

# Information system for regional environmental initiatives\*

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## Abstract

This article presents an IT project for an information system embodied in a mobile application, designed to support and promote regional environmental initiatives. The application provides users with a suite of tools for active participation in environmental protection and fosters community ecological awareness. Key features of the information system include an interactive map of ecological issues and initiatives, where users can report environmental threats, such as illegal landfills or water pollution, and track the progress of their resolution. An environmental events section allows users to register for, receive notifications about, and participate in events such as area cleanups or tree planting. Within the IT project, a comparative analysis of existing software solutions and practices related to environmental initiatives was conducted. System processes were modeled, requirements were defined, a database was designed, and a mobile application prototype was developed. The results of the work are presented and substantiated using data systematized in the form of UML diagrams. Leveraging a user-friendly interface and extensive functionality, this information system aims to serve as an effective tool for supporting environmental initiatives. The implementation of this system will facilitate more efficient monitoring of ecological problems, event planning, and informed decision-making for environmental protection. Furthermore, the incorporation of artificial intelligence (AI) algorithms for data analysis and trend prediction is considered for future development, to provide advanced insights and optimize environmental management strategies.

## Keywords

information system, regional environmental initiatives, UML diagrams, artificial intelligence, mobile application

## 1. Introduction

In the current context of active urbanization and industrialization, environmental issues are becoming increasingly relevant for all regions. The deterioration of the environment, accumulation of waste, and pollution of water and air resources necessitate immediate attention at both local and global levels. Effective resolution of environmental problems requires not only heightened public awareness but also active civic participation. Modern technologies play a pivotal role in the development of online platforms for disseminating environmental information and engaging the community in environmental protection activities. The use of specialized software applications that enable citizens to promptly report environmental issues, participate in initiatives, and access useful information to reduce their personal impact on nature is a powerful tool.

The IT project of an environmental initiatives information system offers a range of functionalities, including an interactive map of environmental issues, an event calendar, educational content, a discussion platform, and gamified mechanisms for incentivizing user

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activity. This approach allows not only for effective citizen information dissemination but also for motivating them towards practical actions. The implementation of the information system will contribute to more active community engagement in addressing environmental issues, improving the ecological situation in the region, and fostering an environmentally conscious society.

## **2. Formulation of the problem**

Environmental challenges have reached a critical level regionally, necessitating active engagement not only from authorities but also from the public. Complexities in managing environmental initiatives and low public awareness highlight the need for innovative approaches to involve the population in addressing environmental problems. Key aspects of the regional environmental issues include low public awareness of ecological practices with many citizens lacking adequate information on how their actions impact the environment and what practical steps can mitigate this impact illegal landfills and territorial pollution where a lack of information on illegal landfills and other local pollution sources results in their slow removal and the community rarely having the opportunity to report such issues promptly or track their resolution progress weak civic engagement in environmental initiatives due to underdeveloped mechanisms for motivating and incentivizing public participation limiting active involvement in activities aimed at improving the ecological situation and the need for information support and coordination of environmental activities where a centralized platform for citizens to find information on environmental events register for activities and receive reminders is frequently lacking.

To address these issues, an IT project for developing a mobile application is proposed, which will integrate functionality for reporting environmental problems, accessing educational content, and obtaining information about environmental events. This information system will facilitate the rapid recording of environmental issues, engage citizens in active participation in their resolution, and enhance awareness regarding environmental protection.

Competition in the field of ecology is increasing as environmental initiatives become more popular and the number of software applications used grows. However, most of them are aimed at general environmental tasks, which makes the proposed mobile application, with its focus on regional initiatives, unique and tailored to the specific needs of the community.

The most prevalent methodologies for engaging and retaining users of environmental initiative mobile applications encompass gamification. This involves rewards and achievements for active participation and task completion, incentivizing users to maintain consistent interaction with the application. Additionally, reminders and personalized notifications are crucial, where users receive alerts regarding new events, reminders for registered activities, and notifications concerning the resolution status of environmental issues. Social integration and communication are also vital, with the platform facilitating a forum for users to discuss environmental initiatives, exchange experiences, and provide mutual motivation. Finally, educational content plays a significant role, characterized by the continuous updating of an eco-news section, tips, and instructions, thereby generating valuable content that enhances users' environmental awareness.

This approach to mobile application development allows for the creation of not only an information platform but also an effective tool for uniting the community around environmental initiatives and supporting regional conservation efforts.

The scientific newness of the research lies in the development of a context-aware mobile information system that uniquely integrates several key aspects to empower regional environmental initiatives. Firstly, it introduces an interactive, user-driven platform for real-time reporting and monitoring of ecological issues, fostering direct community engagement in environmental stewardship. Secondly, the system combines this reporting functionality with a

comprehensive environmental event's module, streamlining participation in local conservation activities through integrated registration and notifications. Furthermore, the novelty is underscored by the systematic IT project lifecycle, encompassing comparative analysis, process modeling using UML, defined requirements, database design, and mobile application prototyping, all specifically tailored to the domain of regional environmental initiatives. Finally, the forward-looking consideration of artificial intelligence algorithms for future data analysis and trend prediction in environmental management distinguishes this work by anticipating advanced capabilities for informed decision-making and optimized ecological strategies.

### **3. Analysis of recent studies and publications**

Information systems are crucial tools for supporting various stages of regional environmental initiatives, including planning, implementation, monitoring, and evaluation [1]. They provide data and tools for identifying environmental issues within a region, such as pollution levels or resource depletion. Through information systems, environmental objectives can be established, and action plans can be developed for the implementation of initiatives. Geographic Information Systems (GIS) are particularly valuable for spatial planning and the visualization of environmental data, enabling the analysis of geographical aspects of environmental problems and initiatives [2]. Furthermore, information systems can incorporate modeling and simulation capabilities to forecast the outcomes of different environmental initiatives, aiding in making informed decisions regarding the most effective intervention strategies.

Information systems are also essential for supporting the implementation and coordination of regional environmental initiatives. They can facilitate coordination among various stakeholders, including government agencies, non-governmental organizations, businesses, and citizens [3]. Online platforms and portals, which are part of information systems, enable information sharing and collaboration among stakeholders, allowing them to stay informed about progress and coordinate their efforts. Mobile technologies and sensors, integrated into information systems, play a key role in data collection and real-time monitoring during the implementation of initiatives [4].

Monitoring and evaluation are integral components of successful environmental initiatives, and information systems play a crucial role in this regard. Information systems include environmental monitoring systems that collect data on key environmental indicators, such as air and water quality, biodiversity, and more. Data analysis and visualization tools, which are part of information systems, enable the assessment of the effectiveness of initiatives, identifying trends and patterns in environmental data [5]. Reporting and communication of monitoring results to stakeholders and the public, which is facilitated by the functionality of information systems, is also an important aspect [6].

In Ukraine, environmental monitoring systems exist, such as SaveEcoBot and Envimonitor, which provide information on air quality, radiation levels, and other environmental indicators [7, 8]. There are also initiatives related to the use of GIS for environmental management, for example, the ONOVA GIS HUB, which is used for documenting destruction and planning recovery [9].

Recent research in the field of information systems for regional environmental initiatives indicates a growing interest in the use of mobile technologies and interactive maps to support and promote such initiatives [10]. In particular, the significant potential of mobile applications in encouraging environmentally responsible behavior among various population groups, including youth, urban residents, and schoolchildren, should be emphasized. These applications often employ gamification, educational elements, and personal environmental impact tracking features to enhance user engagement and foster beneficial habits.

Interactive maps are a key component of many environmentally focused information systems, providing visualization of environmental issues, access to geospatial data, and the ability to report environmental threats. In mobile applications, they serve as effective tools for raising awareness, engaging citizens in environmental monitoring, and supporting decision-making in the field of sustainable development. The active use of mobile platforms allows for the involvement of a wide range of volunteers in collecting environmental data, expanding the capabilities of scientific research and enhancing public environmental awareness [11].

The development of effective mobile information systems for environmental initiatives requires consideration of technical aspects such as user-friendliness, GIS functionality integration, data security, and scalability. Analyzing user engagement and incentivizing behavioral change through the use of such applications is also crucial, where gamification, social features, and personalized feedback play a significant role. Particular attention should be paid to user registration and environmental event notification systems, which are important for the organization and coordination of regional initiatives. The specific context of Ukraine, with its environmental challenges exacerbated by the war, necessitates the development and implementation of information systems tailored to its unique needs. These systems can support damage assessment, resource management, and the implementation of green recovery strategies.

#### **4. Formulation of the purpose of the article**

The aim of this article is to develop an information system in the form of a mobile application designed for monitoring environmental problems, planning activities, and raising awareness about important regional environmental protection issues.

The primary task of the information system is to provide convenient access to environmental information and establish an interactive platform where users can report environmental issues, register for events, discuss initiatives, and exchange experiences. The system also aims to stimulate active citizen participation in conservation activities through gamification and information dissemination, thereby encouraging greater involvement in the protection of the region's ecology.

The scientific novelty of this proposed IT project is multifaceted, addressing key limitations in existing solutions and offering substantial advancements in environmental management. Unlike fragmented existing solutions, this approach delivers a unified and comprehensive platform that seamlessly integrates the reporting of environmental threats, real-time tracking of resolution progress, and active participation in ecological events. This holistic, user-centric design, embodied in an intuitive mobile application, significantly enhances community engagement and fosters a more streamlined, effective approach to environmental protection.

A core innovation is the system's interactive map of ecological issues. This feature not only allows for the real-time visualization of environmental threats, such as illegal landfills or water pollution, but crucially, enables users to track the resolution progress of their reported issues. This level of transparency and immediate feedback is a significant departure from many current systems, fostering greater accountability and empowering community members by making their impact visible. The proposed approach also lays a robust foundation for the future by explicitly considering the integration of artificial intelligence (AI) algorithms for data analysis and trend prediction. While the initial system focuses on data systematization through rigorous modeling and database design (as evidenced by the detailed UML diagrams), the planned AI incorporation represents a substantial scientific novelty. This forward-looking integration aims to transcend reactive problem-solving, moving towards proactive environmental management strategies that offer advanced insights and optimize decision-making capabilities, a critical gap in many existing environmental solutions.

## 5. Mathematical models for environmental initiatives

Developing a mobile application to support and promote regional environmental initiatives represents a pressing scientific and applied challenge in the field of computer science. This endeavor integrates methods from artificial intelligence, machine learning, spatial databases, and mobile technologies to effectively address complex environmental issues. The core of this task lies in creating an integrated digital platform that will foster increased environmental awareness among the population, coordinate volunteer activities, monitor environmental conditions, and optimize resource allocation for the implementation of nature conservation projects.

A mathematical model for the app's functionality can be represented by several interconnected components. Firstly, for efficient collection and analysis of environmental data, such as air and water quality or soil pollution levels, a data aggregation model  $D = \{d_1, d_2, \dots, d_n\}$  is employed. Here, each  $d_i$  is a feature vector characterizing a specific environmental parameter. This data can originate from sensors, user input, or open databases.

For identifying and classifying environmental problems, a machine learning model, such as a Support Vector Machine (SVM) or neural networks, is utilized. Let  $X$  be the input feature space, and  $Y = \{y_1, y_2, \dots, y_k\}$  be the set of environmental problem categories. The classification function  $f: X \rightarrow Y$  is then defined as  $f(x) = \text{argmax}_{y \in Y} P(y|x)$ , where  $P(y|x)$  is the probability that object  $x$  belongs to class  $y$ .

Resource allocation optimization for environmental initiatives can be modeled as a linear programming problem. Let  $R = \{r_1, r_2, \dots, r_m\}$  be the set of available resources, and  $P = \{p_1, p_2, \dots, p_l\}$  be the set of environmental projects. The objective is to maximize the total effectiveness of the projects subject to resource constraints:

$$\max \sum_{j=1}^l c_j x_j \quad (1)$$

subject to:

$$\sum_{j=1}^l a_{ij} x_j \leq r_i, \quad i \in \{1, \dots, m\}, \quad (2)$$

$$x_j \in \{0, 1\}, \quad j \in \{1, \dots, l\}, \quad (3)$$

where  $x_j$  equals 1 if project  $j$  is selected and 0 otherwise;  $c_j$  is the effectiveness of project  $j$ ; and  $a_{ij}$  is the amount of resource  $i$  required for project  $j$ .

Finally, for effective user interaction and coordination of volunteer activities, a social interaction graph  $G = (V, E)$  is used, where  $V$  is the set of users and  $E$  is the set of connections between them. Optimizing information dissemination and volunteer engagement can be analyzed using shortest path algorithms or clustering algorithms on the graph, allowing for the identification of active groups and target audiences for environmental campaigns. Thus, developing such a mobile application extends beyond mere programming, evolving into a comprehensive scientific and applied research endeavor that integrates advanced computer science methodologies to address pressing environmental challenges.

## 6. Presenting the main material

Currently, mobile applications in the field of ecology are gaining popularity due to the increasing awareness of the importance of environmental conservation. They assist users in monitoring their impact on nature, developing eco-friendly habits, and uniting people around environmental initiatives [12, 13, 14].

Litterati is a mobile application that engages users in documenting waste problems worldwide. Through photo capture and geolocation, users contribute to creating a map of polluted locations [15].

Too Good To Go is a web application aimed at reducing food waste by facilitating communication between users and stores that offer surplus products at discounted prices. While not directly addressing environmental problems, it promotes sustainable consumption and waste minimization [16].

EcoBuddy enables users to monitor their ecological footprint and participate in activities aimed at its reduction. The application provides tips, reminders, and rewards, thereby fostering motivation for environmentally responsible behavior among individuals [17].

iNaturalist is a conservation application that allows users to record their biodiversity observations, thereby contributing to a better understanding of local ecosystems [18].

Info Grove is utilized by cities and towns to inform residents about environmental issues, damaged infrastructure, and other concerns. It is beneficial for municipalities seeking to enhance feedback and communication with citizens [19].

When comparing the IT project with similar software products, it distinguishes itself by its ability to provide interactive participation and enhance user engagement in addressing these issues. One of its key advantages is the capacity to track the resolution status of environmental problems, which fosters a sense of real impact on change. Unlike most comparable applications that focus solely on reporting environmental issues, this information system enables users to observe progress in problem resolution, thereby serving as an additional incentive for participating in activities and reporting new issues.

Gamification within the information system will foster greater user engagement. Badges and rewards will provide motivation for users to participate in events and actively assist in addressing environmental issues. While other applications may offer limited forms of incentivization, only this IT project implements a comprehensive reward system, making the process interesting and engaging for people of all ages.

The information system will simplify the process of engaging in environmental activities through an integrated events calendar with registration capabilities. This allows users to easily discover events, register for participation, and receive reminders, significantly facilitating organization and enhancing participation in local initiatives. Furthermore, through extensive educational content and ecological tips, users can learn proper waste management practices, receive practical recommendations for reducing environmental impact, and become more knowledgeable in the field of ecology.

A key feature of the system is the presence of a platform for community interaction. Through a forum, the information system will provide space for exchanging ideas, discussing current issues, and proposing solutions. This fosters an active environmental community, promoting mutual support and experience sharing. The IT project will not only inform users but also unite them around environmental problems, encouraging them to take responsibility for their resolution.

The regional environmental initiative's information system is expected to enhance ecological awareness through educational content and timely information on environmental issues, empowering users to identify solutions and adopt environmentally responsible behaviors. Furthermore, it will drive community engagement in proactive measures through an event calendar and reminder system, encouraging participation in activities such as clean-up campaigns,

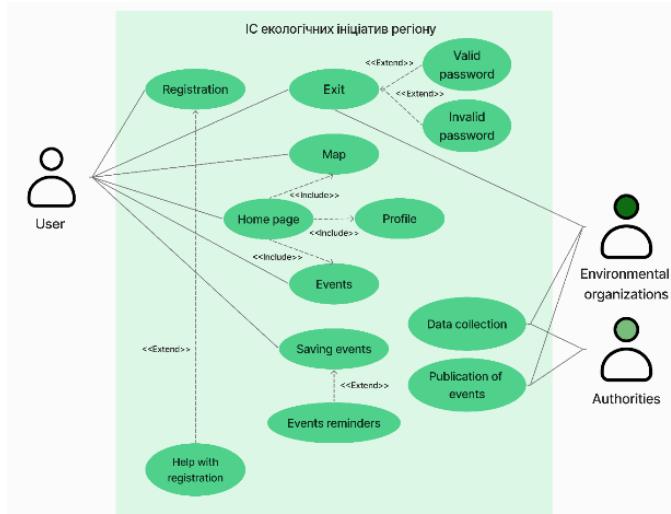
tree planting, and other initiatives, thereby increasing public involvement. Effective monitoring of environmental problems will be facilitated by an interactive map with issue-reporting and resolution-tracking capabilities, providing authorities and activists with comprehensive data for rapid response.

The core functionalities of the information system include:

- user registration and authorization: the system provides the ability to register new users and authorize existing ones;
- data collection on environmental problems and initiatives: users can add information about environmental problems (e.g., illegal landfills, water pollution) with geolocation, photo, and description;
- information displays on an interactive map: the system displays current data on a map, where users can view environmental problems and initiatives in real-time;
- event calendar and event registration: organizers of environmental events can add new events to the calendar, allowing users to view upcoming events (e.g., clean-up campaigns, tree planting) and register for participation;
- notifications and reminders: the system sends users notifications about upcoming events and reminders for events they have registered for;
- gamification and rewards: users receive badges for adding new initiatives, participating in events, and engaging in forums.

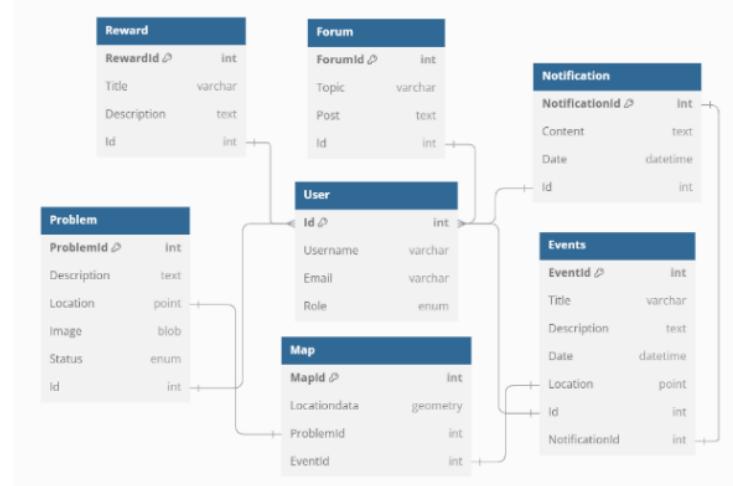
These steps can be adapted and expanded according to the specific requirements and needs of users. Furthermore, it is crucial to ensure data security, ease of use, and high system performance.

The next stage in the information system design is the construction of UML diagrams using the Unified Modeling Language, which is an integral part of graphical representation. Figure 1 illustrates the use case diagram, which delineates the system's usage scenarios and its users performing specific functions.



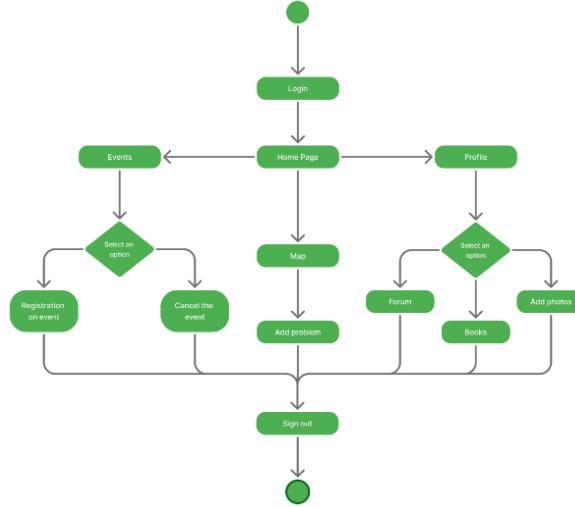
**Figure 1:** UML use case diagram.

The UML class diagram of objects, which implement the core operational processes of the information system developed in the IT project, is depicted in Figure 2.



**Figure 2:** UML diagram of object classes.

Subsequently, a state and transition diagram was designed to visualize the behavior of the system or its individual components. Figure 3 depicts the UML state diagram of the overall functionality of the regional environmental initiatives information system.



**Figure 3:** UML states diagram.

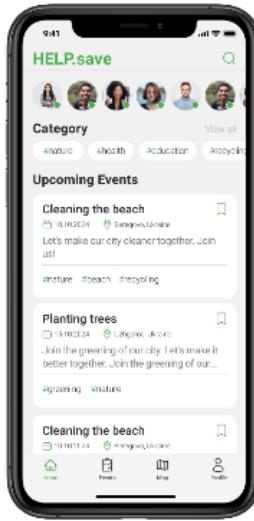
A prototype of an information system is a rapid and straightforward method to articulate an application concept. The demonstration of a prototype facilitates the visualization of the interface design and logic. Figure 4 illustrates a prototype of a mobile application for an information system dedicated to regional environmental initiatives.

The initial screen of the mobile application features the title, logo, several authentication options (Google, Facebook), and registration capabilities.



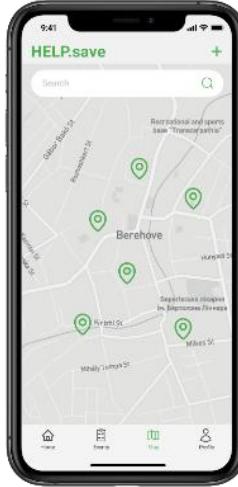
**Figure 4:** Prototype of the mobile application's initial screen.

Figure 5 depicts the application's main screen, where users can view upcoming events and select event categories for personalized recommendations. Each event includes: title, date, location, and a brief description. A tab bar is located at the bottom of the screen, enabling users to navigate through the application.



**Figure 5:** Prototype of the mobile application's main screen.

Figure 6 illustrates a screen displaying a map of environmental issues, which are visualized on the map. Additionally, users can contribute their own initiatives by tapping the "+" icon located in the upper right corner of the screen.



**Figure 6:** Prototype of the mobile application's map interface.

Consequently, this information system, designed to support regional environmental initiatives, represents a pivotal advancement in cultivating public ecological consciousness and promoting active civic engagement in mitigating environmental challenges. The system's deployment is anticipated to catalyze the formation of an environmentally conscientious society by providing a robust platform for seamless communication among citizens, organizations, and local governance bodies. Integrating interactive functionalities, including a spatially referenced environmental issue mapping interface, an event scheduling and management module, educational resource dissemination, and gamified participation mechanisms, users are empowered to not only access real-time environmental data but also to directly contribute to remediation efforts. Furthermore, the incorporation of AI algorithms for predictive analytics, anomaly detection, and personalized user engagement is proposed. This will enable the system to automatically identify environmental hotspots, forecast potential ecological risks, and tailor educational content and engagement strategies to individual user profiles, thereby optimizing the efficacy of regional environmental initiatives and fostering a data-driven approach to sustainable development.

## 7. Conclusions

This study investigates the fundamental architectural and functional paradigms of an IT project, specifically an information system realized as a mobile application, tailored to facilitate and augment regional environmental initiatives. The primary analytical focus is directed towards the application's core functionalities, notably an interactive geospatial mapping interface for environmental issue reporting. This interface empowers users to contribute geo-referenced event data, including multimedia documentation and descriptive metadata, and to monitor the resolution lifecycle of reported environmental anomalies. Concurrently, the system integrates an event calendaring module, enabling citizens to register for, receive notifications regarding, and access comprehensive details concerning environmental events, thereby promoting active civic participation in regional ecological stewardship.

A comparative analysis of the proposed IT project against extant software solutions was performed, revealing distinct advantages such as integrated issue resolution tracking and a gamified incentivization framework for user engagement. These features are designed to enhance the system's appeal to a diverse user base, fostering not only information dissemination but also tangible contributions to environmental remediation.

The conceptual modeling of this information system was executed utilizing the Unified Modeling Language, resulting in the development of comprehensive use case, class, and state

diagrams. These diagrams elucidate the system's structural composition and the interactive dynamics between users and core application components. The use case diagram delineates user interaction patterns, specifically focusing on event registration, issue reporting, and experience sharing. The class diagram outlines the system's object-oriented architecture, defining attributes and relationships to ensure data integrity and processing efficiency. The state diagram models the dynamic state transitions inherent in the system's operational lifecycle. Furthermore, the integration of AI algorithms for anomaly detection, spatial data analysis, and predictive modeling is proposed. This will enable the system to automatically identify environmental degradation patterns, forecast potential ecological risks, and optimize resource allocation for remediation efforts. AI-driven personalized recommendations for user engagement, based on behavioral analytics, are also considered to enhance user participation and system effectiveness.

Therefore, this information system is designed to elevate environmental awareness, stimulate citizen participation in ecological initiatives, and provide a robust platform for collaborative interaction between environmental activists and organizations. The deployment of the information system is projected to enhance the efficacy of regional environmental initiatives, foster collaborative civic engagement, and contribute to the amelioration of environmental conditions. This underscores the imperative for continued development and support of such digital solutions in pursuit of a sustainable future.

## **Declaration on Generative AI**

The authors have not employed any Generative AI tools.

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