Sources

For the repository to be able to get the most out of other existing open-linked-data repositories an import policy had to be defined. The policy specifies the way that existing data and metadata are handled. Regarding metadata, these are copied into the repository. On the contrary, external

assets and data files are linked through their Universal Resource Identifier (URI). The process of importing data is done by using the provided functionality and specifying the source of data to be imported. In this paper, an example is provided by integrating knowledge sources for a Zenodo repository implemented in the Context of a Horizon Europe project. Main digitisations of Archaeological sites of Crete can be accessed through this repository and are linked to using the aforementioned import functionality. Imported data appear in the form of knowledge assets in the repository with the distinction that the actual data are linked remotely rather than being available directly through the local infrastructure (see Figure 10).

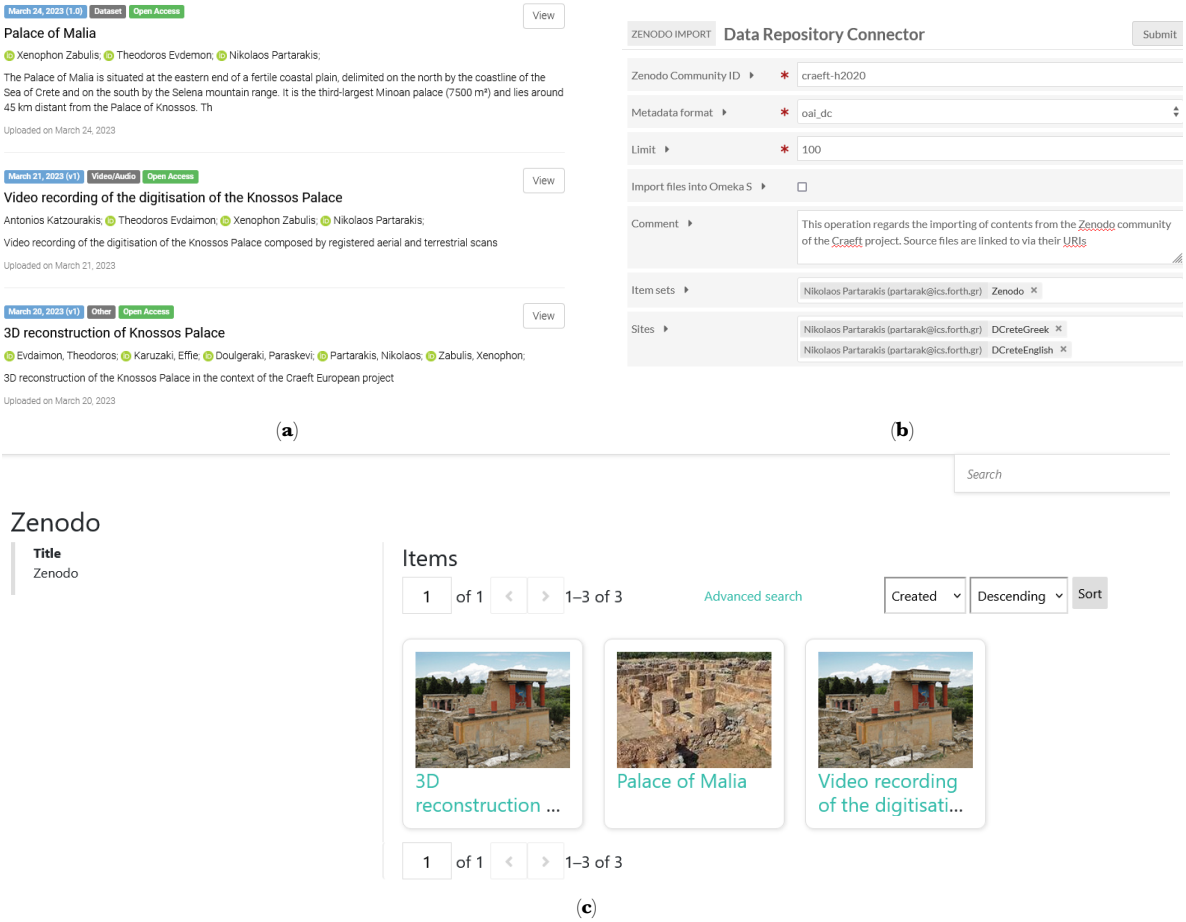


Figure 10. (**a**) Source Data on Zenodo; (**b**) Configuring data import; (**c**) online preview of the imported collection.

6. Conclusions & Future Work

In this paper, we presented the design and implementation of an open repository of cultural and touristic content to act as an aggregator of multimedia content for individuals, public authorities and private organisations involved in tourism promotion and digital tourism services thus promoting responsible tourism practices. To provide a valid proof of concept we ingested and curated data from the region of Crete and created all the required interfaces for providing access to this content both for humans and digital services. At the same time, we made it possible to ingest data from externally linked open data sources and provided the possibility of expanding the knowledge base through user contributions. These features allowed us to validate our initial hypothesis and the main concept of this research work proving the feasibility of such an approach in the context of tourism sustainability. Of course, this approach can be only fully validated with the official launching and running of the project for a sufficient amount of time. Since now the project is in its concluding phase we expect to be officially online during the summer of 2023 and validated until the first semester of 2024.

An important drawback of the proposed approach in conjunction with other research results contributed to the closely linked domain of CH representation regards the presentation of the represented knowledge. This research work makes the first step towards providing an open repository for tourism content, but by closely analysing the digital CH domain we can draw

examples of the exploitation of knowledge. The most prominent one build on the scientific domain of Narratology and regards the implementation of a semantic representation system for the representation and presentation of Narratives [63–65]. Narratives as a formal way of representing stories can enhance the adaptability of tourism content to various contexts and occasions. Making a comparison with the approach provided in this work while we provide more sufficient handling, dissemination and integration of open data the aforementioned approach has enhanced expressive power which is what we are going to pursue in the near future.

Based on the above discussion we envision two directions of improvement. The first improvement regards the planning of a mobile app version of the repository with the main objective of providing access to cultural content while on the move and additionally enhancing the crowdsourcing features of the platform by allowing users to contribute new content from their mobile phones. Such an extension will make it possible to support in the future personalised tour mobile guides and at the same time provide the features of sharing experiences and content by visitors while being at the destination, thus providing a more experience-centric approach to tourism content.

The second improvement regards the representation of Narratives in the repository. In this context, we are considering the integration with the "Story Map Building and Visualising Tool" that allows the creation of Narratives in the form of story maps and timelines using the digital object collected in public datasets [66].

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Data Availability

Data is available upon request.

Author Contributions

Conceptualization: N.P.; Data curation: N.P., E.K., S.N., A.N., & E.Z.; Formal analysis: N.P., E.K., S.N., A.N., E.Z., & C.S.; Funding acquisition: N.P.; Investigation: N.P., E.K., S.N., A.N., E.Z., & C.S.; Methodology: N.P., & E.K.; Project administration: N.P.; Resources: C.S.; Software: N.P., E.K., S.N., A.N., & E.Z.; Supervision: C.S.; Validation: S.N., A.N., & C.S.; Visualization: N.P., & E.K.; Writing – original draft: N.P.; Writing – review & editing: N.P., E.K., S.N., A.N., E.Z., & C.S.;

Conflicts of Interest

The authors have no conflict of interest to declare.

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