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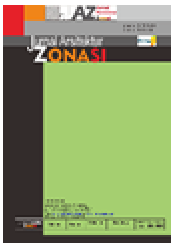

Eco-Resilient Design for Flood Disaster Mitigation Centers in Mempawah Regency: A Community Adaptation Strategy

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ABSTRACT

Flooding is one of the most frequent hydrometeorological disasters in Indonesia, particularly in coastal and lowland regions such as Mempawah Regency, West Kalimantan. Recurring flood events are caused by extreme rainfall, river overflow, tidal inundation, land-use change, river sedimentation, and inadequate drainage infrastructure, resulting in significant environmental, social, and economic impacts on local communities. Existing evacuation and disaster-response facilities in Mempawah Regency remain limited, temporary, and insufficient to support long-term disaster preparedness, emergency response, and community resilience. This study aims to examine the application of the Eco-Resilient design approach in the development of a Flood Disaster Mitigation Center as a strategy for strengthening community adaptation to recurring flood disasters. The research employs a descriptive qualitative method through site analysis, user analysis, functional analysis, precedent studies, and evaluation of Eco-Resilient design principles. The proposed design integrates ecological sustainability, physical and structural resilience, spatial and hydrological planning, socio-resilience, and techno-resilience into a unified architectural system. Design strategies include elevated building systems, green-blue infrastructure, floodable landscapes, permeable surfaces, modular spatial arrangements, retention ponds, rainwater harvesting systems, and integrated evacuation routes. The findings indicate that the Eco-Resilient approach is capable of creating an adaptive and multifunctional disaster mitigation facility that supports safe evacuation, disaster education, environmental management, emergency coordination, and post-disaster recovery. The study concludes that the integration

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of ecological, social, spatial, and technological resilience can transform flood mitigation facilities into proactive and sustainable socio-ecological infrastructure for flood-prone coastal areas.

1. INTRODUCTION

Indonesia is highly vulnerable to hydrometeorological disasters, particularly flooding. Its archipelagic geography, high rainfall intensity, extensive river basin systems, coastal lowlands, and rapid land-use transformation have contributed to recurring flood events across many regions. Flooding is not only triggered by natural factors such as extreme rainfall, river overflow, and tidal inundation, but is also intensified by anthropogenic pressures, including the reduction of water catchment areas, inadequate drainage capacity, river sedimentation, and the conversion of permeable surfaces into built-up areas (BMKG, 2024; BNPB, 2024; BRIN, 2024). In the context of climate change, flood risk has become increasingly complex, particularly in coastal and lowland areas where extreme rainfall may coincide with sea level rise and tidal flooding. Therefore, flood mitigation requires not only emergency response mechanisms, but also spatial, ecological, and architectural strategies that are adaptive, resilient, and sustainable.

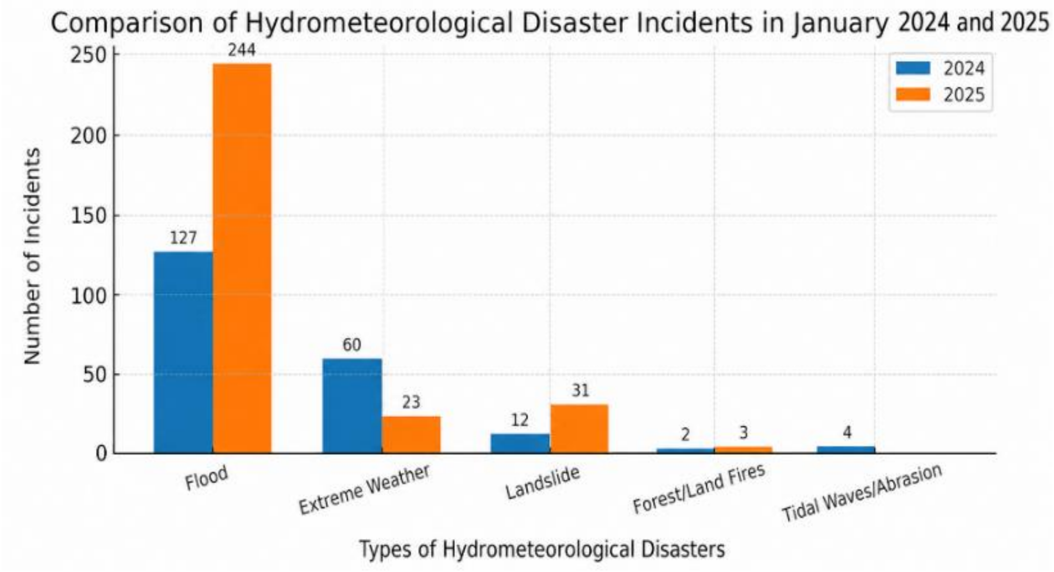

Figure 1. Comparison Chart of Hydrometeorological Disasters in 2024 and 2025
Source: (BNPB, 2025)

Table 1. Ranking of Flood Causes and Impacts in Indonesia

Rank	Causes of Flooding	Impact	Affected Areas
1	Extreme rainfall / extreme weather Source: (BMKG, 2024; BNPB, 2024)	High-intensity rainfall occurring in a short period or over several consecutive days becomes a direct trigger for major floods in many areas. BMKG recorded extreme rainfall of more than 150 mm/day in 81 locations during 2024.	Jakarta, West Kalimantan, Aceh, West Sumatra
2	Loss of tree cover / land-use change Source: (BRIN, 2024; WRI Indonesia, 2024)	The conversion of forests into plantations and settlements reduces the soil's absorption capacity and increases surface runoff by up to 35% (WRI Indonesia, 2024).	Central Kalimantan, West Kalimantan, Riau, South Sumatra, Central Java
3	Inadequate drainage Source: (Detik.com, 2024; Kementerian PUPR, 2023)	Blocked waterways, development in water catchment areas, and low urban drainage capacity worsen waterlogging and flooding.	Jakarta, Bekasi, Surabaya, Semarang, Medan, Makassar

Rank	Causes of Flooding	Impact	Affected Areas
4	Topography / natural conditions Watersheds, valleys, and large rivers Source: (Liputan6.com, 2024; WRI Indonesia, 2024)	Flat and valley-shaped landforms, along with the presence of many large rivers, increase the risk of river overflow, especially during extreme rainfall.	West Kalimantan: Kapuas Watershed; Central Java: Serayu Watershed; Central Aceh
5	Land subsidence and tidal flooding Source: (BRIN, 2024; WRI Indonesia, 2024)	Land subsidence in coastal areas and rising sea levels worsen annual tidal flooding.	North Jakarta, Pontianak, Demak, Pekalongan, Semarang

Source: Author’s analysis based on (BMKG, 2024; BNPB, 2024; BRIN, 2024; Kementerian PUPR, 2023; WRI Indonesia, 2024)

Mempawah Regency is one of the coastal regions in West Kalimantan with a high level of flood vulnerability. The regency is located on the western coast of West Kalimantan and is crossed by the Mempawah River, which flows into the Natuna Sea. Several areas in Mempawah are characterized by lowland topography, approximately 0–5 meters above sea level, with flat terrain and swamp-dominated landscapes. These physical conditions increase the potential for water accumulation caused by rainfall, river overflow, and tidal inundation, particularly in settlements and public facilities. Flooding in Mempawah Regency is generally caused by the interaction of extreme rainfall, overflow of the Mempawah River, upstream water discharge, and tidal flooding, forming a compound flood condition that results in wider inundation and longer flood duration (BPBD Kabupaten Mempawah, 2025; Purwadi, 2025). In several flood events, inundation may last for 10 to 15 days due to river sedimentation, insufficient drainage performance, and flat topographical conditions.

The flood issue in Mempawah Regency is not only related to natural hazards, but also to the limited capacity of existing evacuation and mitigation facilities. Current evacuation posts are still temporary, scattered, and often rely on residents’ houses, schools, mosques, or public buildings that were not specifically designed as disaster shelters. Existing evacuation facilities consist of 15 posts, yet they can only accommodate approximately 7,000 people, or around 34% of the affected population. Basic facilities such as clean water, sanitation, sleeping areas, and health services remain limited, while access to evacuation points is often disrupted by floodwater. This condition indicates that flood management in Mempawah is still largely reactive and has not been supported by a permanent, integrated, and adaptive mitigation facility.

To cope with recurring flood events, local communities in Mempawah have developed indigenous knowledge and adaptation strategies, including flood-adaptive building forms (e.g., stilt houses with high foundations, additional non-permanent floors called *parak*, and two-story houses), flood recognition habits (observing rainfall intensity, tidal conditions, and upstream flood signals), information dissemination (using traditional tools such as *kentongan* as well as modern platforms like WhatsApp groups), evacuation processes (voluntary mutual cooperation utilizing public buildings as temporary shelters), and environmental maintenance practices (routine community cleaning of rivers and canals, as well as mangrove replanting in coastal areas) (Hediyanti & Rianti, 2021). Studies in other flood-prone regions of West Kalimantan have similarly emphasized the importance of community-based mitigation, including the use of stilt houses and temporary bridges, as well as continuous disaster education to enhance local resilience (B et al., n.d.). Furthermore, research on coastal flood mitigation has demonstrated that structural measures such as elevated buildings, mangrove planting, and polders, along with non-structural measures like early warning systems and public training, are effective in reducing tidal flood risks (Pratama et al., 2025). These findings collectively underscore the multi-hazard flood environment of Mempawah Regency and the urgent need for an integrated mitigation infrastructure that is responsive to both fluvial and coastal flood risks.

Figure 2. Flood vulnerability and local flood issues in Mempawah Regency
Source: Author’s analysis, 2026

Previous studies and design precedents on disaster mitigation facilities indicate that resilient architecture should integrate protection, education, coordination, and post-disaster recovery. The Disaster Mitigation Research Building at Nagoya University emphasizes structural resilience and public education, while the Taguig Center for Disaster Management highlights community-based emergency coordination. Marina Barrage in Singapore further demonstrates the integration of flood control, public education, water management, and ecological infrastructure within a multifunctional facility. These precedents show that disaster mitigation architecture should not merely function as emergency infrastructure, but should also serve as an educational, ecological, and social system that supports long-term preparedness and adaptation.

Recent research has reinforced this direction by highlighting the importance of integrated water resources management within the Smart City concept, including the implementation of blue-green infrastructure and sponge city principles to enhance urban water resilience (Šulyová & Kubina, 2022). Furthermore, the development of intelligent infrastructure that embeds sensors, real-time data analysis, and machine-learning-based decision support has been identified as a key enabler for improving disaster response, community resilience, and public safety (Dunaway & Murphy, 2017). However, most existing precedents and studies focus on earthquake research facilities, urban emergency command systems, or large-scale flood control infrastructure. Limited attention has been given to an integrated flood disaster mitigation center specifically designed for coastal lowland areas affected by recurring compound floods, such as Mempawah Regency. Therefore, the novelty of this article lies in the application of the Eco-Resilient design approach to integrate flood-adaptive architecture, green-blue infrastructure, community education, emergency shelter, command center functions, and disaster-response technology within one architectural system.

The Eco-Resilient approach is relevant because it combines ecological sustainability and disaster resilience within architectural and spatial design. The ecological aspect emphasizes harmony with natural systems through green-blue infrastructure, rain gardens, bioswales, floodable landscapes, retention ponds, permeable surfaces, and rainwater harvesting. Meanwhile, the resilience aspect emphasizes the ability of buildings and supporting systems to withstand, absorb, adapt to, and recover from flood impacts through elevated structures, modular spatial systems, corrosion-resistant materials, multi-access evacuation routes, a command center, and early warning systems (Ma & Ren, 2025; UNDRR, 2024; UNEP, 2023). Through this approach, architecture is positioned not only as a physical shelter, but also as a socio-ecological system that supports environmental management, disaster preparedness, and community resilience.

Based on this background, this article addresses the following research question: how can the Eco-Resilient design approach be applied to a Flood Disaster Mitigation Center in Mempawah Regency as a strategy for community adaptation to recurring flood disasters? This article aims to discuss the translation of ecological sustainability, physical and structural resilience, spatial and hydrological design, socio-resilience, and techno-resilience into architectural design. Through this approach, the proposed facility is expected to function not only as a safe shelter during flood events, but also as a center for disaster education, coordination, environmental management, and long-term community resilience in coastal Mempawah.

2. RESEARCH METHODS

This study uses a descriptive qualitative design method to examine the application of the Eco-Resilient approach in the design of a Flood Disaster Mitigation Center in Mempawah Regency. The descriptive qualitative method was selected because the study focuses on interpreting site conditions, flood vulnerability, community needs, spatial requirements, and design strategies rather than measuring them through statistical procedures. Qualitative design research is widely used in architectural studies to explore spatial relationships, environmental responses, and human-centered design strategies through interpretative and contextual analysis (lzbieta Danuta Niezabitowska, 2018).The method is used to systematically describe the relationship between flood risk, architectural response, ecological infrastructure, and community adaptation in the proposed design.

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- **Primary Data**

  Primary data were obtained directly from the research object through field observation, documentation, and interviews. The primary data collection aimed to identify the existing conditions of the site, flood-related problems, community needs, and the limitations of existing evacuation facilities in Mempawah Regency.

  1. Site Analysis

     Site analysis was conducted through direct observation of the proposed site and its surrounding environment. The physical analysis included site orientation, accessibility, road circulation, topography, drainage conditions, rainfall response, wind direction, sun orientation, surrounding land use, and flood vulnerability. The analysis was used to understand the potential and constraints of the site as the basis for determining the design response.

  2. User Analysis

     User analysis was conducted to identify the types of users, activity patterns, and spatial needs within the Flood Disaster Mitigation Center. The users include local communities, students, flood evacuees, volunteers, health workers, logistics officers, building managers, disaster-response teams, BPBD, government agencies, and supporting organizations. This analysis became the basis for determining circulation patterns, zoning, and the relationship between spaces.

- **Secondary Data**

  Secondary data were obtained from literature studies, previous research, government documents, maps, regulations, and design precedents. The data were used to strengthen the theoretical foundation and support the design analysis related to flood mitigation, disaster-resilient architecture, and the Eco-Resilient approach.

  1. Functional Analysis

     Functional analysis was carried out to determine the main functions of the building based on disaster phases. During normal conditions, the facility functions as a center for disaster education, training, simulation, and community awareness. During flood events, the building functions as an evacuation shelter, command center, logistics distribution area, emergency health service, and temporary protection space. After flood events, the facility supports coordination, data collection, and community recovery.
  2. Precedent Analysis

     Precedent analysis was conducted by studying several disaster mitigation facilities, including The Disaster Mitigation Research Building at Nagoya University, Taguig Center for Disaster Management, and Marina Barrage in Singapore. The analysis focused on building function, spatial organization, circulation, disaster-response systems, ecological infrastructure, and architectural strategies that are relevant to the proposed design.
  3. Eco-Resilient Approach Analysis

     The Eco-Resilient approach was analyzed through five main principles: ecological sustainability, physical and structural resilience, spatial and hydrological design, socio-resilience, and techno-resilience. These principles were translated into design strategies such as elevated buildings, floodable landscapes, rain gardens, bioswales, retention ponds, permeable surfaces, rainwater harvesting, modular spaces, integrated evacuation routes, command center facilities, and early warning systems.
- **Design Synthesis**

  Design synthesis was conducted by integrating the results of site analysis, user analysis, functional analysis, precedent analysis, and Eco-Resilient approach analysis. This stage produced the main design concept, spatial zoning, building massing, circulation system, structural response, landscape strategy, and disaster-support facilities. Design synthesis in architectural research is important for translating analytical findings into spatial and environmental design solutions through an iterative and research-based process (Boling & Abramenka-lachheb, n.d.). The design synthesis aims to create a mitigation center that is adaptive to recurring floods, supports emergency response, and strengthens community resilience in Mempawah Regency.

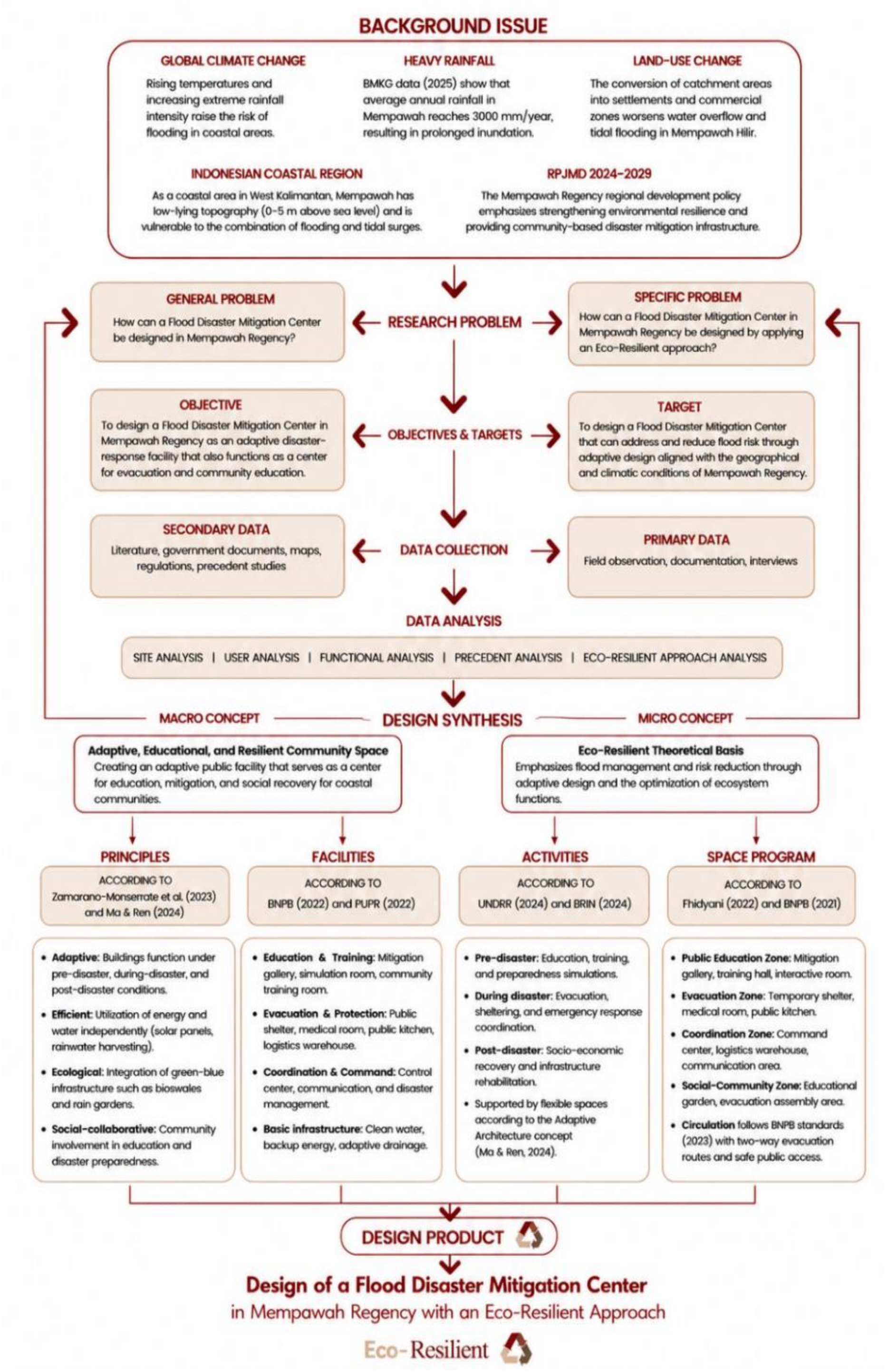


Figure 3. Research and Design Process Framework
Source: Author’s analysis, 2026

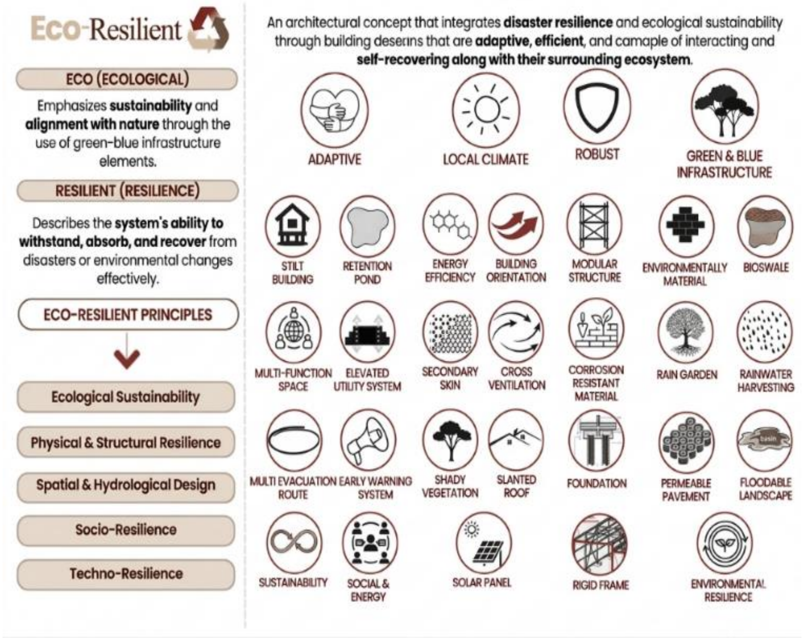
3. RESULT AND DISCUSSION

The design of the Flood Disaster Mitigation Center in Mempawah Regency is developed as an architectural response to recurring flood disasters in coastal lowland areas. The design focuses on the integration of disaster mitigation functions, community adaptation, and ecological water management through the Eco-Resilient approach. The discussion is organized into five design aspects: the Eco-Resilient approach, area and building zoning, building mass, interior space, and exterior space. These aspects explain how the design responds to flood vulnerability, evacuation needs, community education, and environmental resilience.

3.1 Eco-Resilient Approach

The Eco-Resilient approach serves as the primary design framework for the Flood Disaster Mitigation Center in Mempawah Regency. This approach integrates ecological sustainability and disaster resilience to develop a building system that not only withstands flood impacts but also enhances environmental recovery and community adaptation. According to the United Nations Environment Programme, Eco-Resilient design utilizes nature-based solutions to strengthen environmental resilience while restoring ecological systems (UNEP, 2023). In this design, the building is conceived not merely as an emergency shelter, but as an integrated socio-ecological infrastructure that accommodates multiple functions, including education, evacuation, coordination, logistics, healthcare services, and post-disaster recovery. This aligns with the concept of resilience defined as the ability of systems and communities to resist, absorb, adapt, and recover from hazards without losing their essential functions (UNDRR, 2024).

Resilience also involves the capability of physical and operational systems to sustain performance, recover efficiently, and adapt to future disturbances (Seyedmohsen Hosseini, Kash Barker, Ramirez-Marquez, 2016). Urban resilience frameworks emphasize adaptive capacity, system flexibility, and long-term sustainability in disaster-prone environments. In flood-prone coastal regions, resilient systems are expected to support not only physical protection against hazards but also ecological balance, spatial adaptability, emergency response capacity, and post-disaster recovery. The integration of environmental, social, and infrastructural resilience within architectural and urban design is therefore essential to improve community preparedness and reduce long-term flood vulnerability (Shi, Y.; Zhai, G.; Xu, L.; Zhou, S.; Lu, Y.; Liu, H.; Huang, 2021).



Emphasizes **sustainability** and **alignment with nature** through the use of green-blue infrastructure elements.

Describes the **system's ability to withstand, absorb, and recover** from disasters or environmental changes effectively.

An architectural concept that integrates **disaster resilience** and ecological sustainability through building deserns that are **adaptive, efficient**, and camaple of interacting and **self-recovering along with their surrounding ecosystem.**

Figure 4. Principles and Applications of Eco-Resilient Concept
Source: Author’s analysis, 2026

The Eco-Resilient approach is implemented through five interconnected principles: ecological sustainability, physical and structural resilience, spatial and hydrological design, socio-resilience, and techno-resilience. These principles reflect the integration of environmental, physical, and social systems within architectural design (Ma & Ren, 2025).

Flood-resilient urban design integrates green infrastructure and spatial planning strategies to reduce flood vulnerability while improving environmental performance. Adaptive urban resilience strategies encourage flexible and environmentally responsive systems that are capable of reducing vulnerability while maintaining urban functionality during disasters (Ahern, 2020). The detailed implementation of these principles is translated into specific design strategies and spatial configurations, as summarized in Table 2. The integration of green-blue infrastructure, elevated structures, risk-based zoning, community-oriented spaces, and technological systems collectively enhances flood adaptability, environmental performance, and community resilience (BNPB, 2024; Khodadad, Mina; Ahuilar-Barajas, Ismael; Khan, 2023; Mannucci et al., 2022).

Table 2. Implementation of Eco-Resilient Design Principles in the Flood Disaster Mitigation Center

Design Principle	Concept Strategy	Design Implementation	Expected Impact
Ecological Sustainability	Green-blue infrastructure integration	Application of bioswales, rain gardens, retention ponds, permeable surfaces, and floodable landscapes	Reduces surface runoff, increases infiltration, minimizes flood risk, and improves environmental quality
	Sponge site strategy	Site designed to absorb, store, and gradually release rainwater	Reduces surface flooding and relieves drainage system pressure
	Floodable landscape	Open spaces designed to temporarily accommodate water	Minimizes infrastructure damage and maintains functionality during floods
Physical & Structural Resilience	Elevated building system	Main structure raised above flood level	Protects primary functions and ensures building operability during flood events
	Rigid frame structure	Use of reinforced structural system resistant to water pressure	Enhances structural stability and durability
	Modular structure	Flexible and expandable spatial modules	Supports adaptive use and future development
	Corrosion-resistant materials	Use of durable materials for humid and flood-prone conditions	Reduces maintenance and prolongs building lifespan
Spatial & Hydrological Design	Flood risk-based zoning	Division into safe, transition, and flood-adaptive zones	Ensures safety of critical functions while allowing controlled flooding
	Integrated water flow system	Site layout follows natural hydrological patterns	Improves water management and reduces runoff impact
	Multi-functional space	Spaces adaptable for normal and emergency conditions	Enhances building efficiency and usability
	Integrated evacuation paths	Direct and accessible circulation connecting all zones	Ensures safe, fast, and inclusive evacuation
Socio-Resilience	Community-based design	Provision of community spaces and public plazas	Strengthens social interaction and community preparedness
	Disaster education facilities	Training rooms, workshops, and simulation spaces	Increases awareness and disaster preparedness

Design Principle	Concept Strategy	Design Implementation	Expected Impact
	Inclusive shelter system	Spaces designed for diverse user groups	Ensures accessibility and equity during emergencies
	Multi-function spaces	Spaces usable in both disaster and non-disaster conditions	Maximizes building utilization and community engagement
Techno-Resilience	Command center integration	Centralized control and coordination space	Improves disaster response efficiency
	Early warning system	Integration of real-time monitoring and alerts	Enables early response to flood events
	Communication systems	Digital networks connecting stakeholders	Enhances coordination among agencies and communities
	Emergency support systems	Backup utilities and disaster-response infrastructure	Ensures operational continuity during emergencies

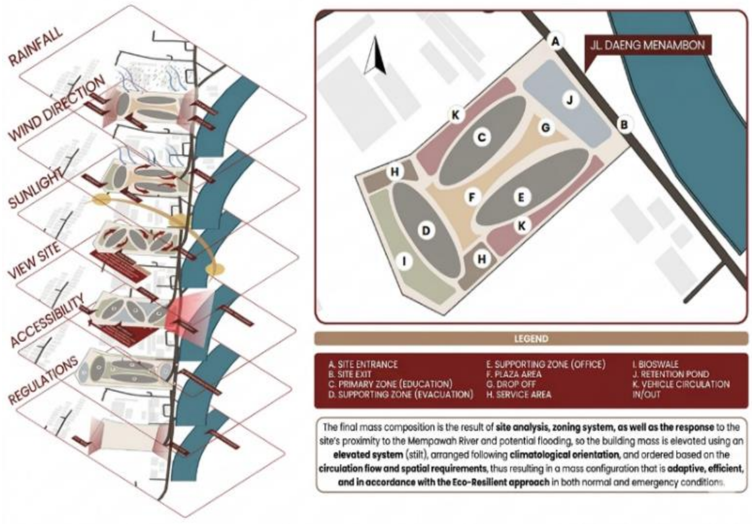
Source: Author's analysis, 2026

Overall, the Eco-Resilient approach positions the Flood Disaster Mitigation Center as a comprehensive and adaptive infrastructure. The design not only provides physical protection against flooding but also integrates ecological systems, social functions, and technological support to enhance long-term resilience. This reinforces the role of architecture as a socio-ecological system that contributes to sustainable disaster mitigation and community adaptation in Mempawah Regency.

3.2 Zoning Concept

The zoning concept of the Flood Disaster Mitigation Center in Mempawah Regency is developed based on a risk-responsive and function-based spatial organization. The zoning strategy aims to ensure that each function of the building operates effectively under both normal and disaster conditions, Flood-resilient spatial planning requires zoning strategies that separate critical functions from flood-adaptive areas to minimize disaster risk and maintain operational continuity (Dong, X.; Zhang, X.; Li, 2022).

The site is divided into three primary zones: safe zone, transition zone, and flood-adaptive zone. The safe zone accommodates critical functions such as the command center, emergency health services, main shelter areas, and administrative spaces. These functions are placed in the highest and most secure areas of the site to minimize flood risk and ensure operational continuity during disaster events.



The final mass composition is the result of **site analysis, zoning system, as well as the response** to the site's proximity to the Mempawah River and potential flooding, so the building mass is elevated using an **elevated system** (stilt), arranged following **climatological orientation**, and ordered based on the **circulation flow and spatial requirements**, thus resulting in a mass configuration that is **adaptive, efficient, and in accordance with the Eco-Resilient approach** in both normal and emergency conditions.

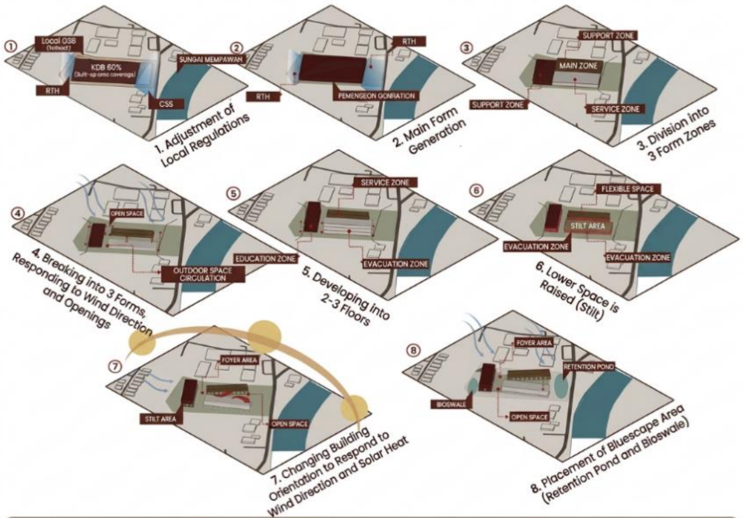
Figure 5. Zoning Concept
Source: Author's analysis, 2026

The flood-adaptive zone is allocated for open spaces, retention areas, landscape elements, and public plazas. This zone is intentionally designed to accommodate temporary water storage during flood events through floodable landscapes and permeable surfaces. By allowing certain parts of the site to interact with water, the zoning strategy reduces pressure on drainage systems and enhances ecological performance.

Overall, the zoning concept reflects a balance between safety, functionality, and environmental responsiveness. It ensures that critical functions remain protected while allowing non-critical areas to adapt dynamically to flood conditions.

3.3 Massing Concept

The building massing is designed as a response to both environmental conditions and functional requirements. The massing strategy emphasizes adaptability, permeability, and climatic responsiveness, Flood-adaptive architecture enhances building resilience by enabling structures to respond dynamically to changing flood conditions (Song, Y.; Deng, 2022).



The final building mass composition is the result of **site analysis, zoning system**, and **response** to the proximity of the site to the Mempawah River and flood potential, so the building mass is elevated using a **stilt system**, arranged following **climatological orientation**, and ordered based on **circulation flow and space needs,** thus generating a mass configuration that is **adaptive, efficient, and in accordance with the Eco-Resilient approach** in both normal and emergency conditions.

Figure 6. Mass Transformation
Source: Author’s analysis, 2026

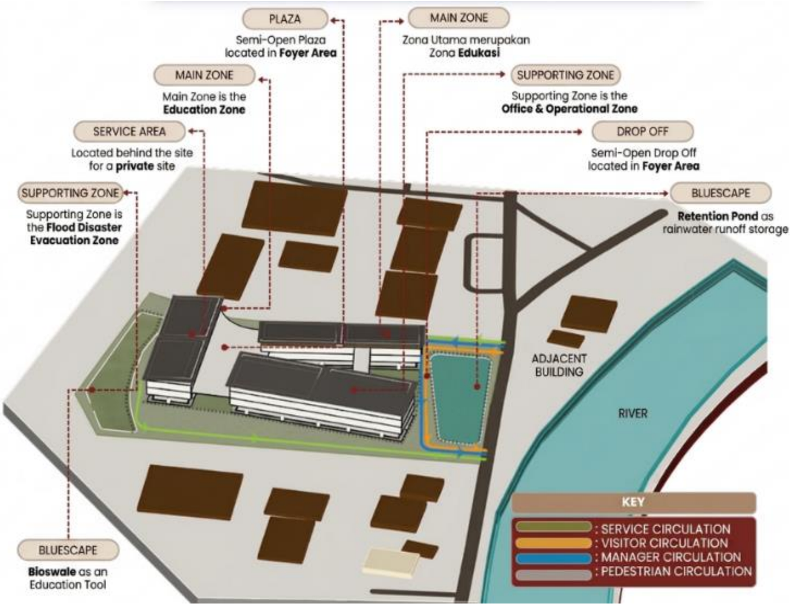


Figure 7. Final Mass and Main Circulation
Source: Author’s analysis, 2026

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The massing composition reflects a balance between solid and void, creating a dynamic spatial experience while maintaining environmental performance. This approach ensures that the building is not only resilient to floods but also responsive to the tropical climate of Mempawah.

3.4 Circulation System

The circulation system is designed to ensure efficient movement, safety, and accessibility under both normal and emergency conditions. It integrates horizontal and vertical circulation paths that respond to evacuation needs and functional zoning.

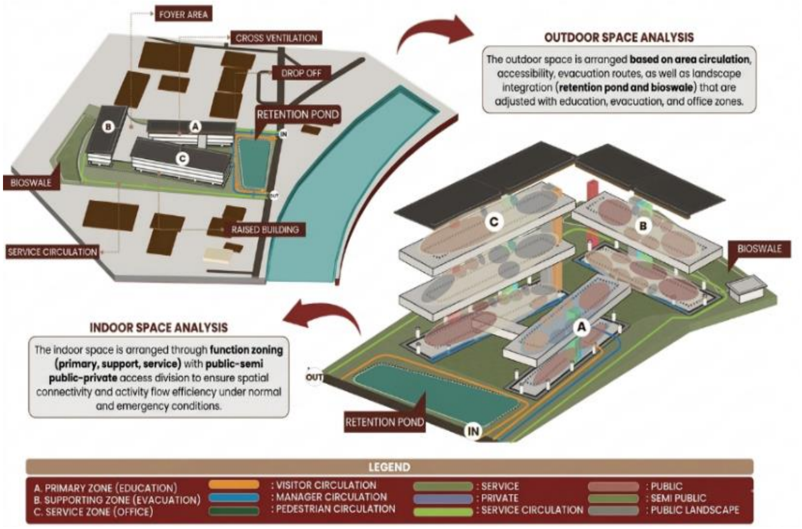

Figure 8. Implemetation Circulation in Indoor and Outdoor
Source: Author’s analysis, 2026

Primary circulation routes connect key functions such as the command center, shelter areas, medical facilities, and logistics zones. These routes are designed to be direct, unobstructed, and easily identifiable to facilitate rapid movement during emergencies.

Vertical circulation, including ramps and stairs, is designed with consideration for accessibility and flood conditions. Ramps are prioritized to ensure inclusive access for all users, including vulnerable groups such as the elderly, children, and people with disabilities. Emergency evacuation routes are clearly defined and separated from regular circulation paths to avoid congestion during disaster situations. These routes are connected to safe assembly points located in elevated areas of the site.

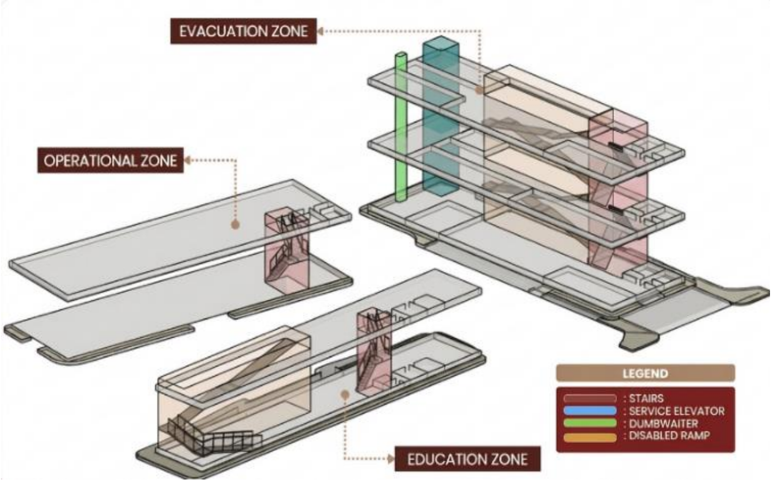

Figure 9. Vertical Transportation in The Building
Source: Author’s analysis, 2026

The circulation system also integrates outdoor pathways that connect the building with open spaces and landscape areas. These pathways remain functional during normal conditions while also serving as evacuation routes during floods. Through this approach, circulation becomes not only a means of movement but also a critical component of disaster response and safety planning.

3.5 Exterior Concept

The exterior design emphasizes the integration of ecological systems, landscape functionality, and environmental resilience. The outdoor spaces are not treated as passive elements but as active components of the flood mitigation strategy. Blue-green infrastructure strategies are increasingly recognized as effective approaches for reducing pluvial flood risk and improving long-term urban resilience in rapidly developing flood-prone areas (Fappiano, F., Maurer, M., & Leitão, 2025). Green-blue infrastructure forms the basis of the exterior concept, The sponge city concept improves urban flood resilience through integrated water retention, infiltration, and ecological drainage systems (Zhang, K.; Chui, 2019).

Figure 10. Implementation of Green-blue Infrastructure
Source: Author’s analysis, 2026

The landscape is designed as a flood-adaptive environment, Flood adaptation strategies in the built environment require integrated ecological infrastructure and spatial flexibility to improve long-term urban resilience (Mannucci et al., 2022). Sustainable water storage systems and controlled surface runoff management are important strategies in reducing flood pressure and improving long-term hydrological resilience within river basin environments (Eriyagama et al., 2021). This approach transforms the site into a resilient ecological system that works in harmony with natural processes.

Figure 11. Implementation of Elevated Building and Permeable Pavemant
Source: Author’s analysis, 2026

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Vegetation selection is based on local species that are tolerant to water fluctuations and capable of supporting ecological balance. These plants contribute to shading, cooling, and improving microclimatic conditions.

Figure 12. Implementation of Bioswale and Secondary Skin
Source: Author's analysis, 2026

Public open spaces such as plazas and gathering areas are integrated within the landscape to support community activities during normal conditions. These spaces also function as flexible zones during emergencies.

Figure 13. Implementation on Public Area
Source: Author's analysis, 2026

Overall, the exterior concept reinforces the Eco-Resilient approach by combining environmental performance, social function, and adaptive design strategies. It ensures that the site remains functional, sustainable, and resilient in the face of recurring flood events.

4. CONCLUSION

This study shows that the Eco-Resilient design approach can be effectively applied to the development of a Flood Disaster Mitigation Center in Mempawah Regency as a strategy for addressing recurring flood disasters in coastal lowland areas. The integration of ecological sustainability, physical and structural resilience, spatial and hydrological design, socio-resilience, and techno-resilience results in an architectural system that is adaptive, functional, and responsive to flood risks. Design strategies such as elevated building systems, green-blue infrastructure, risk-based zoning, floodable landscapes, and integrated evacuation circulation enhance the building's ability to withstand flood impacts while maintaining operational continuity during emergency conditions.

Figure 14. Final Design
Source: Author’s analysis, 2026

The findings of this study indicate that the Eco-Resilient approach improves environmental resilience and flood adaptability through the integration of ecological and resilient architectural strategies. The implementation of green-blue infrastructure elements such as bioswales, rain gardens, retention ponds, floodable landscapes, and permeable pavement contributes to reducing surface runoff, increasing water infiltration, and minimizing the impacts of extreme rainfall and tidal flooding. In addition, the sponge-site strategy enables the site to absorb, store, and gradually release excess rainwater, thereby reducing pressure on drainage systems and improving hydrological performance during flood events. Furthermore, the integration of adaptive landscape systems, shady vegetation, and water-sensitive design strategies supports environmental balance, microclimatic adaptation, and long-term ecological resilience.

In addition, the proposed mitigation center functions not only as an emergency shelter but also as a socio-ecological infrastructure that supports community education, disaster coordination, environmental management, and long-term resilience. This approach shifts the role of architecture from a reactive solution toward a proactive and adaptive system in disaster mitigation. Therefore, the Eco-Resilient approach offers a relevant and sustainable design strategy for flood-prone coastal areas such as Mempawah Regency. Future research may focus on evaluating building performance effectiveness and integrating advanced monitoring technologies to further improve resilience outcomes and disaster-response efficiency.

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