A WEB-BASED FLOOD INFORMATION MANAGEMENT SYSTEM FOR IMPROVED RESCUE AND RECOVERY DECISIONS

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ABSTRACT: This paper presents the development of the Flood Rescue and Recovery Management System, designed to address inefficiencies in current flood response methods, which often rely on slow manual coordination and limited data sharing. The study aims to develop a user-friendly web-based platform that streamlines flood information sharing, enhances accessibility and improves decision-making for rescue and recovery. Core functionalities encompass user-submitted help requests, real-time flood alerts, risk heatmap visualization, resource allocation based on risk scores, task management and a chat room for coordination. Built on Agile principles like rapid communication and flexible planning, this system tackles issues such as delayed responses and poor data sharing. While the tool has not yet been validated in real-world scenario, it simplifies coordination, increases community engagement and provides reliable data for stakeholders. This paper explains how the tool was built, its benefits, and how it can support faster and smarter flood response. Future work will focus on real-world deployment and user testing to validate its effectiveness.

KEYWORDS: *Flood Management; Disaster Response; Web-based Tool; Agile Principles; Real-time Alert System*

1.0 INTRODUCTION

Floods are one of the most frequent natural disasters in Malaysia. They happen almost every year, especially during the monsoon season [1]. Floods cause the most damage each year by leading to loss of life, sickness and destruction of property and between July 2012 and January 2019, Malaysia had the highest number of people affected by floods among ASEAN countries [2]. Floods can happen for many reasons, such as heavy and continuous rain, rapid urban growth, river sediment buildup, cutting down forests, and poor drainage systems [3]. The Department of Irrigation and Drainage (2017) reported that floods in several Malaysian states between December 2021 and January 2022 caused total losses of RM6.1 billion (USD 1.46 billion) [4]. Floods are quite predictable and mostly happen along the east coast, especially in Kelantan, Terengganu, and Pahang, as well as in Johor and Melaka in the south, and Perlis, Kedah, and Perak in the north [5].The increasing frequency and severity of these disasters, driven by anthropogenic climate change and inadequate governance, underscore the need for robust flood risk management (FRM) strategies [6].

Traditional flood control methods may not be enough, and using non-structural ways like better urban planning, emergency management, and understanding community behavior can help reduce the damage caused by floods [7]. However, challenges such as insufficient knowledge-sharing mechanisms, fragmented disaster management strategies and the professionalization of community groups can hinder effective implementation [8]. Knowledge management practices, which focus on creating, sharing, and utilizing knowledge, are critical for minimizing disaster impacts by informing mitigation and preparedness efforts [9]. Effective decision-making during disasters is critical for saving lives and reducing damage. In times of crisis, decision-makers must quickly assess the situation, gather accurate information, and act under extreme pressure. The ability to make sound decisions in high-stress, uncertain conditions is essential, as poor decision-making can lead to widespread consequences for communities, economies, and the environment. Therefore, improving decision-making processes in emergencies is a crucial aspect of disaster management, requiring timely actions, collaboration, and strategic planning [10]. When unexpected disasters occur, emergency managers face rapidly evolving and complex situations. This concept, known as situational evolution, describes how emergencies develop over time and how decision-making must adapt at each stage [11]. A correct

decision can save countless lives and protect animals, whereas an incorrect decision may result in significant economic losses and public dissatisfaction [12]. Effective planning involves the identification of evacuation points, shelter locations, and the management of critical resources like food, water, and medical supplies. Quick, well-planned decisions not only save lives but also reduce long-term social and economic impacts, highlighting their critical role in flood-prone regions [13].

This study introduces a Flood Information Management Tool designed to address these shortcomings by leveraging modern web technologies and Agile development principles. The tool provides a comprehensive platform for real-time flood monitoring, risk assessment, resource allocation and community engagement. Key features include real-time alerts, flood risk heatmaps, task management boards, discussion rooms for inter-agency collaboration and user-driven rescue and recovery requests. These functionalities aim to improve decision-making, optimize resource use, and foster trust between authorities and communities.

2.0 LITERATURE REVIEW

The increasing prevalence of floods has spurred research into technology-driven disaster management systems, with a focus on improving preparedness, response, and recovery. Najafi et al. (2024) emphasize the importance of high-resolution, impact-based early warning systems for riverine flooding, highlighting their ability to provide timely and accurate alerts [14]. Such systems rely on real-time data integration, which aligns with the proposed tool's use of water level and rainfall data to generate flood risk scores and heatmaps. Similarly, Leeonis et al. (2024) advocate for flood hazard mapping to enhance preparedness and resource allocation, demonstrating the effectiveness of risk visualization in prioritizing high-risk areas [15]. These studies underscore the need for dynamic tools that deliver actionable insights to decision-makers.

The primary tool for flood management in Malaysia, the Department of Irrigation and Drainage's InfoBanjir system, provides real-time water level and rainfall monitoring, flood warnings and river basin data. However, it lacks features for community engagement, such as user-driven rescue or recovery requests and inter-agency collaboration, such as real-time discussion platforms or task management. The

proposed system addresses these gaps by integrating real-time data with community input through rescue and recovery requests and collaborative features like discussion rooms and task management boards, offering a novel, comprehensive approach tailored to Malaysia's flood management needs.

Collaboration and communication are critical for effective flood management. Oktari et al. (2020) argue that knowledge management practices, such as inter-agency information sharing, significantly improve disaster response coordination [9]. This is supported by Alam and Ray-Bennett (2021), who highlight the role of clear communication in building trust and aligning stakeholders during emergencies [6]. The proposed tool's discussion room and task management board directly address these needs by facilitating real-time collaboration and task tracking. Additionally, Puzyreva et al. (2022) emphasize the professionalization of community engagement, noting that involving affected populations in decision-making enhances response efficiency and trust [8]. The tool's rescue and recovery request feature embodies this principle by enabling users to communicate their needs directly.

Agile methodologies have gained traction in disaster management due to their flexibility and iterative nature. Saad et al. (2021) propose an Agile information-based framework for flood management, emphasizing continuous delivery and stakeholder involvement [16]. This aligns with Beekharry et al. (2016), who advocate for Agile approaches to adapt to the dynamic nature of natural disasters [17]. The proposed tool incorporates these principles through its iterative development process and adaptive resource allocation based on risk scores. Furthermore, Zhong et al. (2025) highlight the importance of data-driven resource allocation to enhance urban flood resilience, reinforcing the tool's approach to prioritizing high-risk areas [18]. However, Hammood et al. (2021) note that many flood early warning systems lack empirical validation, a limitation also acknowledged in this study [19]. Collectively, these works highlight the potential of technology-driven, Agile-based solutions to transform flood management, providing a strong foundation for the proposed tool.

3.0 METHODOLOGY

The Flood Information Management Tool was developed using the Django framework for the backend and MySQL for the database. The

system followed an Agile approach, allowing continuous updates based on data. Core features such as user recovery or rescue requests, real-time alerts, risk heatmaps and task management were implemented through Django, while MySQL handled data storage and retrieval. The system was organized into four stages—Initiation, Adaptive Response Planning, Deployment, and Monitoring & Feedback—to deliver a comprehensive and adaptive flood management solution.

Figure 1, the flood management framework, organizes the web tool's functionalities into four stages: Initiation (Stage A), Adaptive Response Planning (Stage B), Deployment (Stage C) and Monitoring & Feedback (Stage D). Each stage aligns with the features of the web tool and ensures a comprehensive flood response strategy.

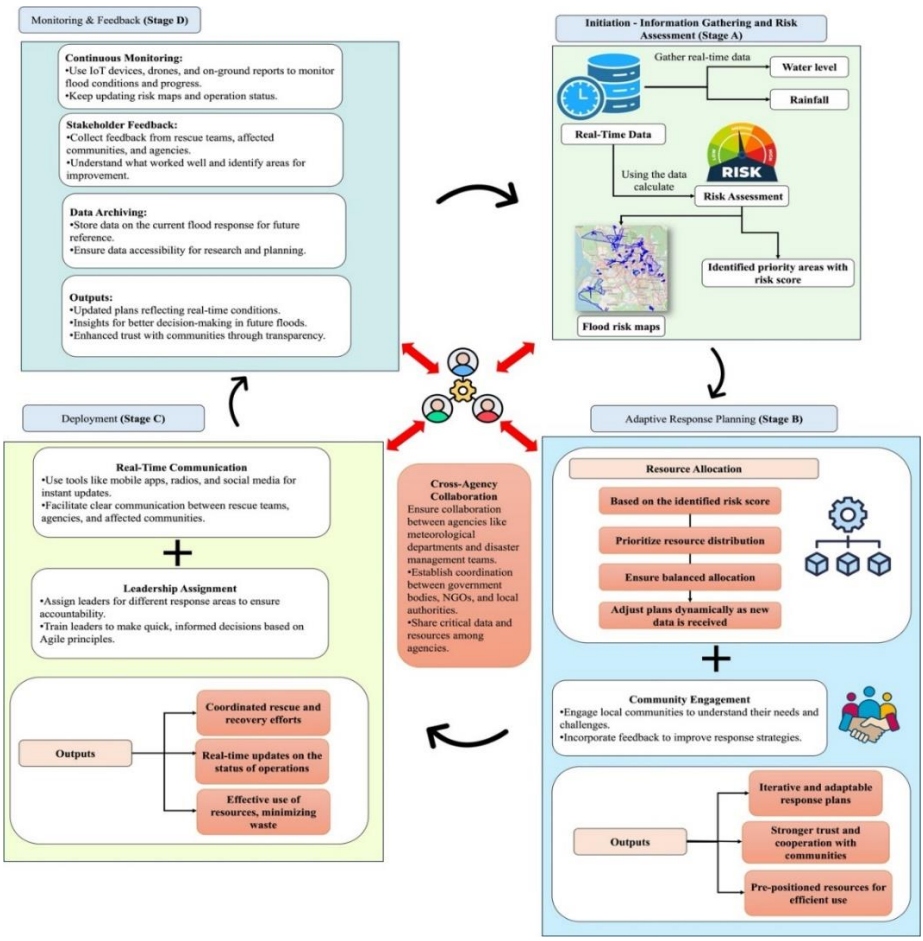


Figure 1: Flood Management Framework

In Stage A (Initiation - Information Gathering and Risk Assessment), the system collects real-time data on water levels and rainfall. The system calculates a flood risk score based on three factors: rainfall reading, water level reading and the area size. A higher rainfall amount, rising water levels and larger affected area will result in a higher risk score and based on the risk score generated the flood risk maps. These maps are displayed on the admin's dashboard as a heatmap, where admins can see current alerts and identify high-risk areas. For example, a densely populated area with high rainfall and rising water levels will have a higher risk score, highlighted in red on the heatmap. This stage ensures that admins have a clear picture of the flood situation, allowing them to prioritize response efforts effectively. Users can also view current alerts and preparedness notices on their interface, keeping them informed about the situation. Stage B (Adaptive Response Planning) focuses on resource allocation and community engagement. Using the flood risk score from Stage A, the system prioritizes resource distribution. For instance, areas with a high-risk score receive more boats and rescue teams, while lower-risk areas may receive supplies for recovery. Community engagement is a key feature here—users can submit requests for rescue or recovery, ensuring their needs are communicated directly to the system. This stage ensures that resources are allocated efficiently while keeping the community involved in the process. Stage C (Deployment) emphasizes real-time communication and leadership assignment, both facilitated by the web tool's features. Admins can use the discussion room to chat and coordinate during emergencies. For example, if a rescue team needs additional boats, they can communicate this need to other agencies in real-time, ensuring quick action. The task management board allows admins to assign tasks, such as deploying a rescue team to a high-risk area and track their status (to-do, in-progress, or done). This feature ensures that all tasks are organized and completed efficiently. This stage ensures that the response is well-coordinated and that resources like boats and teams are deployed effectively. Stage D (Monitoring & Feedback) focuses on continuous monitoring and improvement. The web tool's admin interface displays the heatmap and current alert list, allowing admins to monitor flood conditions in real-time. For example, if water levels rise in a previously low-risk area, the system updates the risk score and alerts admins through the warning list. Users can also access current alerts and preparedness notices, ensuring they stay informed about the situation. The system archives data on the current flood response, such as the number of rescues completed and resources used, for future planning. This stage ensures that the system remains adaptive, learns from each flood event, and builds trust with the community through

transparency.

The outputs of this methodology are significant. The web tool provides real-time updates on the flood operations, ensuring that admins and users are always informed. It promotes efficient resource use by prioritizing high-risk areas and minimizing waste. The system fosters collaboration between agencies through the discussion room and strengthens ties with communities by allowing users to submit requests and view alerts. By archiving data and incorporating feedback, the web tool supports iterative and adaptive response plans, ensuring better preparedness for future floods.

4.0 RESULT AND DISCUSSION

The flood information management web tool uses Agile principles to improve flood response with flexible, collaborative, and iterative features. Table 1 maps the tool's features to Agile principles.

Table 1: Mapping Tool Features to Agile Principles

Agile Principle	Tool Feature	Relevance to Decision-Making	Figure
Early and continuous delivery	Current Alert and Preparedness Notice	Real-time disaster forecasting and warning systems provide simple, flexible tools for disaster management, enabling faster responses [9].	Figures 2, 3
Frequent delivery of working software	Flood Risk assessment and Heatmap	Flood hazard maps and risk score from different data resolutions helps decision-makers choose the best method for managing flood risks, improving preparedness and resource use [15 - 14].	Figures 4, 5
Communication and Collaboration	Discussion Room and Task Management Board	Agency collaboration during disasters shares critical knowledge, boosting emergency response. Clear communication builds trust among decision-makers and teams. Open departmental and community communication improves flood risk management and emergency decisions [9 - 6]	Figures 6, 7
Community Engagement	Rescue and Recovery request from affected people	Community involvement in decision-making ensures flood management uses current information, improves coordination, aligns decisions with needs, and boosts efficiency and collaboration in response efforts. [17 - 20].	Figures 8, 9

Adaptive Response Planning	Resource allocation based on risk scores	Allocating resources using flood risk scores enables prioritized, data-driven decisions, optimizing response efficiency and minimizing losses in high-risk areas [18]	

Figure 2 and Figure 3 illustrated the web tool's preparedness notice and alert feature shares real-time flood updates, following Agile's early and continuous delivery principle. It sends simple alerts about rising water or risky areas, helping emergency teams and communities act fast. For example, a warning about a flooding river prompts quick boat deployment. These updates keep everyone informed, reducing delays in sending supplies like boat. The tool's easy design ensures even non-tech users understand alerts, building trust as communities feel supported. Decision-makers, like local officials, use these alerts to prioritize help, ensuring resources reach those in need. This feature supports flood management by providing timely information, aligning with Agile's focus on delivering tools that work right away. It enhances the potential to save lives by speeding up responses.

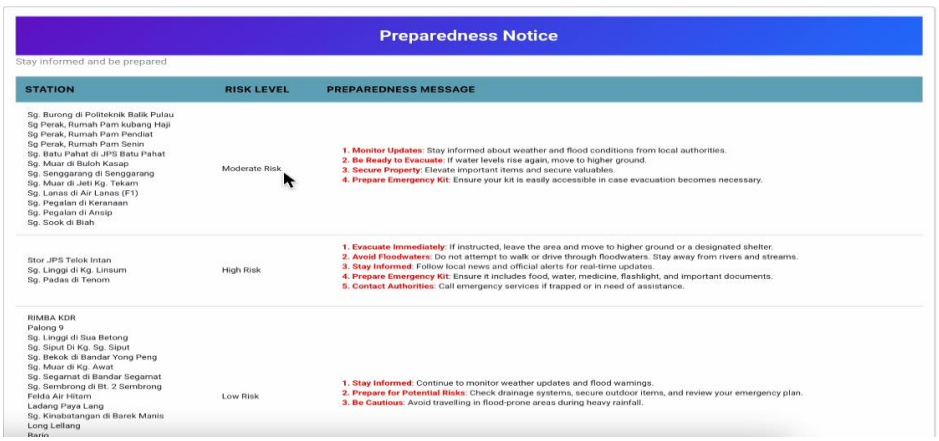
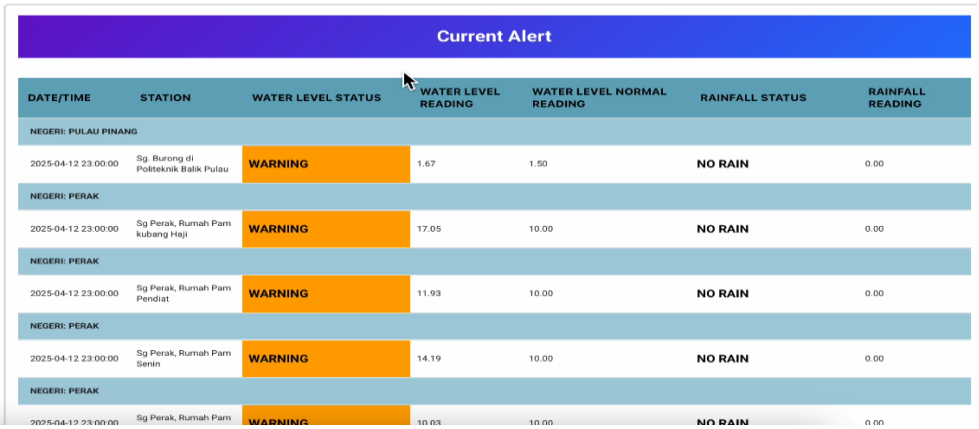


Figure 1: Preparedness Notice Interface



Current Alert

DATE/TIME	STATION	WATER LEVEL STATUS	WATER LEVEL READING	WATER LEVEL NORMAL READING	RAINFALL STATUS	RAINFALL READING
NEGERI: PULAU PINANG						
2025-04-12 23:00:00	Sg. Burong di Politeknik Balik Pulau	WARNING	1.67	1.50	NO RAIN	0.00
NEGERI: PERAK						
2025-04-12 23:00:00	Sg Perak, Rumah Pam kubang Haji	WARNING	17.05	10.00	NO RAIN	0.00
NEGERI: PERAK						
2025-04-12 23:00:00	Sg Perak, Rumah Pam Pendiat	WARNING	11.93	10.00	NO RAIN	0.00
NEGERI: PERAK						
2025-04-12 23:00:00	Sg Perak, Rumah Pam Senin	WARNING	14.19	10.00	NO RAIN	0.00
NEGERI: PERAK						
2025-04-12 23:00:00	Sg Perak, Rumah Pam	WARNING	10.03	10.00	NO RAIN	0.00

Figure 2: Current Alert for Flood

Figure 4 and Figure 5 highlighted the heatmap and flood risk assessment feature uses real-time data, like rainfall and water levels, to show high-risk areas, following Agile's frequent software delivery principle. The heatmap highlights danger zones in bright colors, helping admins spot where floods are worst. The alert list shows warnings and risk scores, guiding decisions. Built step-by-step, these tools stay accurate, helping choose a standard way to manage risks. For example, a high-risk area on the heatmap gets boats first, improving resource use.

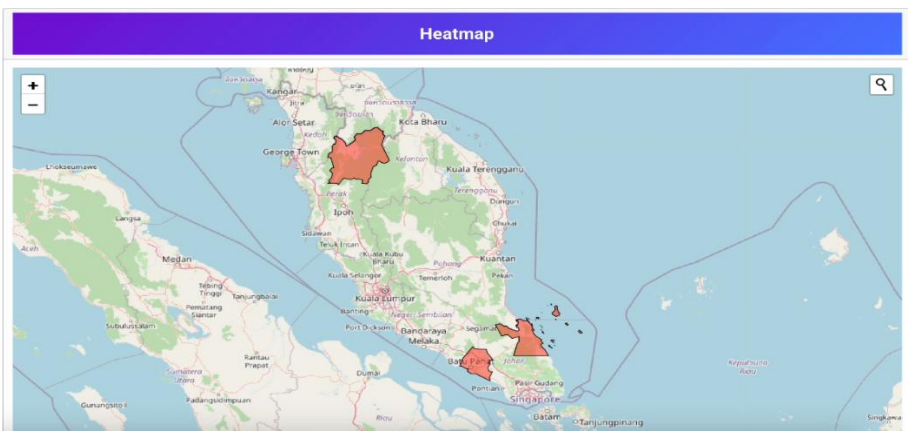


Figure 3: Heatmap for Affected Area

STATION	RISK SCORE
Muara Sg. Jawi (F2)	0.18
Muara Sungai Pinang S18 (F2)	0.47
Sg. Perak di Pasang Api	0.73
Sg Perak, Rumah Pam kubang Haji	6.77
Sg Perak, Rumah Pam Pendiat	4.70
Sg Perak, Rumah Pam Senin	5.64
Sg. Batu Pahat di JPS Batu Pahat	0.92
Sg. Endau di Kg. Labong	0.40
Sg. Belemang Besar di Simpang 5 Darat	1.63
Sg. Muar di Kg. Awat	7.63
Sg. Muar di Buloh Kasap	3.40
Sg. Pulai di Kg. Ulu Pulai	0.75

Figure 4: Calculated Risk Score

Figure 6 and Figure 7 displayed the discussion room and task management board enable agency collaboration, following Agile's communication principle. The discussion room allows real-time chats, so teams can share updates, such as requesting additional boats, reducing confusion. The task board assigns tasks, like deploying teams, and tracks progress (to-do, in-progress, done). These tools share knowledge, boosting response speed and building trust through clear communication. Open communication improves flood risk management by keeping everyone aligned.

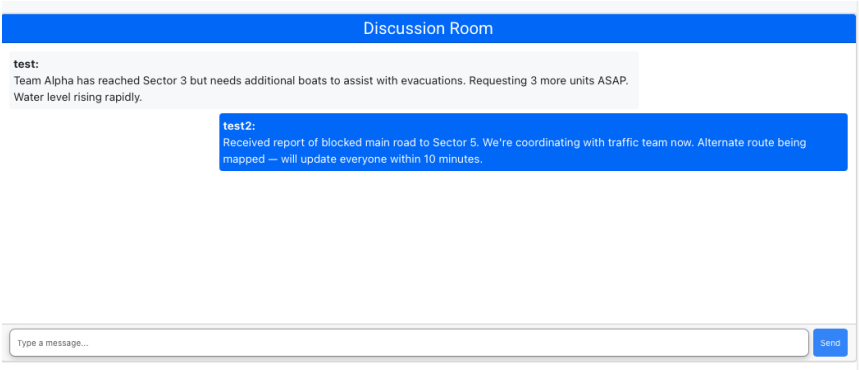


Figure 5: Discussion Room Interface

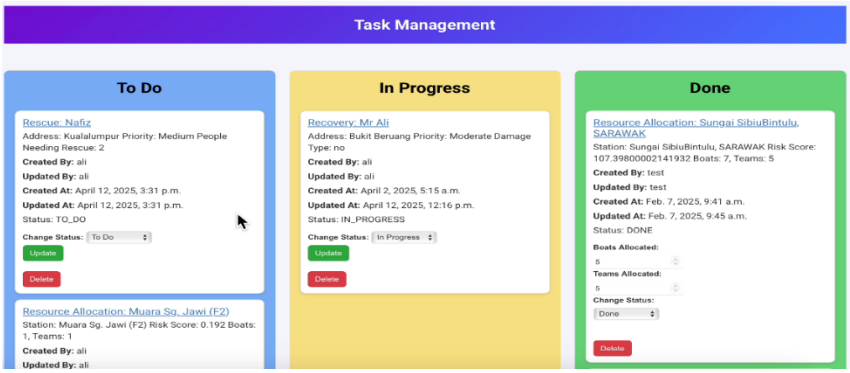


Figure 6: Task Management Interface

Figure 8 and Figure 9 presented the rescue and recovery request feature lets flood-affected people report needs, like boats or food, following Agile's community engagement principle. This ensures responses match real-time community needs. Users also see alerts, staying informed about risks. This builds trust, as communities feel heard. The feature improves coordination by linking needs to teams, ensuring resources go to the right places. Community input aligns decisions with actual conditions, like targeting hard-hit areas. Feedback improves future responses, such as stocking more supplies. This empowers communities and makes flood management more effective by meeting real needs.

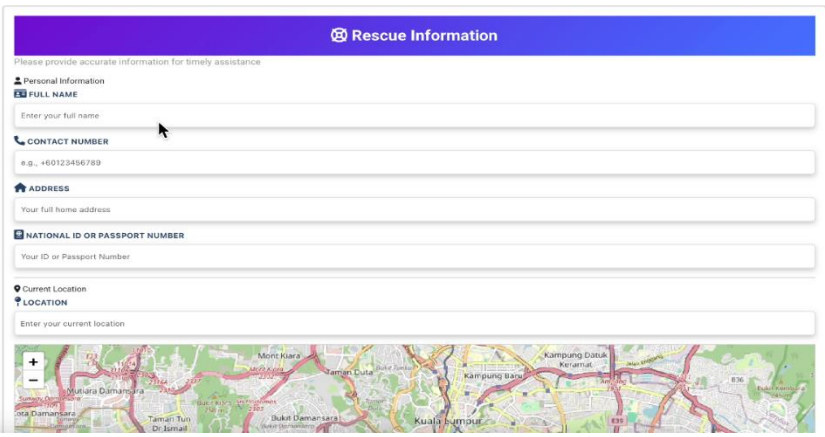


Figure 7: Rescue Request Form

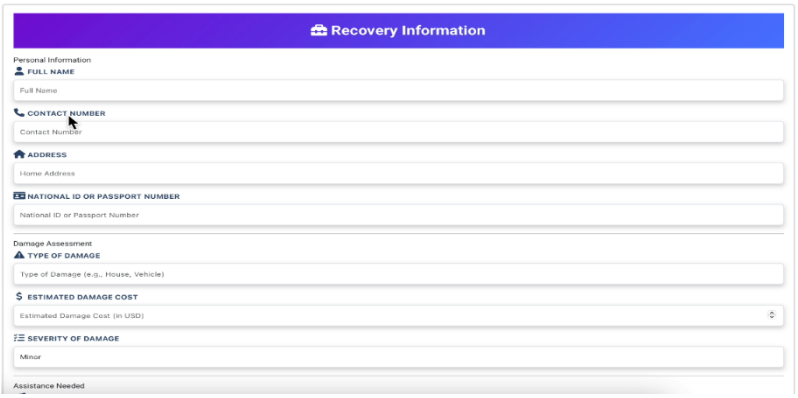


Figure 8: Recovery Request Form

The resource allocation feature uses risk scores to send help where needed, following Agile's adaptive planning principle. It assigns resources, like teams, based on flood risks. For example, a high-risk score sends boats to a flooded town. The tool adjusts plans if new risks arise, supported by a centralized database with reliable data. This flexibility avoids costly infrastructure and ensures sustainable responses. This makes flood management responsive and effective for future crises.

By aligning with Agile principles, the web tool improves flood management by ensuring user involvement, delivering real-time tools, supporting flexible task management, promoting collaboration, and enabling continuous improvement. These features reduce response times, enhance resource allocation, and build community trust. Although the system has not been tested with real data, its design demonstrates a practical application of Agile methodology, offering a scalable solution for flood management that can adapt to varying conditions and stakeholder needs.

5.0 LIMITATIONS

The primary limitation is the lack of empirical data to validate the tool's effectiveness. The evaluation is theoretical, relying on literature and Agile principles. Future work will involve real-world deployment, user testing with agencies and communities and validation through pilot studies in flood-prone regions like Kelantan.

6.0 CONCLUSION

This study introduces a flood management web tool guided by Agile principles to enhance response efficiency, coordination and decision-making. Key features—real-time alerts, risk heatmaps, collaboration tools, community input and adaptive planning—are designed to address common disaster challenges. The tool promotes flexibility, user engagement and continuous improvement, aligning well with Agile values. While its effectiveness remains theoretical due to the lack of real-world testing, the design demonstrates strong potential for practical application. Future work will focus on deploying the tool in actual flood scenarios to validate its usability, effectiveness, and impact on disaster preparedness and response.

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REFERENCES

[1] M. Ikhwan *et al.*, "Application of Sendai Framework for Disaster Risk Reduction in Food Security During Flood Disaster in Malaysia: A Narrative Review," Malaysian Journal of Medicine and Health Sciences, vol. 19, no. 4, pp. 332–341, 2023, doi: 10.47836/mjmhs19.4.46.

[2] Z. Zainal Abidin *et al.*, "Implementation of Flood Emergency Response System with Face Analytics." [Online]. Available: www.ijacsa.thesai.org

[3] O. N. Shazwani, T. Wardah, and C. K. Nursalleh, "Integrated Flood Modeling for Klang River Basin Using HEC-HMS and Radar Rainfall Input," *International Journal of Environmental Science and Development*, vol. 15, no. 4, pp. 176–184, 2024, doi: 10.18178/ijesd.2024.15.4.1483.

[4] N. A. Jafry, J. Suhaila, F. Yusof, S. R. M. Nor, and N. E. Alias, "Enhancing flood risk assessment in the Johor River Basin through trivariate copula," *Journal of Water and Climate Change*, vol. 15, no. 4, pp. 1820–1839, Apr. 2024, doi: 10.2166/wcc.2024.624.

[5] H. Mohd Zahari, N. A. M. Zainol, and A. Ismail, "Media Information, Flood Images, and Perceptions in Times of Flood," *Sustainability (Switzerland)*, vol. 14, no. 17, Sep. 2022, doi: 10.3390/su141710623.

[6] E. Alam and N. S. Ray-Bennett, "Disaster risk governance for district-level landslide risk management in Bangladesh," *International Journal of Disaster Risk Reduction*, vol. 59, Jun. 2021, doi: 10.1016/j.ijdrr.2021.102220.

[7] S. Santoro, R. Lovreglio, V. Totaro, D. Camarda, V. Iacobellis, and U. Fratino, "Community risk perception for flood management: A structural equation modelling approach," *International Journal of Disaster Risk Reduction*, vol. 97, Oct. 2023, doi: 10.1016/j.ijdrr.2023.104012.

[8] K. Puzyreva et al., "Professionalization of community engagement in flood risk management: Insights from four European countries," *International Journal of Disaster Risk Reduction*, vol. 71, Mar. 2022, doi: 10.1016/j.ijdrr.2022.102811.

[9] R. S. Oktari, K. Munadi, R. Idroes, and H. Sofyan, "Knowledge management practices in disaster management: Systematic review," Dec. 01, 2020, *Elsevier Ltd*. doi: 10.1016/j.ijdrr.2020.101881.

[10] S. N. A. Zubir, S. Thiruchelvam, K. N. M. Mustapha, Z. C. Muda, A. Ghazali, and H. Hakimie, "An Evaluation on Factors Influencing Decision making for Malaysia Disaster Management: The Confirmatory Factor Analysis Approach," in *IOP Conference Series: Materials Science and Engineering*, Institute of Physics Publishing, Jan. 2018. doi: 10.1088/1757-899X/291/1/012023.

[11] L. Zhou, X. Wu, Z. Xu, and H. Fujita, "Emergency decision making for natural disasters: An overview," Mar. 01, 2018, *Elsevier Ltd*. doi: 10.1016/j.ijdrr.2017.09.037.

[12] V. Radosavljevic, G. Belojevic, and N. Pavlovic, "Tool for decision-making regarding general evacuation during a rapid river flood," *Public Health*, vol. 146, pp. 134–139, May 2017, doi: 10.1016/j.puhe.2017.01.025.

[13] F. Santana-Robles, E. S. Hernández-Gress, R. Martínez-López, and I. J. González-Hernández, "Quick-Response Model for Pre- and Post-Disaster Evacuation and Aid Distribution: The Case of the Tula River Flood Event," *Logistics*, vol. 8, no. 1, Mar. 2024, doi: 10.3390/logistics8010008.

[14] H. Najafi et al., "High-resolution impact-based early warning system for riverine flooding," *Nat Commun*, vol. 15, no. 1, Dec. 2024, doi: 10.1038/s41467-024-48065-y.

[15] A. N. Leeonis et al., "Mitigating flood risk at Shah Alam, Malaysia for sustainable development," *Discover Sustainability*, vol. 5, no. 1, Dec. 2024, doi: 10.1007/s43621-024-00504-y.

[16] M. F. M. Saad, A. A. Latif, and M. Othman, "Agile information-based framework for flood management," *IOP Conf Ser Mater Sci Eng*, vol. 1088, no. 1, p. 012048, Feb. 2021, doi: 10.1088/1757-899x/1088/1/012048.

[17] D. Beekharry, M. Tony, M. D. Beekharry, M. Blanks, R. Rameezdeen, and T. Ma, "An Agile approach to Natural Disaster Management," 2016. [Online]. Available: https://www.researchgate.net/publication/310798828

[18] J. Zhong et al., "Pre-disaster flood prevention funds allocation and benefit analysis considering social vulnerability to enhance urban sustainable flood resilience," *International Journal of Disaster Risk Reduction*, vol. 119, Mar. 2025, doi: 10.1016/j.ijdrr.2025.105324.

[19] W. A. Hammood, R. A. Arshah, S. M. Asmara, H. Al Halbusi, O. A. Hammood, and S. Al Abri, "A systematic review on flood early warning and response system (FEWRS): A deep review and analysis," Jan. 01, 2021, *MDPI AG*. doi: 10.3390/su13010440.

[20] K. Puzyreva et al., "Professionalization of community engagement in flood risk management: Insights from four European countries," *International Journal of Disaster Risk Reduction*, vol. 71, Mar. 2022, doi: 10.1016/j.ijdrr.2022.102811.