e-ISSN 2621-8062
Elipsoida : Jurnal Geodesi dan Geomatika
Vol 09 No 01, (2026)

WEBGIS-BASED ONLINE MULTI-HAZARD COASTAL MAPPING IN DEMAK REGENCY, INDONESIA

Harjayanti Nasfa Isyfa'lana[1*], Muhammad Abraham Haris Pramudya Teja Sakti[1], Arief Laila Nugraha[1], Moehammad Awaluddin[1], Fauzi Janu Amarrohman[1]
[1]Department of Geodetic Engineering, Faculty of Engineering, Diponegoro University, Semarang, Indonesia, 50275
Corresponding author(s) e-mail: harjayantin@gmail.com*

(Received 19 June 2026, Accepted 30 Juli 2026, Published 31 Juli 2026)
DOI: https://doi.org/10.14710/elipsoida.2026.33191

ABSTRACT
Demak Regency is a coastal area along the northern coast of Java that is increasingly exposed to environmental pressure from natural processes and human activities, resulting in coastal multi-hazards. Previous studies have mainly focused on single-hazard assessments and have not sufficiently integrated a multi-hazard approach. This study applies the Coastal Hazard Wheel (CHW) 3.0 method to identify coastal multi-hazard levels in Demak Regency and presents the results through an interactive WebGIS platform. The WebGIS, publicly accessible at https://bit.ly/CHWDemakWebGIS, is developed as a single portal using ArcGIS Experience Builder. The system consists of a Home page built with ArcGIS StoryMap providing an overview of the study area and methodology, an Interactive Map using ArcGIS Web Map for spatial visualization of coastal multi-hazard distribution, a Dashboard presenting statistical information in graphical form, and a Usability Testing module using ArcGIS Survey123 to evaluate user experience. Evaluation was conducted through program testing and usability testing. Results indicate that all system functions operate properly across smartphones, laptops, and multiple web browsers without functional errors. Usability evaluation produced an average score of 4.66, categorized as excellent. The integration of CHW 3.0 and WebGIS is expected to support effective identification, visualization, and management of coastal multi-hazards in Demak Regency.

Keywords : ***Coastal Hazard Wheel (CHW), Coastal Area of Demak Regency, GIS, Multi-Hazard, WebGIS.***

1. INTRODUCTION

Coastal areas play a vital role in supporting ecological, social, and economic functions that sustain human livelihoods (Sari et al., 2025). However, these regions are increasingly vulnerable to various hazards resulting from climate change and anthropogenic activities (Irsadi et al., 2022). Demak Regency, located on the northern coast of Java, Indonesia, is recognized as one of the areas with a high level of vulnerability to coastal disasters (Primasti et al., 2021).

Previous studies have shown that the coastal zone of Demak is exposed to multiple hazards, including tidal flooding, coastal erosion, and significant shoreline changes (Chrysanti et al., 2024; Irsadi et al., 2022). In Sayung District, the extent of tidal inundation has increased due to sea-level rise and land subsidence (Khairullah et al., 2024). These conditions have resulted in the loss of settlements, infrastructure, aquaculture ponds, and mangrove ecosystems (Fikriyah & Dewa, 2025).

Geographic Information Systems (GIS) and WebGIS have been widely applied in coastal disaster risk assessment and mitigation because they provide effective spatial visualization to support decision-making processes (Lathifah et al., 2024; Rahadiati et al., 2022). Nevertheless, the integration of the Coastal Hazard Wheel (CHW) method into GIS-based coastal multi-hazard analysis remains limited, particularly in Indonesia.

In response to this gap, this study aims to develop and present a GIS-based online multi-hazard coastal map for Demak Regency through an interactive WebGIS platform. The proposed system is expected to support coastal hazard mitigation, spatial planning, and sustainable coastal zone management.

2. DATA DAN METHODS

2.1 Study Area

Demak Regency is one of the regencies in Central Java Province, Indonesia, geographically located between 6°43'26"–7°09'43" South Latitude and 110°27'58"–110°48'47" East Longitude. Astronomically, the regency is situated along the northern coast of Java Island and is directly bordered by the Java Sea to the north. The study area covers approximately 67.975 km of coastline extending from Babalan Village to Sriwulan Village and encompasses several coastal districts within Demak Regency.

The analysis was conducted within a coastal zone extending 500 m inland from the digitized 2025 shoreline. The study area was subsequently divided into grid-based analysis units measuring 100 m × 100 m using the *Grid Index Features* tool. The resulting spatial grid is presented in **Figure 1**.

2.2 Research Tools and Data

The research employed both hardware and software components to support data processing, WebGIS development, and system evaluation. The tools used in this study are described as follows:

1. Hardware
   The hardware used in this study included a Lenovo IdeaPad Gaming 3 laptop for data processing, coastal multi-hazard map development, and WebGIS testing, as well as a smartphone for evaluating the functionality and usability of the WebGIS platform.
2. Software
   The software and platforms utilized in this study are described as follows:
   a. ArcMap 10.8 was used for data processing and the preparation of coastal multi-hazard datasets, which were subsequently stored in a geodatabase.
   b. ArcGIS Online served as a web-based platform for managing, storing, and sharing spatial data, as well as integrating supporting applications such as Web Map, Dashboard, and Story Map for coastal multi-hazard map presentation.
   c. ArcGIS StoryMap was used to develop introductory content and provide general information regarding the background, objectives, and methodology of the coastal multi-hazard mapping process in Demak Regency.
   d. ArcGIS Web Map was employed to display the processed spatial data and multi-hazard mapping results in an interactive format.
   e. ArcGIS Dashboard was used to present statistical information related to coastal hazard and multi-hazard conditions in a concise and informative manner.
   f. ArcGIS Survey123 was utilized to design questionnaires and conduct user experience assessments of the developed WebGIS application.

All datasets used in this study were obtained under open-access licensing agreements that permit their use for academic and research purposes (Raha & Deb, 2025).

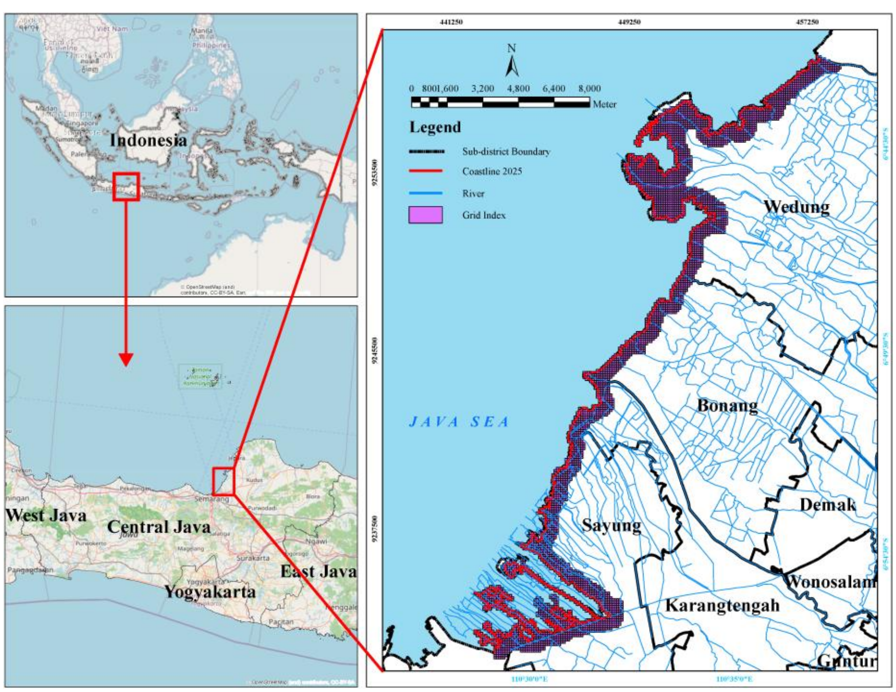


Figure 1. Study Area

2.3 Research Workflow

The research workflow provides a general overview of the stages and procedures carried out in this study.

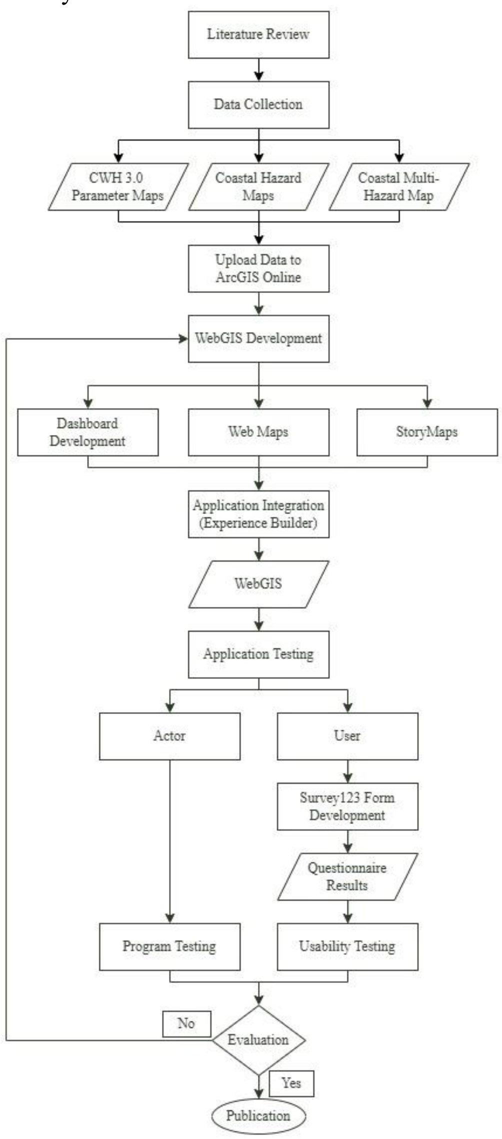


Figure 2. Research Workflow

2.4 Research Procedure

The research procedure is summarized in the research workflow. Error! Reference source not found. illustrates the research stages, beginning with a literature review and data collection. The datasets used in this study include Coastal Hazard Wheel (CHW) 3.0 parameter maps, coastal hazard maps, and coastal multi-hazard maps generated from the analysis. Subsequently, all datasets were uploaded to ArcGIS Online for further visualization and integration. Error! Reference source not found. presents the WebGIS development workflow, including application development, feature integration, and system feasibility evaluation.

2.4.1 Literature Review

A literature review was conducted through an examination of previous studies related to coastal hazards at both global and national scales. The review aimed to identify relevant references, examine recent research developments, and establish the theoretical foundation of this study. Previous studies have demonstrated that the Coastal Hazard Wheel (CHW) method can effectively identify and spatially map coastal hazard levels based on the physical and environmental characteristics of coastal areas. Furthermore, the method can support the development of mitigation strategies and coastal zone management practices (Alwi et al., 2025; Su et al., 2021). In Demak Regency, high coastal vulnerability is influenced by shoreline changes, low-lying topography, and the degradation of mangrove cover, which increase the potential for coastal erosion and tidal flooding (Fikriyah & Dewa, 2025; Primasti et al., 2021). To facilitate the dissemination of coastal hazard information, WebGIS can be employed as an interactive and accessible visualization platform, enabling users to better understand coastal conditions and supporting decision-making processes (Capolupo et al., 2021; Raharjo et al., 2023). Therefore, this study integrates the Coastal Hazard Wheel (CHW) method with WebGIS technology to analyze and visualize coastal multi-hazards in Demak Regency.

2.4.2 Data Collection

This study employed the Coastal Hazard Wheel (CHW) version 3.0 method to analyze coastal hazards based on the physical and environmental characteristics of coastal areas. The parameters used in the analysis include geological layout, wave exposure, tidal range, flora/fauna, sediment balance, and storm climate. Based on these parameters, the CHW method generates five categories of coastal hazards: ecosystem disruption, gradual inundation, saltwater intrusion, erosion, and flooding. Subsequently, the hazard categories were integrated to derive a coastal multi-hazard index, which was then classified into four hazard levels: low, moderate, high, and very high. The resulting datasets were used in the WebGIS development process and uploaded to the ArcGIS Online platform for visualization and dissemination purposes (Handifa et al., 2023).

2.4.3 WebGIS Development

In web-based systems, processed data can be presented in a visual format, enabling users to understand information more effectively (Adisti et al., 2025). The WebGIS was developed through the following stages.

1. The home page was created using ArcGIS StoryMaps to provide an overview of the study area, the background of coastal issues in Demak Regency, the analytical method employed (CHW 3.0), and information about the developers of the application.
2. The interactive map was developed using ArcGIS Web Map to display the processed spatial data in an interactive format that can be widely accessed by the public (Raharjo et al., 2023). This page incorporates various features and widgets designed to facilitate user interaction and improve the accessibility, interactivity, and informativeness of the presented information (Odi Nugrahanto et al., 2021).
3. The dashboard was created using ArcGIS Dashboard to present statistical information related to coastal hazard and multi-hazard potential in a concise and informative manner through visual elements such as charts and tables (Adisti et al., 2025).
4. A usability assessment page was developed using ArcGIS Survey123 to evaluate the ease of use of the system from the users' perspective. The evaluation was based on Jakob Nielsen's usability framework, which consists of five key components: *learnability, efficiency, memorability, errors,* and *satisfaction* (Pardjono et al., 2024).
5. All components of the coastal multi-hazard visualization system were integrated into a single portal using ArcGIS Experience Builder, providing a unified platform for information access, visualization, and user interaction.

2.4.4 Application Feasibility Testing

In WebGIS development, a testing process is required to ensure that the application functions properly and meets user requirements. Application feasibility testing generally consists of two types of evaluation: functionality testing and usability testing.

1. Functionality testing was conducted by the administrator through direct operation of the application on two types of devices, namely laptops and smartphones, using different web browsers to verify the performance and compatibility of the system (Handifa et al., 2023).
2. Usability testing was conducted to evaluate the ease of use of the system based on user experience. This evaluation aimed to determine whether the application was effective, efficient, and easy to understand, as well as to identify the strengths and weaknesses of the developed system (Handifa et al., 2023; Pardjono et al., 2024). The usability assessment was carried out through questionnaire distribution to respondents. The questionnaire employed a five-point Likert scale, as presented in **Table 1** The collected responses were then converted into mean scores to determine the system feasibility level based on the classification shown in **Table 2** (Pardjono et al., 2024).

Table 1. Questionnaire Assessment

Category	SD	D	N	A	SA
Score	1	2	3	4	5

Description:

SD : Strongly Disagree
D : Disagree
N : Neutral
A : Agree
SA : Strongly Agree

Table 2. Mean Square Classification

No	Category	Score Range
1.	Very Poor	0 < x < 1
2.	Poor	1 < x < 2
3.	Fair	2 < x < 3
4.	Good	3 < x < 4
5.	Very Good	4 < x < 5

3. RESULT AND DISCUSSION

3.1 Result and Analysis of the WebGIS Application

The results of this study are presented through a WebGIS application that can be easily accessed via the internet using various devices, including desktop computers and smartphones, through the following link: https://bit.ly/CHWDemakWebGIS. This WebGIS platform facilitates the presentation of coastal multi-hazard classification results, enhances spatial interpretation, and broadens access to information for stakeholders. By providing an interactive and user-friendly interface, the system enables users to explore spatial data and better understand the distribution of coastal hazards in Demak Regency. The developed WebGIS is expected to contribute to the provision of coastal hazard information, support sustainable coastal zone management, and assist local communities and government agencies in implementing mitigation and adaptation measures in response to environmental change.

3.2 Result and Analysis of the Story Map Application

The Story Map application was developed to provide an introduction and general overview of the background, objectives, and development process of the GIS-based coastal multi-hazard map for Demak Regency. Through a structured and narrative presentation, the Story Map enables users to understand the context of the study, the analytical methods employed, and the workflow used to process the data and generate coastal hazard and multi-hazard maps. By integrating textual descriptions and visual elements, the Story Map presents information in a more communicative and user-friendly manner. This approach enhances users' understanding of the study and facilitates access to information for a wide range of audiences, including researchers, policymakers, and the general public.

Figure 3. Initial Interface of the StoryMap

The Story Map presents information on the conditions and multi-hazard potential of the coastal area of Demak Regency in a structured and narrative format. As shown in **Figure 3**, the information is organized into several sections accessible through the navigation bar, including an overview of the study area, the background of coastal issues in Demak Regency, the analytical methods employed, the research workflow, the analysis process and results, and information about the application developers. The navigation menu is designed to facilitate user access and enable efficient movement between information sections, thereby improving the overall usability and accessibility of the application.

3.3 Result and Analysis of the Web Map Application

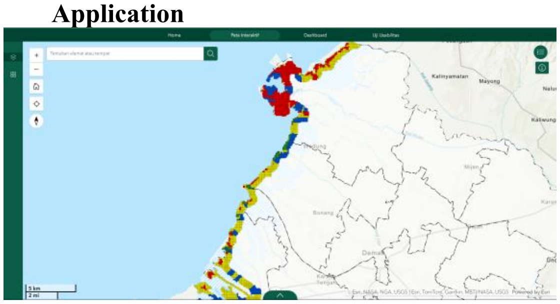


Figure 4. Initial Interface of the Web Map

The Web Map was developed to display the processed spatial data in an interactive format, enabling broad public access to coastal hazard information. The map provides comprehensive information, including the classification results of individual Coastal Hazard Wheel (CHW) parameters, coastal hazard potential maps derived from these parameters, and the coastal multi-hazard potential map of Demak Regency.

As shown in **Figure 4** and **Figure 5**, the Web Map incorporates various features and widgets designed to facilitate user interaction with the application, thereby enhancing the effectiveness and interactivity of information delivery. These tools enable users to explore spatial data more efficiently and support a better understanding of coastal hazard conditions in the study area. The available features and widgets of the application are described as follows.

1. Navigation Panel
   The navigation panel consists of several tools designed to facilitate map interaction and navigation. The Zoom In (+) tool is used to enlarge the map view, allowing users to examine specific areas in greater detail. Conversely, the Zoom Out (-) tool reduces the map scale, enabling users to view a broader geographic extent. The Default Map View tool restores the map to its initial display extent, while the Find My Location tool allows users to identify their current location directly on the map. In addition, the Reset Map Orientation tool returns the map orientation to its default position (north-up), thereby improving map readability and facilitating more accurate navigation.
2. Search
   The search tool is used to quickly locate specific places or features on the map. This functionality enables users to efficiently identify the desired area without having to manually navigate the map, thereby improving accessibility and user experience.
3. Basemap Gallery
   The basemap gallery allows users to change the underlying map display according to their needs and preferences. Various basemap options are available, including satellite imagery, topographic maps, and street maps, providing flexibility for data visualization and interpretation.
4. Layer List
   The layer list provides users with the ability to control the visibility of map layers by activating or deactivating selected datasets. This functionality enables information to be displayed selectively, allowing users to focus on specific spatial data relevant to their needs

and facilitating more effective map exploration and analysis.

5. Legend
   The legend assists users in interpreting the symbols, colors, and classifications displayed on the map. By providing explanations for each map element, the legend facilitates a clearer understanding of the spatial information presented and supports accurate interpretation of coastal hazard and multi-hazard data.
6. Information
   The information panel provides guidance on the use of the WebGIS application, enabling users to better understand its features and functionalities. This component helps users utilize the application more effectively and enhances the overall user experience.
7. Attribute Table
   The attribute table is used to display detailed information about spatial features or locations shown on the map in a tabular format. This functionality allows users to access and examine attribute data associated with each feature, thereby supporting more comprehensive spatial analysis and data interpretation.
8. Pop-Up Feature
   The pop-up feature is used to display detailed information about a specific spatial feature or location when a user selects an area on the map. The information presented may include attribute data, such as parameter values, hazard classifications, and other relevant details. This functionality enables users to examine location-specific information more comprehensively and enhances their understanding of the spatial characteristics represented on the map.

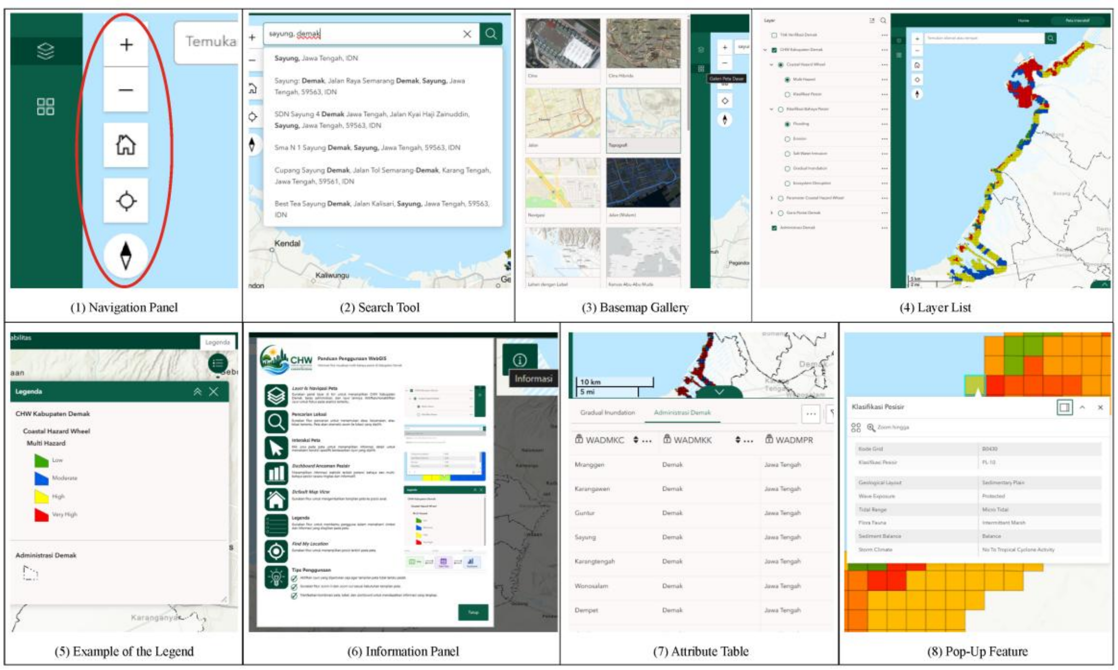


Figure 5. Features and Widgets of the Application

3.4 Result and Analysis of the Dashboard Application

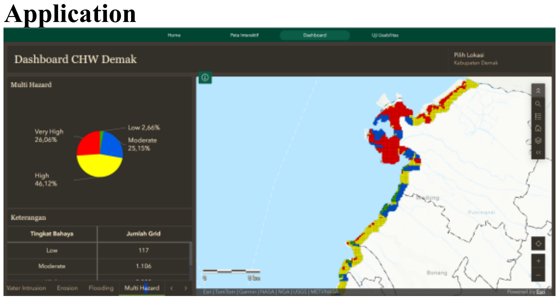
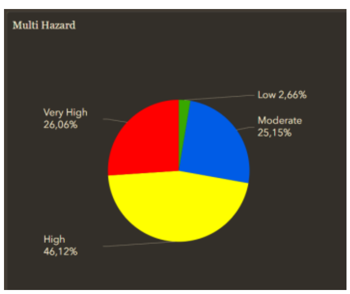


Figure 6. Dashboard Interface

The Dashboard was developed to present statistical information related to coastal hazard and multi-hazard potential in a concise and informative manner. The displayed statistics include the distribution of hazard levels across Demak Regency as well as detailed information for each district within the study area. Through the location selection feature, users can display specific data for a selected district, as illustrated in **Figure 6** and **Figure 7**.

Several features and widgets available in the dashboard are similar to those provided in the Web Map application. In addition to these shared functionalities, the dashboard includes several additional features, which are described as follows.

1. Pie Chart
   The pie chart is designed to display the proportion or percentage of each hazard-level category within a selected area in a visual format. By using a pie chart, users can easily compare the distribution of hazard levels and identify the dominant hazard category in the displayed area. This visualization facilitates data interpretation and improves understanding of the spatial distribution of coastal hazards and multi-hazards.
2. Information Table
   The information table is intended to present detailed information on the number of grid cells within each hazard-level category in a structured and quantitative manner. Through this table, users can identify the exact number of grid cells associated with each hazard class, thereby complementing the visual information provided by the pie chart. This feature enhances the accuracy of data interpretation and supports a more comprehensive understanding of hazard distribution patterns within the study area.
3. Select Location
   The Select Location feature allows users to choose a specific study area at the district level. Once a location is selected, all information displayed on the map and dashboard is automatically updated according to the chosen area. This functionality enables users to perform more focused analyses of coastal hazard and multi-hazard potential and obtain information that is relevant to their specific area of interest.
4. Select a Tab
   The Select a Tab feature is used to choose the type of coastal hazard information displayed on the dashboard. Through this feature, users can switch between different hazard categories, including *ecosystem disruption, gradual inundation, saltwater intrusion, erosion, flooding,* and *multi-hazard*. As a result, users can more easily explore and understand each hazard type according to their information needs.

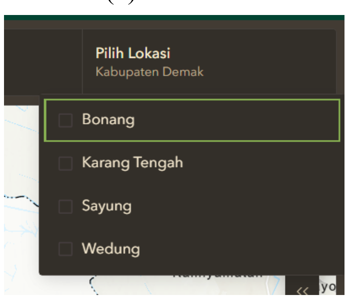


(1) Pie Chart

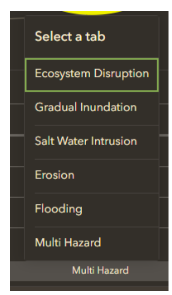
Keterangan

Tingkat Bahaya	Jumlah Grid
Low	117
Moderate	1.106
High	2.028
Very High	1.146

(2) Information Table



(3) Select Location



(4) Select a Tab

Figure 7. Features and Widgets of the Dashboard

3.5 Results and Analysis of Application Feasibility Testing

Application feasibility testing is an essential stage in the system development process to ensure that the developed application functions properly and meets user requirements. This evaluation not only focuses on technical aspects but also considers system compatibility across different devices and the overall user experience during operation.

3.5.1 Functionality Testing

Functionality testing was conducted on desktop computers and smartphones to evaluate system performance across different devices. As a web-based application, testing was also performed using multiple browsers to assess compatibility and functionality. The results were analyzed to verify that all features operated as intended and to identify any device- or browser-specific issues. A summary of the testing results is presented in **.**

Based on the functionality testing results presented in Error! Not a valid bookmark self-reference., the WebGIS application demonstrated satisfactory performance across two different screen sizes. The testing was conducted using two types of devices: a desktop computer and a smartphone. The desktop device was a Lenovo IdeaPad Gaming 3 laptop with a 15.6-inch display and a resolution of 1920 × 1080 pixels, while the mobile device was an iPhone 14 Pro with a 6.1-inch display and a resolution of 2556 × 1179 pixels. These different screen resolutions were used to evaluate the application's ability to adapt its interface to both large and small displays.

WebGIS was tested using multiple web browsers, including Google Chrome, Mozilla Firefox, Opera, Microsoft Edge, Safari, and Opera Mini, on both desktop and smartphone devices.
Based on the testing results, the application operated successfully across all browsers without significant compatibility issues. The WebGIS interface remained well structured, all features functioned properly, loading performance was smooth, and no functional errors were encountered on either device. On the desktop, map visualization and feature exploration were more effective due to the larger display area, providing a more comfortable and comprehensive user experience. Meanwhile, the application remained fully accessible and functional on smartphones, although navigation was relatively less convenient because of the smaller screen size. These results indicate that the developed WebGIS is compatible with various browsers and devices, while desktop access is recommended for users seeking a more optimal WebGIS experience.

Table 3.

Based on the functionality testing results presented in Error! Not a valid bookmark self-reference., the WebGIS application demonstrated satisfactory performance across two different screen sizes. The testing was conducted using two types of devices: a desktop computer and a smartphone. The desktop device was a Lenovo IdeaPad Gaming 3 laptop with a 15.6-inch display and a resolution of 1920 × 1080 pixels, while the mobile device was an iPhone 14 Pro with a 6.1-inch display and a resolution of 2556 × 1179 pixels. These different screen resolutions were used to evaluate the application's ability to adapt its interface to both large and small displays.

WebGIS was tested using multiple web browsers, including Google Chrome, Mozilla Firefox, Opera, Microsoft Edge, Safari, and Opera Mini, on both desktop and smartphone devices.
Based on the testing results, the application operated successfully across all browsers without significant compatibility issues. The WebGIS interface remained well structured, all features functioned properly, loading performance was smooth, and no functional errors were encountered on either device. On the desktop, map visualization and feature exploration were more effective due to the larger display area, providing a more comfortable and comprehensive user experience. Meanwhile, the application remained fully accessible and functional on smartphones, although navigation was relatively less convenient because of the smaller screen size. These results indicate that the developed WebGIS is compatible with various browsers and devices, while desktop access is recommended for users seeking a more optimal WebGIS experience.

Table 3. Functionality Testing Result

No	Device	Browser	Display	Functional Features	Smooth Loading	Errors Occurred
1.	Desktop	Google Chrome	Appropriate	Yes	Yes	No
2.		Mozilla Firefox	Appropriate	Yes	Yes	No
3.		Opera	Appropriate	Yes	Yes	No
4.		Microsoft Edge	Appropriate	Yes	Yes	No
5.	Smartphone	Google Chrome	Appropriate	Yes	Yes	No
6.		Firefox	Appropriate	Yes	Yes	No
7.		Safari	Appropriate	Yes	Yes	No
8.		Opera Mini	Appropriate	Yes	Yes	No

3.5.2 Usability Testing

Usability testing was conducted by distributing the WebGIS application to respondents and allowing them to directly interact with the available features. After completing the interaction process, respondents were asked to complete a questionnaire to evaluate their user experience with the application. The questionnaire was developed using ArcGIS Survey123 and covered all evaluation aspects included in the usability assessment. Responses were measured using a five-point Likert scale to obtain quantitative scores for each

Table 4.

Table 4, a total of 60 respondents participated in the evaluation, consisting of 19 members of the general public and 41 university students. The devices used to access the WebGIS application included 13 laptops and 47 smartphones. The assessment results indicated that all usability aspects were classified within the Very Good category. The highest average score was obtained for the Satisfaction aspect (4.74), while the lowest average score was recorded for Memorability (4.60). Overall, the WebGIS application achieved an average usability score of 4.66, indicating a very high level of user acceptance. Despite the positive evaluation results, respondents provided several recommendations for further improvement. The question.The usability test results were subsequently analyzed to evaluate the overall quality of the application and identify aspects that may require further improvement. A summary of the usability testing results is presented in

Based on the usability testing results presented in
application was generally perceived as informative and easy to use; however, enhancements to the user interface design, font selection, and responsiveness on mobile devices were suggested. In addition, several technical issues, such as pop-up windows that were difficult to close, were identified and should be addressed in future development. Respondents also recommended improving the clarity of the relationships among hazard indicators, legends, and hazard classifications. Furthermore, additional features were proposed, including affected land-use layers, risk information related to residential areas, administrative labels at the village level, and more user-friendly guidance for operating the application.

Table 4. Usability Testing Results

Evaluation Aspect	ID	Scale					Item Score	Asoect Score	Category
		1	2	3	4	5			
Learnability	A1	1	0	2	12	45	4,67	4,65	Very Good
	A2	0	0	2	17	41	4,65		
	A3	1	0	1	18	40	4,60		
	A4	1	0	0	16	43	4,67		
Efficiency	B1	0	0	1	21	38	4,62	4,67	Very Good
	B2	0	0	0	20	40	4,67		
	B3	0	0	0	17	43	4,72		
	B4	0	0	2	15	43	4,68		
Memorability	C1	0	0	1	18	41	4,67	4,60	Very Good
	C2	0	0	2	18	40	4,63		
	C3	0	0	2	21	37	4,58		
	C4	0	0	3	25	32	4,48		
	C5	0	0	1	20	39	4,63		
Errors	D1	0	0	0	18	42	4,70	4,66	Very Good
	D2	0	0	2	20	38	4,60		
	D3	0	0	1	17	42	4,68		
Satisfaction	E1	0	0	1	9	50	4,82	4,74	Very Good
	E2	0	0	2	16	42	4,67		
	E3	0	0	2	13	45	4,72		
	E4	0	0	0	13	47	4,78		
	E5	0	0	1	16	43	4,70		
Average								4,66	Very Good

4. CONCLUSION

This study demonstrates that the Coastal Hazard Wheel (CHW) method can effectively identify and spatially represent variations in coastal hazard levels across different hazard types and locations in Demak Regency. The resulting coastal multi-hazard information was successfully visualized through an interactive and accessible WebGIS platform. The developed WebGIS enables users to visualize the spatial distribution of coastal hazard levels, compare conditions across different locations, and better understand the relationship between coastal characteristics and hazard levels.

The evaluation results indicate that the WebGIS application performs effectively on both desktop and smartphone devices, although desktop access provides a more optimal environment for map visualization and feature exploration. Therefore, the WebGIS serves not only as a platform for spatial information dissemination but also as a tool for communicating coastal hazard information to communities and stakeholders.

Overall, this study contributes to the advancement of coastal hazard assessment through the integration of the Coastal Hazard Wheel (CHW) method and WebGIS technology. This integration provides detailed, accessible, and user-friendly coastal multi-hazard information that can support mitigation planning and sustainable coastal zone management. Compared with conventional static maps, the WebGIS platform enhances the accessibility and usability of spatial information, thereby supporting more informed and effective decision-making for coastal hazard management in Demak Regency.

ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the Indonesian Geospatial Information Agency (BIG), the Geological Agency of the Ministry of Energy and Mineral Resources of Indonesia, the Copernicus Data Space Ecosystem, the Copernicus ECMWF Climate Data Store (CDS), and CHIRPS for providing the datasets used in this study. In addition, the authors would like to thank the coastal community respondents who participated in the field verification interviews, the respondents involved in the WebGIS usability testing, and all individuals who contributed valuable assistance and feedback during the preparation of this manuscript.

REFERENCES

Adisti, K. P., Nugraha, I., Industri, T., Teknik, F., Sains, D., Timur, J., Rungkut, J., No, M., Gn, K., & Anyar, S. (2025). *Implementasi sistem dashboard untuk visualisasi data monitoring penagihan dengan menggunakan Google Loocker Studio. Jati (Jurnal Mahasiswa Teknik Informatika)*, 9(2), 1854–1861.

Alwi, M., Mutaqin, B. W., & Marfai, M. A. (2025). *Coastal management based on multi-hazard assessment in the very small islands of Karimunjawa, Indonesia*. *Anthropocene Coasts,* 8(1). https://doi.org/10.1007/s44218-025-00069-x

Capolupo, A., Monterisi, C., Saponieri, A., Addona, F., Damiani, L., Archetti, R., & Tarantino, E. (2021). *An interactive webgis framework for coastal erosion risk management. Journal of Marine Science and Engineering*, 9(6). https://doi.org/10.3390/jmse9060567

Chrysanti, A., Adhani, A., Azkiarizqi, I. N., Adityawan, M. B., Kusuma, M. S. B., & Cahyono, M. (2024). *Assessing compound coastal–fluvial flood impacts and resilience under extreme scenarios in Demak, Indonesia. Sustainability (Switzerland),* 16(23). https://doi.org/10.3390/su162310315

Fikriyah, I., & Dewa, J. J. P. K. (2025). *Evaluation mangrove density on the north coast as a means of mitigation danger tidal flood: Case study of Demak Regency*. *Jurnal Ilmiah Telsinas Elektro, Sipil Dan Teknik Informasi*, 8(1), 74–83. https://doi.org/10.38043/telsinas.v8i1.6132

Handifa, M. A., Nugraha, A. L., & Sasmito, B. (2023). *Aplikasi WebGIS ancaman bencana banjir di Kecamatan Sayung, Kabupaten Demak. Jurnal Geodesi Undip*, 12(1), 11–19.

Irsadi, A., Martuti, N. K. T., Abdullah, M., & Hadiyanti, L. N. (2022). *Abrasion and accretion analysis in Demak, Indonesia coastal for mitigation and environmental adaptation. Nature Environment and Pollution Technology,* 21(2), 633–641. https://doi.org/10.46488/NEPT.2022.v21i02.022

Khairullah, K. K., Rifai, A., & Indrayanti, E. (2024). *Studi luasan genangan banjir rob akibat kenaikan muka air laut dan penurunan muka tanah di Kecamatan Sayung, Demak*. *Indonesian Journal of Oceanography*, 6(4), 316–323. https://doi.org/10.14710/ijoce.v6i4.24645

Lathifah, I., Romahurmuzi, M., & Safira, E. (2024). *Pemanfaatan Sistem Informasi Geografis (SIG) dalam pemetaan wilayah bencana tsunami di Pesisir Watulimo Kab. Trenggalek*. *Triwikrama: Jurnal Ilmu Sosial*, 3(8), 21–35. https://doi.org/10.6578/triwikrama.v3i8.3169

Odi Nugrahanto, P., Awaluddin, M., & Laila Nugraha, A. (2021). *Visualisasi secara online ruang terbuka hijau Kecamatan Semarang Timur*. *Jurnal Geodesi Undip*, 10(1), 163–168.

Pardjono, M. M. E., Awaluddin, M., & Nugraha, A. L. (2024). *Perancangan peta infrastruktur Universitas Diponegoro Kampus Tembalang*. *Jurnal Geodesi Undip*, 13(2), 485–494.

Primasti, T. P. G., Hariyadi, Rochaddi, B., Widada, S., & Widiaratih, R. (2021). *Pemantauan kerentanan fisik di Pesisir Kabupaten Demak (Studi Kasus Perubahan Garis Pantai).*

Indonesian Journal of Oceanography, 3(1). https://doi.org/10.14710/ijoce.v3i1.9997

Raha, S., & Deb, S. (2025). *Tourism potential zone mapping for the state of Madhya Pradesh, India using MCDM and Machine Learning Models. Geoplanning,* 12(1), 95–122. https://doi.org/10.14710/geoplanning.12.1.95-122

Rahadiati, A., Sutrisno, D., & Munawaroh. (2022). *Management of coastal flood impact in Rural Area (Case study in Sayung District). IOP Conference Series: Earth and Environmental Science,* 1095(1). https://doi.org/10.1088/1755-1315/1095/1/012006

Raharjo, A. W., Nugraha, A. L., & Sabri, L. (2023). *Desain aplikasi sistem infromasi resiko banjir Kecamatan Sayung berbasis WebGIS. Jurnal Geodesi Undip,* 12(2), 181–190. https://doi.org/10.14710/jgundip.2023.38408

Sari, D. J., Sintia, L., Kurniawan, R., Satmaidi, E., & Wulandari. (2025). *Permasalahan penataan ruang di Pesisir Pantai Panjang antara perlindungan lingkungan untuk wisata alam berkelanjutan dan dorongan pariwisata. Jurnal Hukum dan Kewarganegaraan*, 12(10), 71–80. https://doi.org/10.6679/b9f3dq76

Su, Q., Li, Z., Li, G., Zhu, D., & Hu, P. (2021). *Application of the coastal hazard wheel for coastal multi-hazard assessment and management in the Guang-Fong-Hongkong-Macao Greater Bay Area. Sustainability (Switzerland),* 13(22). https://doi.org/10.3390/su132212623