

## WEBGIS EXTREME WEATHER AND HEALTH FACILITIES IN MAGELANG REGENCY

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### *Abstract*

Magelang Regency, Indonesia, has a high potential for extreme weather disasters due to its unique geographical and hydrological characteristics. This study utilizes WebGIS technology to assess the readiness of healthcare facilities in areas prone to extreme weather events in Magelang Regency. The developed WebGIS platform displays: (1) administrative maps, (2) the spatial distribution of health facilities, (3) extreme weather risk, hazard, capacity, and vulnerability maps, and (4) an analytical identification of healthcare facility readiness. The map used is the 2024 map. This website aims to provide accurate and informative spatial information to support decision-making in extreme weather disaster mitigation planning. User Acceptance Testing (UAT) involving 10 respondents yielded a score of 88.8% (out of 100%), indicating that users 'strongly agree' that the system meets user-friendly criteria

**Keywords :** *WebGIS, Healthcare facilities, Extreme Weather, Magelang Regency, User Acceptance Testing*

### **1. Introduction**

Extreme weather phenomena—including heavy rainfall, strong winds, and hydrometeorological disasters—have become increasingly frequent in Indonesia, particularly in regions with complex topography such as Magelang Regency, Central Java. These events negatively impact social, economic, and environmental sectors. For instance, extreme rainfall often triggers floods and landslides, while strong winds damage infrastructure and disrupt daily activities. Despite these recurring threats, disaster mitigation efforts remain hampered by a lack of detailed, up-to-date, and accessible weather-related spatial data.

Geographic Information Systems (GIS) have been widely used for disaster risk reduction. Recent advances in web-based GIS (WebGIS) enable real-time, location-based visualization and dissemination of spatial information without requiring specialized desktop software (Shen et al., 2021). Several studies have applied WebGIS for flood hazard mapping (Chen et al., 2020) and health facility accessibility (Dewi et al., 2019). However, no existing system specifically integrates extreme weather risk layers with healthcare facility readiness assessments in Magelang Regency.

Therefore, this study aims to: Develop a WebGIS-based system that maps extreme weather hazards, vulnerability, capacity, and risk in Magelang Regency, Identify and analyze the readiness of health facilities (hospitals, puskesmas, clinics) located in extreme weather-prone zones, Provide an interactive platform for the public and authorized agencies (BPBD, Health Office) to support

disaster mitigation planning. This research is significant because it bridges the gap between meteorological disaster data and public health infrastructure preparedness, enabling more effective, evidence-based policy responses.

This study addresses these gaps by developing a WebGIS-based spatial decision support system. By combining meteorological data from various sources, this system will offer interactive visualizations that make it easier for the public and government to monitor weather conditions in real time. This mapping allows users to view forecasts and identify areas vulnerable to the impacts of extreme weather, such as heavy rainfall or strong winds. With the WebGIS platform, weather information can be disseminated more effectively, helping relevant parties take appropriate and swift disaster mitigation measures before negative consequences occur. This system is also expected to serve as a useful tool for safer development planning in areas frequently exposed to extreme weather.

## 2. Method

The method used in this research is an experimental method with a quantitative approach (M. Lutfi et al., 2024). The following are the research steps: literature study, data collection, data processing, needs analysis, webGIS design, system implementation, system testing, and conclusions and recommendations

### 2.1. Literature Study

A systematic literature review was conducted using keywords: "WebGIS," "extreme weather," "disaster risk reduction," "health facility preparedness," and "Magelang Regency." Sources included Google Scholar, Scopus-indexed journals, and official government publications (2019–2024)..

### 2.2. Data Collection

Spatial data were downloaded from the official website of the Regional Disaster Management Agency (BPBD) of Magelang Regency (<https://bpbd.magelangkab.go.id>, accessed: January 15, 2024). All data were projected to UTM zone 49S (WGS 84 datum). The following spatial datasets were obtained:

- a. Extreme Weather Risk Map (scale 1:50,000)
- b. Extreme Weather Hazard Map (scale 1:50,000)
- c. Extreme Weather Capacity Map (scale 1:50,000)
- d. Extreme Weather Vulnerability Map (scale 1:50,000)
- e. Administrative Boundary Map (villages, sub-districts, regency)
- f. Health facility locations (hospitals, puskesmas, clinics) – obtained from Magelang Health Office (2024)

### 2.3. Data Processing

All raster maps were reclassified into vector polygons using QuantumGIS version 3.28 (QGIS Development Team, 2023). Reclassification thresholds followed BPBD Magelang classification standards:

- Risk: Low (0–0.25), Medium (0.26–0.50), High (0.51–0.75), Very High (0.76–1.00)
- Hazard, Capacity, Vulnerability: Similarly categorized

The reclassified vector layers were then overlaid to identify sub-districts with concurrent

high hazard, high vulnerability, and low capacity.

#### 2.4. Requirement Analysis

The requirement analysis consists of two types of analysis: Functional Needs Analysis and Non-Functional Needs Analysis. The following is the Functional Needs Analysis:

- a. Location data for health facilities (hospitals, community health centers, clinics).
- b. Data on areas prone to Extreme Weather (risk, hazard, vulnerability, and capacity maps).
- c. Regional administrative data (village/sub-district/district boundaries).
- d. Identification of health facilities located in Extreme Weather prone zones.
- e. Ranking of facility readiness in response to Extreme Weather.
- f. Thematic map of health facility readiness.

The Non-Functional Needs Analysis is as follows:

- a. The WebGIS system must be accessible with a fast response time (<5 seconds).
- b. The system can be accessed via a browser (desktop & mobile).
- c. The user interface must be intuitive and easy to use.
- d. Protection against sensitive data access (admin login).
- e. Input validation and data sanitization..

#### 2.5. Web GIS Design

The designed WebGIS system must meet the following requirements:

- a. The system can display interactive maps.
- b. The system can display the location of health facilities.
- c. The system can display zones prone to extreme weather.
- d. The system can link readiness data with facility locations.
- e. The system has a filtering feature based on readiness level, vulnerability level, and type of health facility..

#### 2.6. System Implementation

The system is implemented by writing source code using HTML, PHP, and JavaScript programming languages.

#### 2.7. System Testing

System testing aims to ensure that the developed WebGIS runs properly, meets functional requirements, and accurately displays information on the readiness of health facilities in areas prone to Extreme Weather in Magelang Regency. Testing was conducted on several key system features, including:

- a. Mapping health facility locations.
- b. Mapping areas prone to Extreme Weather.
- c. Identification of health facilities in vulnerable zones.
- d. Displaying facility readiness information (capacity, distance from Extreme Weather zones, operational status).
- e. Search and filter functions for facilities based on readiness category.
- f. Map responsiveness across devices (mobile and desktop).

The testing methods used include:

- a. Black Box Testing to test the system's main functions without viewing the internal code structure.
- b. User Acceptance Testing (UAT) to assess whether the system meets the needs of end users (stakeholders related to health and disaster preparedness)

### 2.8. Conclusion

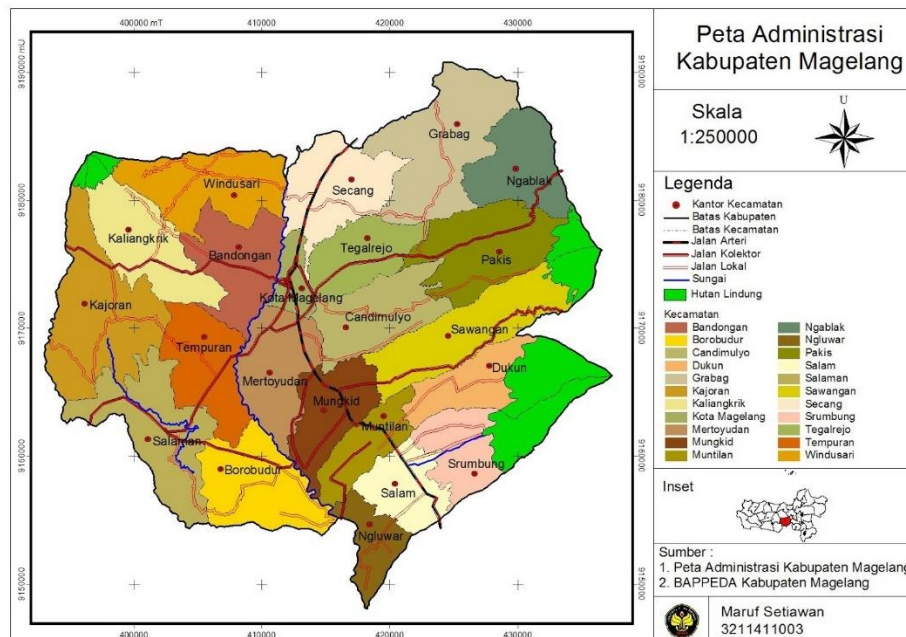
The conclusion is a summary of the research results and discussion.

## 3. Results and Discussion

### 3.1. Research Results

#### a. Overview of Magelang Regency

Magelang Regency, located in Central Java Province, has unique geographic and demographic characteristics, covering an area of 1,085.73 km<sup>2</sup> and divided into 21 sub-districts and 372 villages/wards. Geographically, Magelang is surrounded by the regencies of Temanggung, Semarang, Boyolali, Purworejo, and Wonosobo, as well as the Special Region of Yogyakarta Province, with Magelang City at its center. The topography of this region is dominated by basin-shaped plateaus surrounded by mountains such as Merapi, Merbabu, Andong, Telomoyo, and Sumbing, as well as major rivers such as Progo and Elo. The area's elevation varies between 153 and 3,065 meters above sea level, with an average elevation of 360 meters (M. Lutfi et al., 2024).



**Figure 1.** *Administrative Map of Magelang Regency*

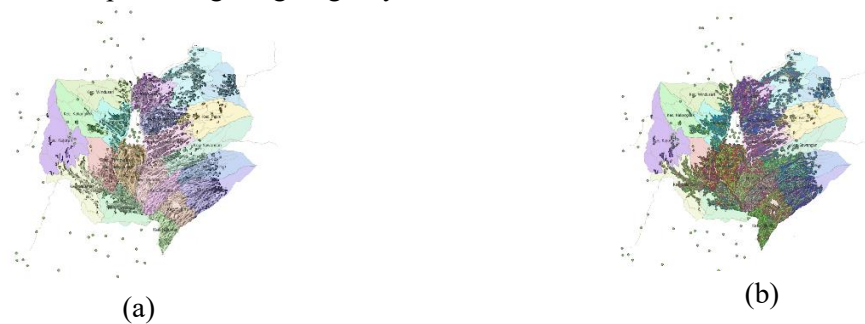
The capacity of health facilities during extreme weather events is crucial to ensuring the continued availability of health services to affected communities. Health facilities such as community health centers (Puskesmas), hospitals, and health posts often face significant

challenges, including infrastructure damage, disruptions to drug distribution, and surges in patients. This capacity depends not only on physical infrastructure but also on the readiness of medical personnel and the continuity of operations during disasters. Extreme weather events often cause health facilities to become inundated, disrupting health services. Below is the result of an overlay process between the distribution of health facilities, the risk of extreme weather, and the administrative map of Magelang Regency (M. M. Lutfi & Ali Machmudi, n.d.)

**b. Data Processing Data**

The first process is reclassification, which involves converting a raster map into a vector map. The following map reclassification results will be analyzed :

- 1) Extreme Weather Risk Map for Magelang Regency



**Figure 2.** Map of the Results of the Extreme Weather Risk Reclassification Process in Magelang Regency, (a) Map Before Reclassification (b) Map After Reclassification

**Table 1.** Extreme Weather Risk Data

| Subdistrict | Area (ha) | Value      | Class |
|-------------|-----------|------------|-------|
| Ngluwar     | 2394.82   | 0.72831678 | High  |
| Salam       | 3182.69   | 0.72831678 | High  |
| Dukun       | 5756.33   | 0.72831678 | High  |
| Muntilan    | 3034.34   | 0.72831678 | High  |

- 2) Extreme Weather Hazard Map for Magelang Regency



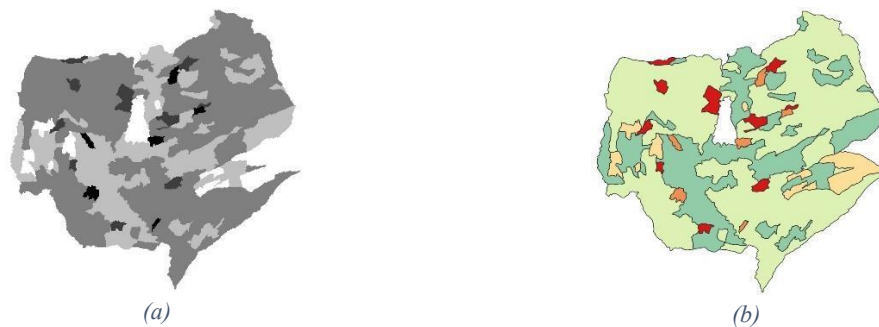
**Figure 3.** Map of the Results of the Extreme Weather Hazard Reclassification Process in Magelang Regency, (a) Map Before Reclassification (b) Map After Reclassification

**Figure 1** (insert corrected map) shows the spatial distribution of extreme weather risk across Magelang Regency. The clustering of high-risk sub-districts in the southern and eastern regions corresponds to low-lying areas near the Progo River, consistent with flood susceptibility patterns reported by (Makarim, 2024). Spatial modeling is also used to identify areas affected by Extreme Weather tidal extreme weathering to provide important information on areas requiring mitigation priority (Dinata & Dalilla, 2024)

**Table 2.** *Extreme Weather Danger Very High*

| Subdistrict | Area (ha) | Value      | Class     |
|-------------|-----------|------------|-----------|
| Ngluwar     | 2394.82   | 0.80000138 | Very High |
| Salam       | 3182.69   | 0.80000138 | Very High |
| Dukun       | 5756.33   | 0.80000138 | Very High |
| Muntilan    | 3034.34   | 0.80000138 | Very High |

3) Map of the Results of the Extreme Weather Capacity Magelang Regency



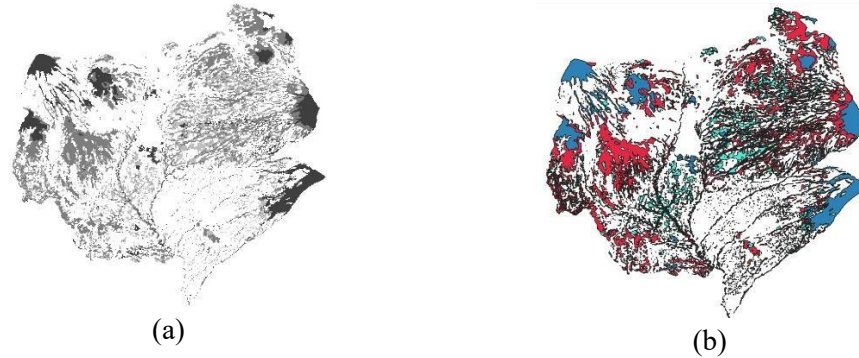
**Figure 4.** *Map of the Results of the Extreme Weather Capacity Reclassification Process for Magelang Regency, (a) Map Before Reclassification (b) Map After Reclassification*

There are differences in Extreme Weather capacity between sub-districts; Muntilan and Dukun have very high Extreme Weather capacity (0.46046701), while Ngluwar and Salam sub-districts have moderate Extreme Weather capacity (0.31806701). This difference indicates that Muntilan and Dukun may have better Extreme Weather infrastructure or management systems than Ngluwar and Salam..

**Table 3.** *Extreme Weather Capacity Data*

| Subdistrict   | Area (ha)   | Value     | Class              |
|---------------|-------------|-----------|--------------------|
| Kec. Srumbung | 6181.130186 | 0.4469336 | Very High Capacity |
| Kec. Dukun    | 5756.329556 | 0.4469336 | Very High Capacity |
| Kec. Muntilan | 3034.343102 | 0.4469336 | Very High Capacity |
| Kec. Sawangan | 7385.03492  | 0.4469336 | Very High Capacity |

4) Extreme Weather Vulnerability Map of Magelang Regency



**Figure 5.** Map of the Results of the Extreme Weather Vulnerability Reclassification Process in Magelang Regency, (a) Map Before Reclassification (b) Map After Reclassification

Social factors such as poverty and inadequate access to mitigation infrastructure also influence vulnerability levels, while low levels of education and income exacerbate the negative impacts of extreme weather disasters (Vivi, 2024). The table below shows extreme weather vulnerability.

**Table 4.** Extreme Weather Vulnerability Data

| Subdistrict    | Area (ha)   | Value     | Class                 |
|----------------|-------------|-----------|-----------------------|
| Kec. Salaman   | 6869.552378 | 0.1983992 | Moderately Vulnerable |
| Kec. Borobudur | 5755.642543 | 0.1983992 | Moderately Vulnerable |
| Kec. Ngluwar   | 2394.821636 | 0.1983992 | Moderately Vulnerable |
| Kec. Salam     | 3182.69499  | 0.1983992 | Moderately Vulnerable |

Based on the data above, several key points can be concluded regarding the hazards, capacity, vulnerability, and risks of Extreme Weather in the Muntilan, Ngluwar, Salam, and Dukun sub-districts in Magelang Regency regarding the following: All four sub-districts have a very high Extreme Weather hazard level, with a value of 0.80000138. This indicates that these areas have significant Extreme Weather potential and require special attention in disaster management.

There are differences in Extreme Weather capacity between sub-districts: Muntilan and Dukun have a very high Extreme Weather capacity (0.46046701), while Ngluwar and Salam have a moderate Extreme Weather capacity (0.31806701). This difference suggests that Muntilan and Dukun may have better infrastructure or systems for managing Extreme Weather than Ngluwar and Salam.

All sub-districts exhibit the same level of Extreme Weather vulnerability, categorized as "Dangerous" with a value of 0.7935968. This indicates that the population and assets in these four sub-districts are at high risk of negative impacts in the event of Extreme Weather. All four sub-districts have a high level of Extreme Weather risk, with a value of 0.72831678. This represents a combination of high hazard and vulnerability, despite variations in Extreme Weather management capacity.

This data emphasizes the importance of comprehensive Extreme Weather mitigation efforts, particularly in Ngluwar and Salam, which have lower Extreme Weather management capacity. Capacity building, vulnerability reduction, implementation of effective early warning systems, and adequate resource allocation for Extreme Weather management are needed in these four sub-districts. A participatory approach is also key to managing Extreme Weather risks. In Bojong Kulur Village, community capacity building through a community-based mitigation program has proven effective in reducing disaster risk (Ramadhan et al., 2024) Furthermore, technology such as the Extreme Weather early detection system has helped the Bakalan Rayung Village community understand risks and improve their response to Extreme Weather warnings (Sa’adah & Mahendri, 2024). The next process is Classification, which is the process of creating vector map classes that will then be displayed in WebGIS.

a. Extreme Weather Capacity Classification Process

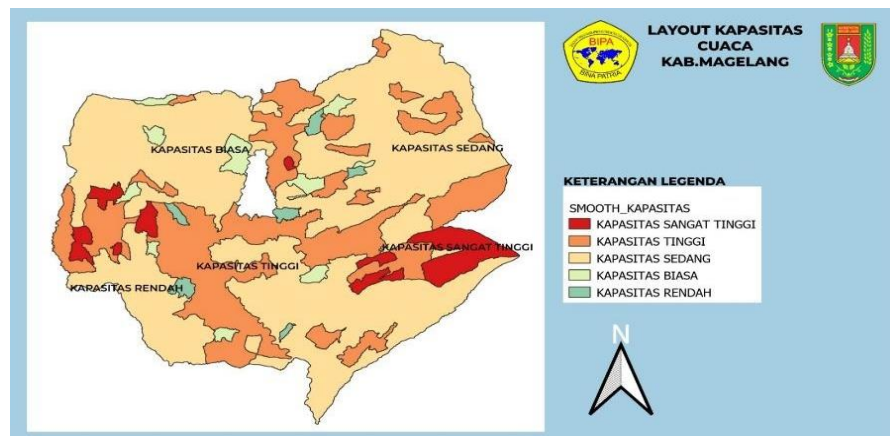


Figure 6. Ekstrim Extreme Weather Capacity Classification Process Results Map

b. Extreme Weather Vulnerability Classification Process

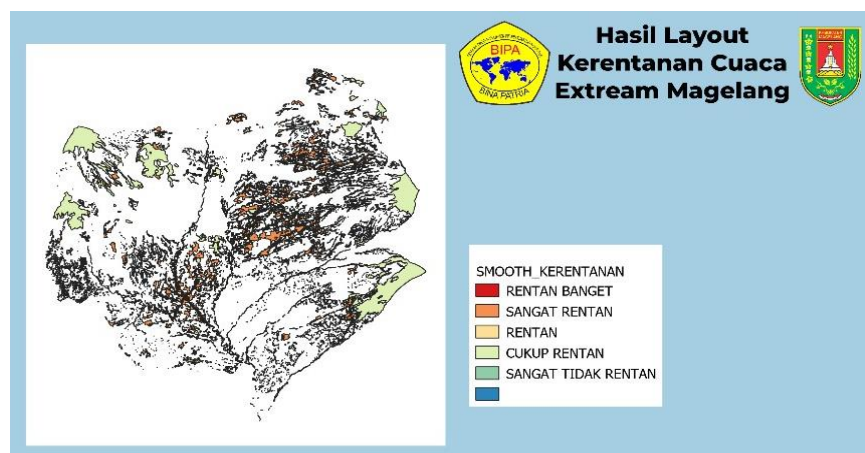
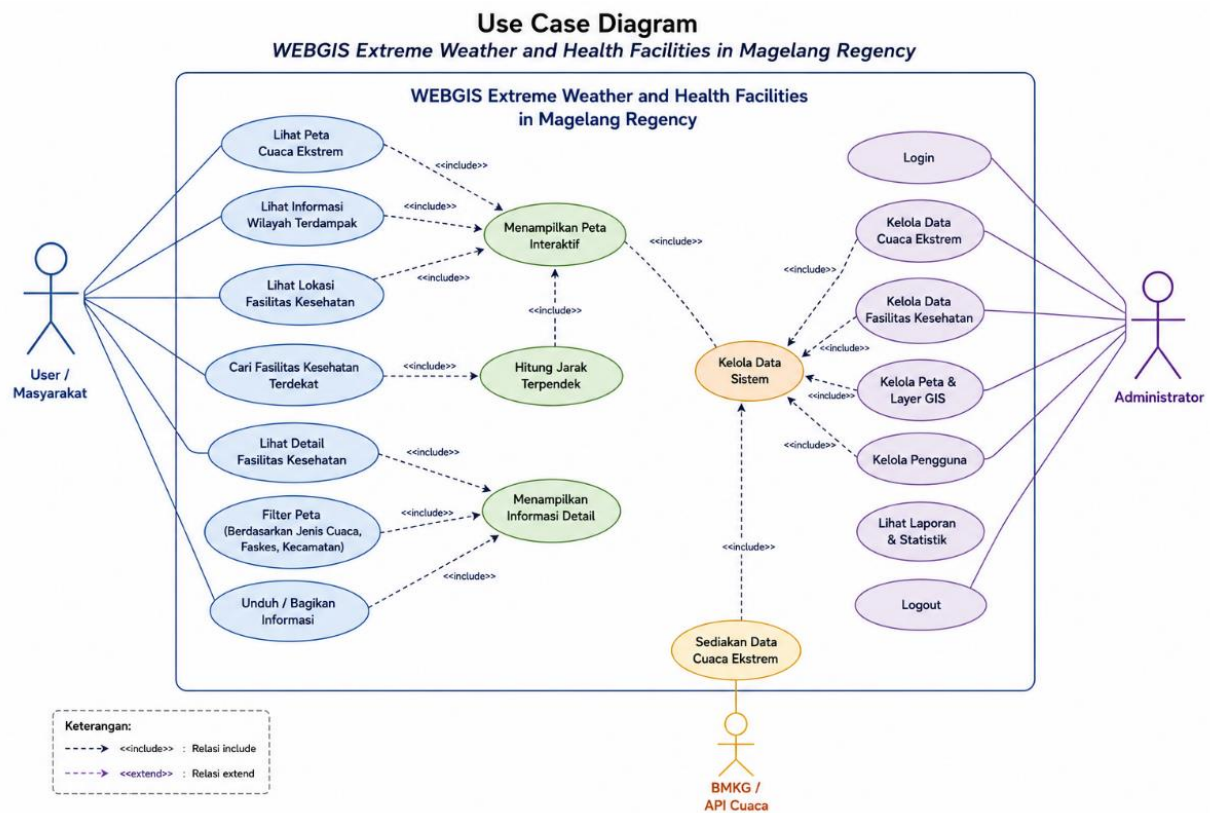


Figure 7. Extreme Weather Vulnerability Classification Results Map

### c. WebGIS Design Results

The WebGIS System Use-Case Diagram for Health Facility Readiness in Extreme Weather-Prone Areas consists of two actors: the Admin, who manages health facility data, manages data on areas prone to extreme weather, and manages facility readiness information. The next actor is the General User (Community/BPBD/Health Office) who can view interactive maps and health facility readiness information. The main use-cases can display interactive maps, display health facilities, display extreme weather-prone zones, and display the readiness status of each facility. The following use-cases are presented.



**Figure 8. Use Case WebGIS**

The following are the results of the WebGIS design that has been created :

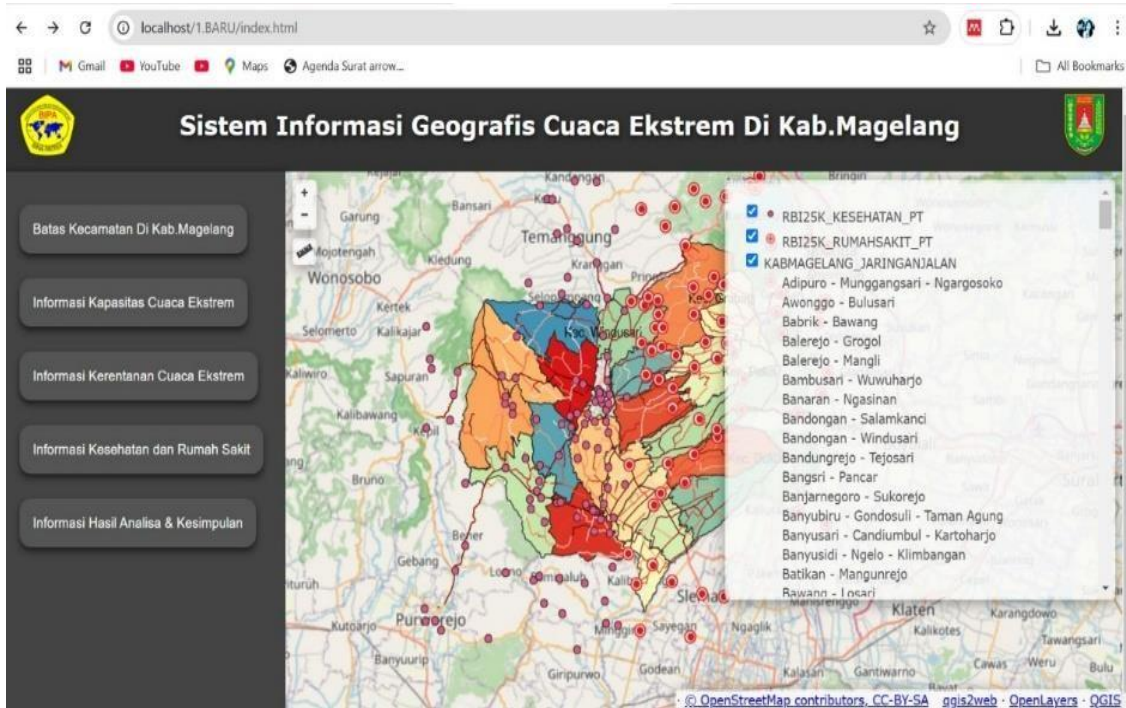


Figure 9. Magelang Regency Extreme Weather Geographic Information System Website Dashboard Page View



Figure 10. Main Menu of the Extreme Weather Geographic Information System Website in Magelang Regency

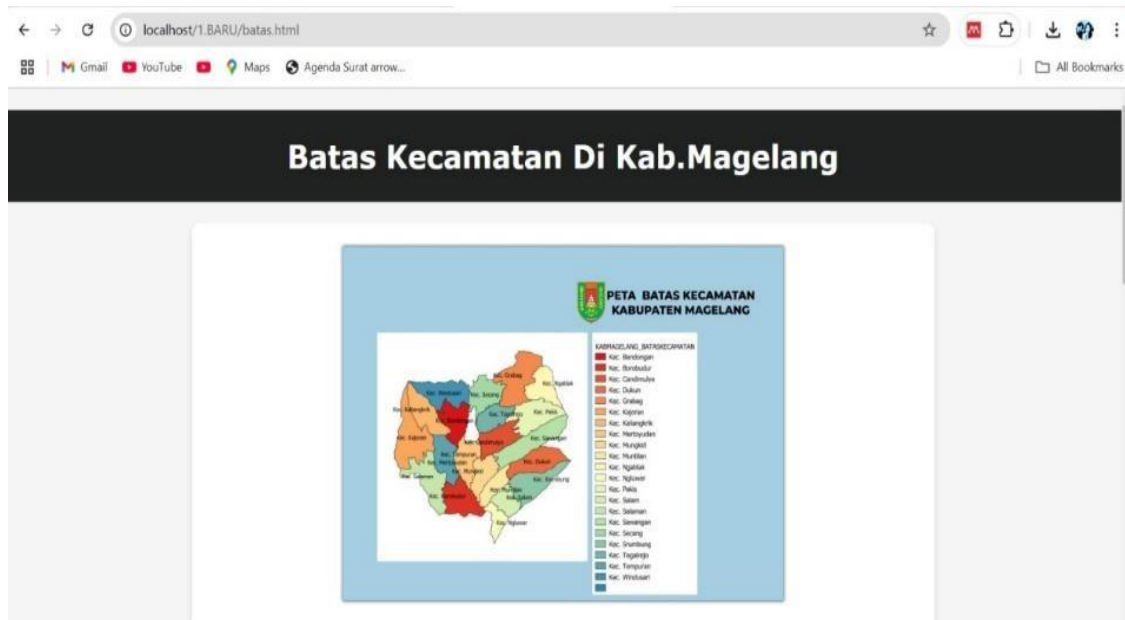


Figure 11. Display of the District Boundary Page of the Extreme Weather Geographic Information System Website in Magelang Regency



Figure 12. Display of the Extreme Weather Capacity Information Page for Magelang Regency

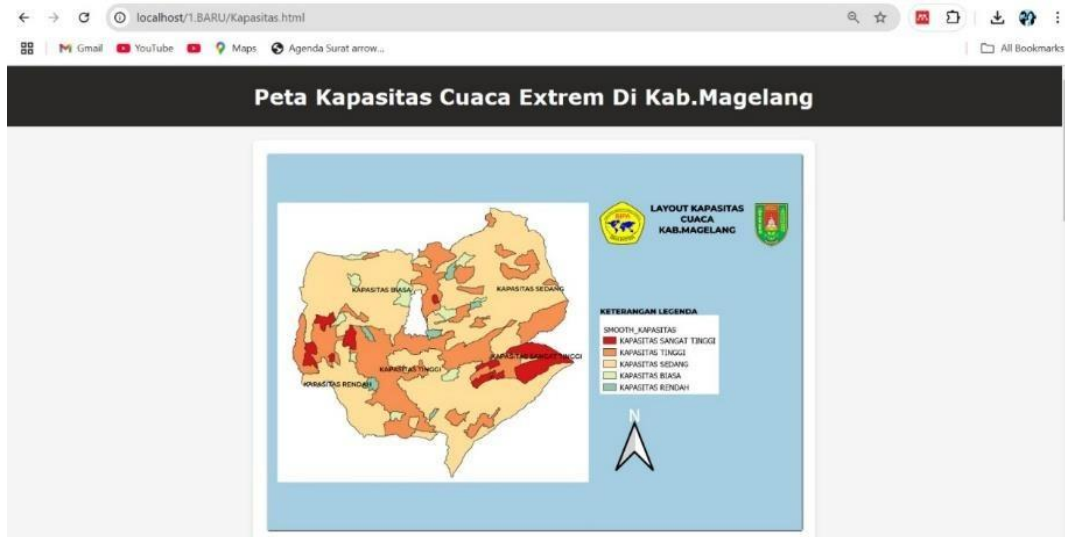


Figure 13. Magelang Regency Extreme Weather Vulnerability Information Page View



Figure 14. Magelang Regency Hospital Information Page Display

This page contains a list of hospitals in Magelang Regency along with detailed information about available healthcare facilities. This feature aims to assist the public in obtaining information regarding accessible healthcare services, especially in emergency situations due to extreme weather. The following is a list of hospitals in Magelang Regency:

**Table 3.** List of Hospitals in Magelang Regency

| No | Code    | Name                                       | Hospital Type |   | Address  |
|----|---------|--|---------------|---|--|
| 1  | 3308014 | RS Umum Daerah Muntilan Kabupaten Magelang | RSUD          | C | Jl. Kartini № 13, Kelurahan Muntilan, Kecamatan Muntilan, Kabupaten Magelang, Jawa Tengah 56411          |
| 2  | 3308017 | RS Umum Aisyiyah Muntilan                  | RSU           | C | Jl. K.H. Ahmad Dahlan № 24, Desa Pucungrejo, Kecamatan Muntilan, Kabupaten, Magelang, Jawa Tengah 56414  |
| 3  | 3308033 | RS Umum Daerah Bukit Menoreh               | RSUD          | D | Jl. Magelang -Purworejo KM 15, Desa Menoreh, Kecamatan Salaman, Kabupaten Magelang, Jawa Tengah 56162    |
| 4  | 3308018 | RS Umum N-21 Gemilang                      | RSU           | D | Jl. Pondok Pabelan, № 5, Desa Pabelan, Kecamatan Mungkid, Kabupaten Magelang, Jawa Tengah 56551          |
| 5  | 3308022 | RS Daerah Merah Putih Kabupaten Magelang   | RSUD          | C | Jl. Magelang -Yogyakarta KM 6, Japunan, Danurejo, Kec. Mertoyudan, Kabupaten Magelang, Jawa Tengah 56172 |
| 6  | 3308021 | RS Umum Syubbanul Wathon                   | RSU           | C | Jl. Magelang Kopeng KM 8, Desa Purwosari, Kecamatan Tegalrejo, Kabupaten Magelang, Jawa Tengah 56192     |

### 3.2. Discussion

The discussion begins by presenting the test results. The testing methods used include :

- a. Black Box Testing to test the system's main functions without viewing the internal structure of the code. The following table shows the Black Box Testing results.

**Table 3.** Black Box Testing Results

| No | Tested Features                   | Expect                                 | Test Data                      | Expected Results                                |
|----|-----------------------------------|--|--------------------------------|---|
| 1  | Displaying a base map             | Open the app                           | WebGIS URL                     | The base map appears.                           |
| 2  | Displaying health facilities      | Click the health facility layer        | Facility Data                  | Facility markers appear on the map.             |
| 3  | Displaying an Extreme Weather map | Click the Extreme Weather hazard layer | Extreme Weather Zone Data      | The Extreme Weather Zone polygon appears.       |
| 4  | Identifying facility readiness    | Click the facility marker              | Facility Readiness Information | An information popup appears based on the data. |
| 5  | Display responsiveness            | Access via mobile/desktop              | Mobile/Desktop Browser         | The display adapts to the device.               |

*b. User Acceptance Testing (UAT)*

User Acceptance Testing (UAT) is the final stage in the software development process, aimed at ensuring that the developed system meets the needs and expectations of end users (M. Lutfi, n.d.). User Acceptance Testing (UAT) is used to assess the system's suitability to user needs and to measure user comfort when using the system to solve problems. In this study, UAT was used to assess whether the system met the needs of end users (stakeholders related to health and disaster preparedness)

**Table 4.** *User Acceptance Testing (UAT) Results*

| No | Features                       | Status  | Description  |
|----|--------------------------------|---------|--|
| 1  | Base map appears               | Passed. | OpenStreetMap basemap displayed                    |
| 2  | Health facility markers appear | Passed. | All markers displayed according to their locations |
| 3  | Readiness data is accessible   | Passed. | Readiness information matches input data           |
| 4  | Readiness filter works         | Passed. | Facility data filtered by category                 |
| 5  | Responsive display             | Passed. | Tests on various devices were successful           |

Meanwhile, the system impact test was administered to users, with results as shown in Table 1 below.

**Table 5.** *System Impact Test Results for Users*

| No    | Questions  | Respondents' Answers |    |   |   |    |
|-------|--|----------------------|----|---|---|----|
|       |  | VA                   | A  | N | D | VD |
| 1     | Is the WebGIS interface easy to understand and use?            | 4                    | 1  | 0 | 0 | 0  |
| 2     | Does map navigation (zoom, pan, click markers) run smoothly?   | 5                    | 0  | 1 | 0 | 0  |
| 3     | Is information easily found in the system?                     | 3                    | 2  | 0 | 0 | 0  |
| 4     | Is the displayed health facility data complete?                | 2                    | 2  | 1 | 0 | 0  |
| 5     | Is data on areas prone to extreme weather clearly available?   | 4                    | 1  | 0 | 0 | 0  |
| 6     | Do health facility locations reflect conditions on the ground? | 4                    | 1  | 0 | 0 | 0  |
| 7     | Is facility readiness information accurate and reliable?       | 3                    | 2  | 0 | 0 | 0  |
| 8     | Is WebGIS accessible from both computers and smartphones?      | 5                    | 0  | 0 | 0 | 0  |
| 9     | Is the WebGIS system fast and responsive?                      | 3                    | 2  | 0 | 0 | 0  |
| 10    | This WebGIS is useful for supporting disaster preparedness.    | 4                    | 1  | 1 | 0 | 0  |
| Total |  | 33                   | 12 | 3 | 0 | 0  |

To calculate the percentage of system test results, you can use the following equation:

$$\text{Percentage of system test results} = \left( \frac{\sum(\text{actual score})}{\text{Maximum score}} \right) \times 100 \% \quad (1)$$

a. Survey result score

$$\begin{array}{r} 33 \times 5 = 165 \\ 12 \times 4 = 48 \\ 3 \times 3 = 9 \\ \hline 222 \end{array}$$

- b. Maximum score  
 $50 \times 5 = 250$
- c. System testing results  
 $\left(\frac{222}{250}\right) \times 100 \% = 88,8 \%$

Table 5 presents the UAT results from 10 respondents. The overall acceptance score was 88.8% (222 out of 250 maximum points), categorized as "Strongly Agree" that the system meets user-friendly criteria. The highest-rated items were map navigation (Q2: mean 4.8/5) and cross-device accessibility (Q8: mean 5.0/5). The lowest-rated item was completeness of health facility data (Q4: mean 3.8/5), indicating that some clinics may be missing from the database.

### Conclusion

This study successfully developed a WebGIS-based extreme weather information system for Magelang Regency that integrates disaster risk layers (hazard, vulnerability, capacity, risk) with healthcare facility location and readiness data. The system enables interactive mapping and querying, supporting disaster mitigation planning by BPBD and the Health Office. User Acceptance Testing yielded an 88.8% satisfaction score, confirming the system's usability and relevance.

However, this study has several limitations:

1. The spatial data used were static (2024); real-time weather data integration was not implemented.
2. Health facility readiness data were self-reported and not independently validated.
3. UAT sample size was small (n=10).

Future work should incorporate real-time weather APIs (e.g., BMKG, OpenWeatherMap), expand the health facility database to include private clinics and pharmacies, and conduct a larger-scale usability study across all 21 sub-districts

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