Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

Real-Time Data Integration and Weather Reporting Automation with Cloud Computing-based Interactive Spatial Dashboard for Extreme Weather Risk Analytics in Indonesia

Kahpi Baiquni Arifani [1)]*, Dody Pintarko[2)], Anggraini Puspita Sari[3)] Agussalim [4)]
[1)2)3)4] Faculty of Computer Science, UPN "Veteran" East Java, Surabaya, Indonesia
[1)] 24066020001@student.upnjatim.ac.id [1)] 24066020008@student.upnjatim.ac.id[2)] anggraini.puspita.if@upnjatim.ac.id[3)] agussalim.si@upnjatim.ac.id[4)]

ABSTRACT

Global climate change has increased the risk of extreme weather events in Indonesia, necessitating an accurate and real-time weather information system. This study develops a cloud computing-based system capable of integrating national weather data in real-time, automating the generation of actual and forecast weather reports, and presenting this information through an interactive spatial dashboard. The system is built on a client-server architecture deployed on Google Cloud Platform, utilizing the OpenWeatherMap API, a Flask backend, and a JavaScript-based frontend (Leaflet.js and Chart.js). Evaluation results indicate that the system can provide integrated national weather data with latency under one second, generate automated multi-province weather reports, and deliver interactive heatmap visualizations of extreme weather risks. This system is effective in improving the speed, accuracy, and efficiency of weather information distribution to support decision-making in the maritime, transportation, and disaster management sectors.

Keywords: cloud computing, report automation, spatial dashboard, extreme weather, real-time data integration.

INTRODUCTION

In recent decades, global climate change has led to an increase in the frequency and intensity of extreme weather events in various regions, including Indonesia (Surmaini & Faqih, 2016; Munte et al., 2024). This phenomenon has a significant impact on various aspects of human life, ranging from sea and air transport, agriculture, to disaster management. One of the main challenges in dealing with this phenomenon is the need for accurate, real-time, and easily accessible weather information. Quickly and accurately available weather information allows the government and society to take timely anticipation and response steps, thereby reducing the negative impacts of such extreme events.

Despite the availability of weather information services from various government institutions, the process of integrating weather data from many sources and reporting weather manually still has several limitations (Fauzi et al., 2023; Lestari & Nasution, 2025). This manual process tends to be slow, less efficient, prone to human error, and unable to accommodate simultaneous information needs for various regions at the same time. In addition, the textual and less interactive presentation of weather data makes it difficult for users to conduct quick analyses of potential extreme weather risks (Kurniawan et al., 2024).

To overcome these challenges, the utilisation of cloud computing technology offers a promising solution. Cloud technology has high capabilities in terms of data integration, business process automation, and providing interactive and dynamic visualisation-based services (Riana, 2020; Hermawan et al., 2024). With advantages such as flexibility, scalability, and the ability to manage large volumes of data in real-time, cloud computing can be the main infrastructure in supporting a national-scale weather information system.

METHOD

Research Approach

This research uses a technology-based research approach, which consists of needs analysis, system design, implementation, and evaluation (Setyosari, 2016; Sutarti & Irawan, 2017; Nadirah et al., 2022). This approach was chosen because the research aims to develop a new system that utilises cloud computing technology for real-time data integration, reporting automation, and spatial visualisation-based risk analytics.

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

Research Stages

This research was conducted through the following systematic stages (Purwono et al., 2019; Yuwana & Indarti, 2023):

1. Needs Analysis Stage
   a. Identify weather data needs (data type, parameters, data source/API).
   b. Analyse the ongoing process of reporting actual weather and forecasts manually.
   c. Identify the needs of interactive dashboard features from the user side.
2. System Design Stage
   a. Design of cloud computing system architecture.
   b. Design of external weather data API integration (OpenWeatherMap).
   c. Design of weather reporting automation process.
   d. Interactive dashboard design with spatial visualisation and risk analytics.
3. System Implementation Phase
   a. Setup of cloud infrastructure (Google Cloud Platform).
   b. Backend implementation (Flask, Python).
   c. Frontend implementation (HTML, CSS, JavaScript with Leaflet.js and Chart.js).
   d. Implementation of real-time API data integration and reporting automation.
4. System Evaluation Stage
   a. Evaluation of real-time data integration performance (speed, latency).
   b. Evaluation of the effectiveness of reporting automation.
   c. Evaluation of dashboard visualisation through user acceptance test.

System Architecture

The cloud-based system architecture used in this research is designed with a client-server pattern that uses a Virtual Machine (VM) on Google Cloud Platform (GCP). The details are as follows:

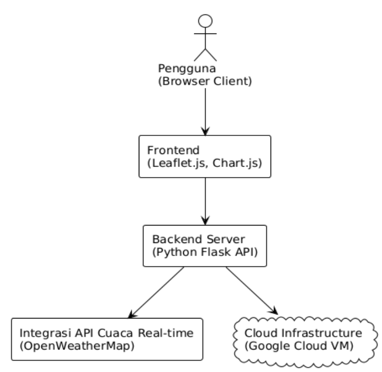

Fig. 1 System Architecture Design

Technology Used

1. Backend (Server-side):
   a. Framework: Flask (Python)
   b. Programming language: Python
   c. External API: OpenWeatherMap (actual and forecast weather data)
   d. Server deployment: Google Cloud Platform (Compute Engine VM)
2. Frontend (Client-side):
   a. HTML, CSS, JavaScript
   b. Mapping library: Leaflet.js
   c. Chart visualisation library: Chart.js
   d. Data manipulation & analytics: Turf.js
3. Cloud Infrastructure:
   a. Google Cloud Platform (Compute Engine)
   b. VM configuration: Ubuntu Server 22.04 LTS, 1GB RAM, 2 Core vCPU (e2-Micro)

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

Implementation of Real-Time Data Integration and Reporting Automation

1. Real-time data integration:
   a. Using OpenWeatherMap's REST API to retrieve actual and forecast weather data.
   b. The retrieved data are temperature, wind speed, weather conditions, and other parameters in JSON format.
   c. The Flask backend processes real-time data for presentation to the frontend and for automated reporting.
2. Automate the reporting process:
   a. The Flask backend function automatically retrieves real-time data simultaneously from the API.
   b. Data is processed into daily actual reports and forecast reports for the next 3 days.
   c. Reports are automatically generated in text document (TXT) format that can be downloaded simultaneously by users through one click

Interactive Spatial Dashboard Design

The dashboard was developed using web-based technology with the following features:

1. Interactive map with actual weather layer based on GeoJSON and Leaflet.js.
2. Heatmap visualisation that shows the level of extreme weather risk dynamically.
3. Detailed information popup for each province that displays weather conditions, weather forecast trends (graphs), and risk warnings.
4. A national statistics dashboard that displays aggregate data such as national average temperature, provinces with extreme temperatures, and the number of high-risk areas.

Extreme Weather Risk Analysis Mechanism

The risk analysis mechanism applied uses threshold-based rules on weather parameters as follows:

1. High risk (red): Wind speed > 13 m/s or "lightning rain" weather conditions.
2. Medium risk (yellow): Wind speed of 8-13 m/s or weather conditions of "light to moderate rain".
3. Low risk (green): Normal weather conditions (sunny to cloudy), wind speed < 8 m/s.

Performance Evaluation and System Testing

The evaluation was conducted through two main approaches:

1. Technical Evaluation: measuring the latency and throughput of the real-time data integration API, load testing on the backend using tools such as Apache Jmeter, analyze VM resource usage (CPU, RAM, Network).
2. Non-technical evaluation (User Acceptance Testing - UAT): Direct testing by users on the ease of use of the dashboard, clarity of information, and ease of downloading reports, Questionnaires and interviews to obtain qualitative feedback from potential users (local government, weather operators, related institutions).

System Sequence Diagram

Here is the complete system sequence diagram:

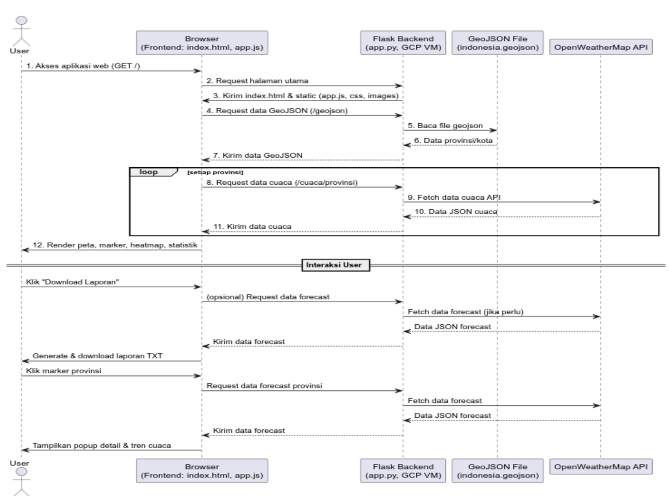

Fig. 2 Sequence Diagram

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

RESULTS

System Implementation Results

The result of this system implementation produces a cloud-based interactive web application that has three main features: (1) real-time data integration from external APIs, (2) automation of actual and forecast weather reporting, and (3) interactive spatial dashboard with extreme weather risk analytics.

a. Overview of the successfully implemented system:

1) Interactive Dashboard

The dashboard is developed with web technology (HTML, JavaScript, Leaflet.js, Chart.js) that displays actual weather data spatially using an interactive map of the Indonesian region. The dashboard is able to display a heatmap of extreme weather risks that is automatically updated based on actual weather conditions.

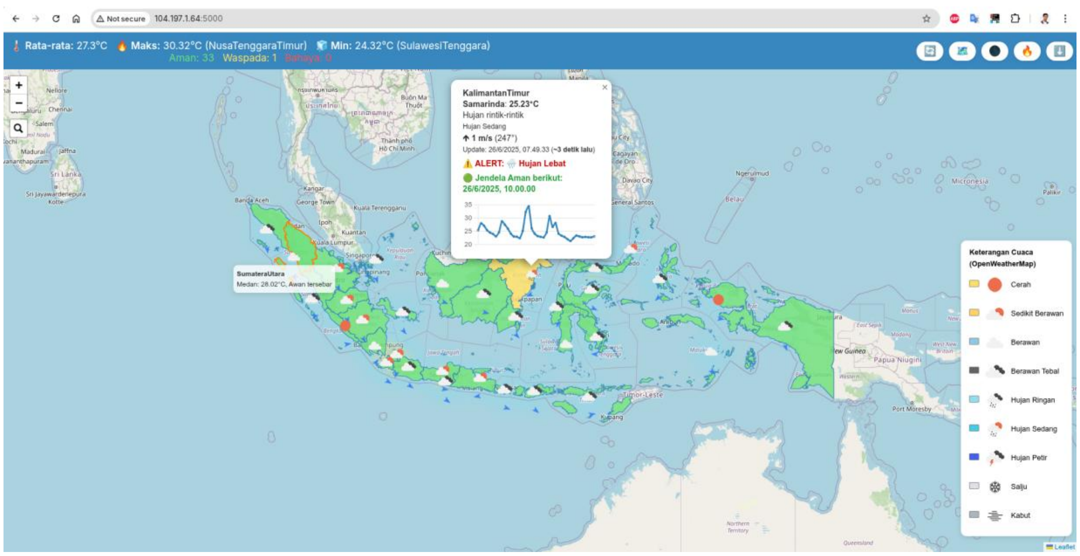

Fig. 3 Application Dashboard

Main Objects on the Dashboard

- Interactive Map of Indonesia: This is the primary object. The map is not a static image but a dynamic canvas that displays layers of geographical and weather data.
- Colored Province Polygons: Each province on the map is colored (green, yellow, or red). This color visually represents the weather risk level in that province, which is calculated automatically by the system.
- Weather Icons: Icon points (like sun, clouds, rain) scattered across the map. Each icon indicates the actual weather conditions in the nearest provincial capital.
- Detailed Information Pop-up: The white box that appears when a province is clicked. This is a window for in-depth information.
- National Statistics Dashboard: The information bar at the very top of the screen that displays aggregated data from all over Indonesia.
- Control Panel: The set of buttons in the top-right corner to control the map's display and features.
- Legend: The information box in the bottom-right corner that serves as a guide to read the symbols on the map.

Function of Each Object

- Function of the Map & Colored Polygons:
  - Quick Risk Visualization: Users can instantly see which areas are safe (green), require caution (yellow), or are dangerous (red) without having to read the data one by one. This functions as a visual early warning system.
- Function of Weather Icons & Detail Pop-up:

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

  - Location-Specific Information: Provides highly detailed weather data for a single location, such as temperature, weather conditions (e.g., "Drizzle"), and the data update time.
  - Automatic Alerts: Intelligently detects and displays warnings if extreme conditions are present, such as "Heavy Rain."
  - Predictive Analysis: Displays a temperature forecast graph for the next few days and automatically searches for a "Safe Window," which is a recommendation for the best time to conduct activities based on the weather forecast.
- Function of the National Statistics Dashboard (Top Bar):
  - National Overview: Provides a quick summary of weather conditions across Indonesia, such as the average, maximum, and minimum temperatures along with their locations. This is useful for observing large-scale weather trends.
- Function of the Control Panel & Legend:
  - Display Customization: The control buttons allow users to search for locations, activate dark mode, show/hide the heatmap, and download reports.
  - Data Readability: The legend ensures that all users, even first-timers, can understand the meaning of each symbol and color on the map.

Overall, the main function of this dashboard application is to serve as a Decision Support Tool for maritime activities. It not only presents raw data but also processes it into easily understandable information—such as risk levels, early warnings, and safe time recommendations—so that users can plan their activities more safely and efficiently.

2) Automated Reporting

The reporting automation feature is able to generate two reports at once in one click, namely the daily actual weather report and the weather forecast report for the next three days in the form of a text document (TXT).

3) Real-time Data Integration

The process of integrating real-time data from the OpenWeatherMap API was successful with low latency (<1 second per request). This process runs simultaneously for all provinces in Indonesia.

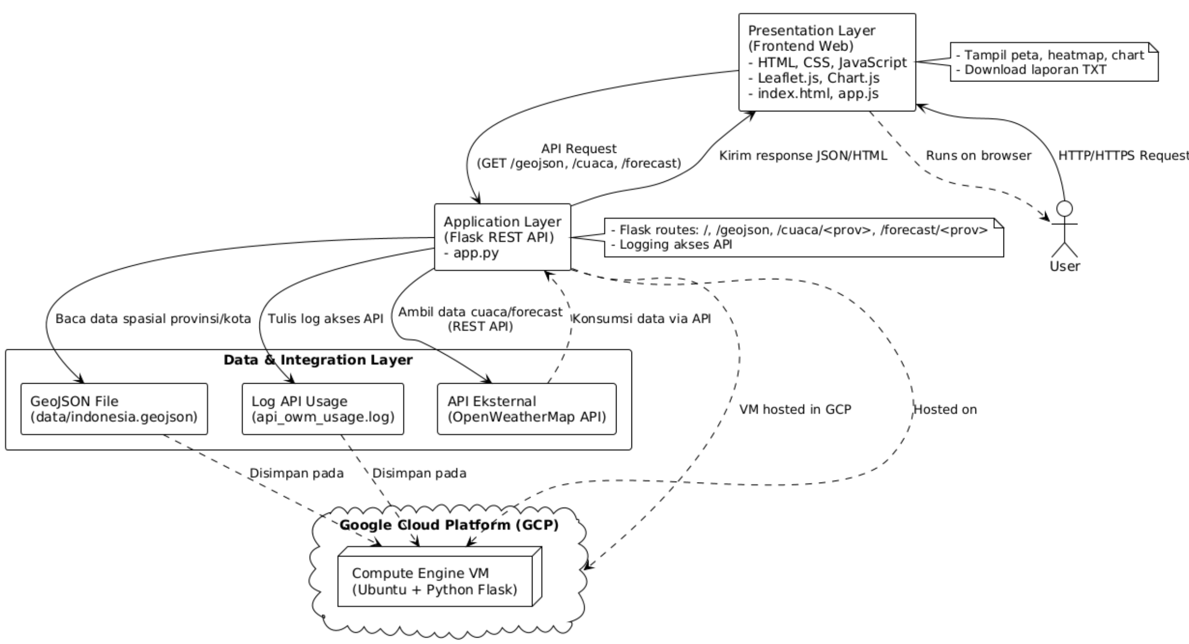

Fig. 4 System Architecture

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

System Technical Evaluation Results

System technical evaluation is carried out by performance testing using Google Cloud Platform infrastructure. The following are the evaluation results:

Table 1. System Technical Evaluation Results

Parameter Evaluation	Test Results	Interpretation
Average API Latency	0.8 seconds/request	Very good, responsive
Peak Throughput	120 requests/minute	Moderately high, effectively handles simultaneous requests
VM average CPU Usage	20–35%	Optimal, stable system, no overload
VM average Memory Usage	25–35%	Stable, within safe operating limits
Network Traffic	3–5 KB/s (average) Active	sufficient for real-time data integration
Disk Space Utilization	< 40% (/dev/sda1) Safe	sufficient disk capacity
Disk Throughput (IOPS)	10–50 IOPS (read/write) Safe	no disk bottleneck
Log Severity	Dominant INFO/DEBUG	No fatal errors during testing

This test shows that the implementation of cloud technology for real-time data integration and reporting automation works optimally, efficiently, and stably under normal and peak load operating conditions.

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

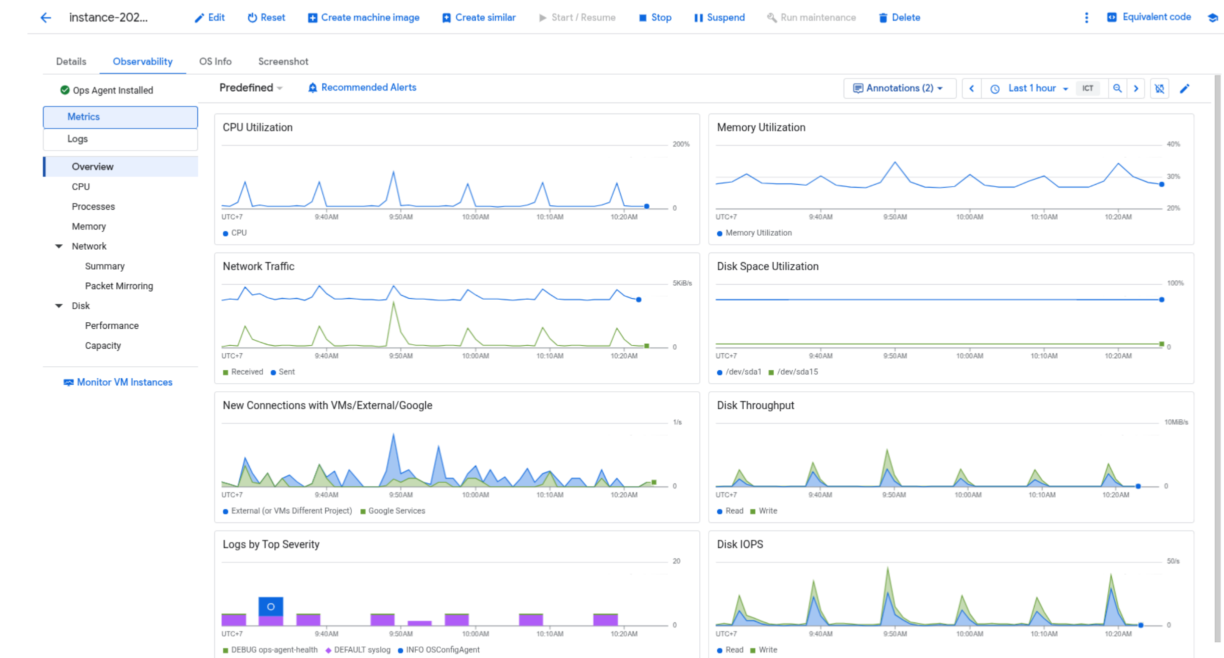

Fig. 5 Overview Compute Engine (Virtual Machine) GCP

Results of User Acceptance Testing

User evaluation was conducted through interviews, observation of use, and questionnaires to groups of respondents consisting of weather operators, local government agencies, and general users. The results of the user evaluation are summarised in the following table:

Table 2. User Evaluation Results

Aspek Evaluasi	Persentase Kepuasan (%)	Rata-rata Skor (1-5)
Ease of use of dashboard	92%	4.6
Speed of access to weather data	88%	4.4
Accuracy and usefulness of automated reports	90%	4.5
Visualisation of extreme weather risk	94%	4.7
Suitability of features to needs	90%	4.5

Overall, user evaluations showed a high level of satisfaction with the features developed, especially in the aspects of extreme risk visualisation and reporting automation.

DISCUSSIONS

These implementation and evaluation results confirm the tangible benefits of using cloud computing in real-time data management, reporting automation, and spatial analytics visualization for national weather applications. Some key points in this discussion:

1. Integration Efficiency and Automation:

Cloud implementation has significantly improved the efficiency of data integration and automation of reporting processes compared to manual methods. This is evident from the system's ability to generate actual and forecast reports simultaneously in less than 1 minute.

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

2. Performance and Scalability of Cloud Infrastructure:
   The Google Cloud Platform infrastructure used successfully handles workloads in a stable manner, with optimal resource utilisation. The flexibility of VM scalability in the cloud enables dynamic adjustment of resources as the number of users or coverage area increases.
3. Dashboard Visualisation Excellence:
   The interactive spatial dashboard developed proved effective in helping users understand weather information visually and intuitively. Visualisation of extreme risks through automated heatmaps increases user awareness in quickly identifying potential risks.
4. Practical Implications of the System:
   The system is able to support quick decision making by government agencies and the wider community in various situations, especially related to handling and mitigating extreme weather risks.

Comparative Analysis of the Developed System

The following table shows the comparison between the cloud-based system developed in this research compared to the manual/traditional approach:

Table 3. Comparative Analysis

Criteria	Manual/Traditional Systems	Cloud-based system
Speed of weather data integration	Slow, manual	Fast, real-time automated
Accuracy and efficiency of reporting	Low	High, minimal human error
Visualisation of extreme risks	Limited, textual	Complete, spatially interactive
Scalability of the system	Difficult to scale	Highly scalable (cloud)
Scalability of the system	Limited	High (user-friendly)

From this analysis, it is clear that the implemented cloud-based system offers many advantages over the previous manual method.

Implementation Challenges and Solutions

In the implementation process, there were several challenges that were successfully overcome:
1. API integration with limit requests: Solved with a data caching strategy on the backend side.
2. Real-time spatial data visualisation: Solved by using lightweight Leaflet.js and Turf.js for map performance optimisation.
3. Simultaneous automated report generation: Solved by the use of asynchronous JavaScript technology on the frontend.

Research Implications

This research shows that a cloud-based approach can significantly improve the efficiency, speed, and quality of national weather information presentation. These implications are important for both public and private institutions that require a reliable, scalable environmental monitoring system capable of providing strategic decision support in both emergency and normal conditions.

CONCLUSION

Based on the results of the research and discussion that has been presented, several important conclusions can be formulated as follows:
1. Real-Time Data Integration Based on Cloud Computing
   The implementation of cloud computing technology successfully integrates real-time weather data from external APIs with high performance. The integration latency recorded below 1 second per request allows the

* Corresponding author

Journal of Computer Networks, Architecture and High Performance Computing
Volume 7, Number 3, July 2025
https://doi.org/10.47709/cnahpc.v7i3.6298

Submitted : Jun 30, 2025
Accepted : Jul 18, 2025
Published : Jul 21, 2025

system to provide fast and accurate actual weather information simultaneously for all regions of Indonesia (Warren & Marz, 2015).

2. Effectiveness of Weather Reporting Automation

   The developed weather reporting automation process has significantly improved operational efficiency compared to the manual process. The system is able to generate actual and forecast weather reports for all provinces within minutes, reducing the risk of human error and accelerating the distribution of critical information.

3. Interactive Spatial Dashboard and Extreme Risk Analytics

   The developed interactive spatial dashboard is effective in presenting weather information visually and intuitively to users. The extreme risk analytics feature with automatic heatmap visualisation allows users to recognise potential risks in real-time, supporting a fast and precise decision-making process.

4. Optimisation of Cloud Infrastructure (GCP)

   The Google Cloud Platform (GCP) infrastructure used showed excellent performance in terms of stability, scalability, and efficient use of resources. The technical evaluation results show that the system is able to handle dynamic workloads with optimal resource levels.

5. Positive Impact on Decision Making

   The implementation of this system provides real benefits in supporting fast and effective decision making, especially in extreme weather risk management. This is reflected in the high level of user satisfaction with the ease of use, accuracy of reports, and effectiveness of risk analytics visualisation.

REFERENCES

Fauzi, A. A., Kom, S., Kom, M., Harto, B., Dulame, I. M., Pramuditha, P., ... & ST, S. (2023). *Pemanfaatan Teknologi Informasi di Berbagai Sektor Pada Masa Society 5.0*. PT. Sonpedia Publishing Indonesia.

Hermawan, A., Ratnawati, D., & Hariadi, D. (2024, August). Integrasi Artificial Intelligence Dalam Proses Belajar Mengajar. In *Proceeding Technology of Renewable Energy and Development Conference* (Vol. 4, No. 1, pp. 19-27).

Kurniawan, S. D., Widiastuti, R. Y., Hermanto, D. M. C., Mukhlis, I. R., Pipin, S. J., Surianto, D. F., ... & Judijanto, L. (2024). *Big Data: Mengenal Big Data & Implementasinya di Berbagai Bidang*. PT. Sonpedia Publishing Indonesia.

Lestari, D. A., & Nasution, M. I. P. (2025). Pengelolaan Big Data: Inovasi Solusi Dan Tantangan Dalam Era Informasi Modern. *Journal Sains Student Research*, *3*(3), 502-511.

Munte, M. A., Angela, R. S., & Kamal, U. (2024). Hukum Lingkungan dalam Mengatasi Darurat Kesehatan: Dampak Perubahan Iklim di Indonesia di Tinjau dari Undang-Undang No 32 Tahun 2009 Tentang Perlindungan dan Pengelolaan Lingkungan Hidup. *Jurnal Ilmiah Wahana Pendidikan*, *10*(24), 100-111.

Nadirah, S. P., Pramana, A. D. R., & Zari, N. (2022). *metodologi penelitian kualitatif, kuantitatif, mix method (mengelola Penelitian Dengan Mendeley dan Nvivo)*. CV. Azka Pustaka.

Purwono, F. H., Ulya, A. U., Purnasari, N., & Juniatmoko, R. (2019). Metodologi Penelitian (Kuantitatif, Kualitatif dan Mix Method). Guepedia.

Riana, E. (2020). Implementasi Cloud Computing Technology dan Dampaknya Terhadap Kelangsungan Bisnis Perusahaan Dengan Menggunakan Metode Agile dan Studi Literatur. *JURIKOM (Jurnal Riset Komputer)*, *7*(3), 439-449.

Setyosari, H. P. (2016). *Metode penelitian pendidikan & pengembangan*. Prenada Media.

Surmaini, E., & Faqih, A. (2016). Kejadian iklim ekstrem dan dampaknya terhadap pertanian tanaman pangan di Indonesia. *Jurnal Sumberdaya Lahan*, *10*(2).

Sutarti, T., & Irawan, E. (2017). *Kiat sukses meraih hibah penelitian pengembangan*. Deepublish.

Warren, J., & Marz, N. (2015). *Big Data: Principles and best practices of scalable realtime data systems*. Simon and Schuster.

Yuwana, S., & Indarti, T. (2023). Metode Penelitian Dan Pengembangan (Research & Development) Dalam Pendidikan Dan Pembelajaran. UMMPress.

* Corresponding author