IJPD The Indonesian Journal of Planning and Development

P-ISSN: 2087-9733 E-ISSN: 2442-983X

Journal Homepage: http://ejournal2.undip.ac.id/index.php/ijpd

Volume 10 No 2, October 2025, 96-105
https://doi.org/10.14710/ijpd.10.2.96-105

OPEN ACCESS

Efforts Towards a More Anticipatory Design for Disasters in Housing and Landscape Planning

Submitted: 16 September 2025
Accepted: 2 February 2026
Available Online: 3 February 2026

Deva Fosterharoldas Swasto [1], Cantya Paramita Marhendra [2]

[1,2]*Department of Architecture and Planning, Faculty of Engineering,*
Universitas Gadjah Mada, Sleman, Indonesia
devafswasto@ugm.ac.id

Abstract

Indonesia has a high risk of natural disasters, especially earthquakes and tsunamis along the coast. Since the 2004 tsunami in Aceh, there has been an increasing awareness of the need for housing and landscape planning that anticipates these disasters. Poor design and quality of housing and landscape environments often lead to fatal impacts when disasters occur, especially in areas where the environment is not responsive to surrounding conditions. This paper analyzes several planning aspects related to these conditions through theoretical and empirical approaches, particularly in residential environmental design and landscape. These conditions are derived from technological rules or principles. It is also expected that examples or lessons from other countries can contribute additional discourse to the writing. From analysis, findings that can be found and proposed are responses to the technological-physical aspects of buildings (i.e. safety and responsiveness), micro-scale housing and landscape design (i.e. building units, clusters, and variety of vegetation), housing and landscape planning at the macro-scale (i.e. land zoning and green proportions), as well as environmental support (i.e. environmental utility, accessibility, and protective landscape).

Keywords: *Anticipatory Disasters, Earthquakes, Housing and Landscape Environmental Planning, and Tsunami*

1. Introduction

Indonesia is a country with a significant vulnerability to natural disasters. Among the most frequent and destructive events are tsunamis, earthquakes, and other fatal incidents such as liquefaction and landslides. Located along the Pacific Ring of Fire, Indonesia is highly susceptible to both earthquakes and tsunamis. The devastating 2004 Aceh earthquake and tsunami, which claimed over 230,000 lives, highlights the severe seismic risk the country faces. Ongoing studies emphasize the critical need for enhanced early warning systems and disaster preparedness to mitigate future risks (Pranantyo et al., 2021), particularly considering the significant seismic hazards posed by both shallow and deep earthquakes in the region (Hutchings & Mooney, 2021). Recent research further underscores the importance of adapting tsunami risk management strategies to address the unpredictable nature of these natural disasters (Suparji et al., 2024).

As mentioned above, since the tsunami incident occurred in Aceh in December 2004, the community has become increasingly aware of the need for planning housing and landscape environments that are more anticipatory for disasters, especially for this type of disaster, as well as earthquake, which also happened in Yogyakarta in May 2006. When viewed from the context of origin, this stems from the seemingly poor design or quality of housing and landscape environments. Many disasters take place in a location where the formed residential environment and landscape is not contextual or being responsive to the surrounding conditions. In such contexts, post-tsunami building reconstruction is shaped by a complex interplay of factors, extending beyond physical infrastructure to include social, economic, and cultural dimensions. This process involves not only the construction of physical structures but also the preservation of social fabric and the enhancement of community resilience and capacity (Nagami et al., 2025; Thiri, 2022; Ochiai & Saito, 2024). Thus, problems arise related to the relatively fatal impact of disasters.

How to Cite:
Swasto, D. F., & Marhendra, C. P. (2026). Efforts Towards a More Anticipatory Design for Disasters in Housing and Landscape Planning. *The Indonesian Journal of Planning and Development, 10*(2), 96-105. https://doi.org/10.14710/ijpd.10.2.96-105

Consequently, integrating resilience into housing and landscape design, particularly in disaster-prone areas, becomes essential not only for mitigating immediate risks but also for fostering long-term community stability and sustainability. This approach emphasizes the importance of adaptive, sustainable housing solutions that evolve with the changing needs of displaced populations (Ghanbarzadeh et al., 2021; Silva & Ballinger, 2021; Kamthonkiat et al., 2023).

Natural disasters, such as floods and earthquakes, exacerbate housing challenges for vulnerable populations, particularly those relying on public housing. Research has shown that severe flooding can reduce the number of public housing units, increase waiting times, and raise tenant rents, though post-disaster aid, such as FEMA's assistance, plays a crucial role in restoring housing availability and lowering rents for affected populations (Davlasheridze & Miao, 2021). Additionally, recovery programs often fail to consider cultural and community needs in post-disaster housing, as demonstrated by the Merapi eruption in Indonesia in 2010, where temporary housing overlooked local traditions and values. Incorporating cultural adequacy is vital for ensuring both physical resilience and social acceptance in housing recovery efforts (Sukhwani et al., 2021). Moreover, effective decision-making frameworks that address these cultural and local dynamics are necessary to enhance the success of post-disaster recovery programs (Pezzica et al., 2021).

This paper tries to analyze several aspects of planning and design related to a more anticipatory strategy for disasters through theoretical and empirical approaches, especially discussed from the aspects of residential environmental design and landscape. The conditions can be derived from theory by Komarudin, (1997), which explains that in general it can be seen that aspects related to housing in Indonesia are land, financing and institutions. These three aspects are also closely related to the development of space in general, where each of these aspects also influences each other. The relationship between these components plays a crucial role in housing development, as highlighted by Jephcott & Robinson (2023), who explore the complexities of housing in high-rise developments, and Moghayedi et al. (2021), who examines the broader challenges faced in urban housing construction, particularly focusing on the need to integrate sustainability principles into affordable housing, including addressing institutional and financial barriers. On the other hand, Kuswartojo et al. (2005), also explains the importance of the government's role in the housing sector, namely as a builder and controller of housing development. These conditions ultimately illustrate the need for clear standards or technical aspects in housing development, including consideration of resilience to disaster risk. The government's role in housing is also critical for providing affordable solutions to low-income communities through policy frameworks and collaboration. In Indonesia, a fragmented approach hampers effective housing policy development, with insufficient coordination between the government, private developers, and communities (Sari, 2023). The government's involvement in post-disaster housing, particularly in Aceh and Yogyakarta, is also vital, where policies and community-based methods have played a key role in rebuilding efforts and ensuring sustainable housing for vulnerable populations (Setyonugroho & Maki, 2024).

According to Indonesian Law Number 1 of 2011 concerning Housing and Settlements, it is stated that housing is a group of houses that function as a residential environment or residential environment which is equipped with environmental facilities and infrastructure. Settlements are part of the living environment outside protected areas, whether in the form of urban or rural areas that function as residential or residential environments and places of activities that support life and livelihoods. In connection with these two meanings, it cannot be forgotten the importance of residential landscaping as a support for existing residential activities. In this context, settlement refers to the process of urban habitation, which includes both planned housing and informal dwellings such as squatter settlements or slums, where populations often face inadequate infrastructure. Landscape is conceptualized as the dynamic spatial configuration within urban areas, shaped by the coexistence of formal and informal sectors, which can lead to both structured and unplanned spaces in cities, particularly in developing countries (Marmin, 2022).

What is meant by resilience, is crucial for both urban planning and housing infrastructure to withstand and recover from natural disasters. In urban planning, resilience is viewed as a transformative approach, with a framework that evaluates five dimensions—economy, society, environment, nature, and governance—to enhance urban resilience (Datola, 2023). For housing infrastructure, resilience is essential for mitigating flood risks. One model integrates DEMATEL, ISM, and Bayesian Networks to assess flood resilience, identifying key parameters (Sen et al., 2021), while another uses Best Worst Method and Dempster-Shafer theory to quantify resilience under uncertainty (Sen et al., 2021). Both frameworks emphasize resilience as a preventive strategy to strengthen systems against future hazards. Apart from that, resilience can also mean tough. In this paper, the ultimate goal is to propose more resilient planning and design considerations.

2. Methods

This paper tries to analyze several aspects of planning and design related to the conditions above, through theoretical and empirical approaches, especially discussed from the aspects of residential environmental design and landscape. The conditions seen are tried to be derived from technological rules or principles. It is also expected that examples or lessons learned from other countries or cases can become additional discourse in the writing.

In general, the method used is descriptive qualitative. The aspects looked at are not only related to the study of applied technology and/or towards methods or discourse on design principles. However, the aspects seen are tried to be derived from technological rules or principles, which are related to technological-physical aspects of buildings, design ideas, and macro- and messo-scale planning, as well as others. It is expected that several examples from other countries or cases (in the form of lessons learned and/or best practices) can provide additional discourse in discussing and concluding this article. As mentioned above, the aim or result of the article is to propose ideas about the principles of planning and design for residential environmental aspect and landscape that are more anticipatory towards disaster.

As previously explained, without intending to reduce the meaning and impact of other disasters, both natural and non-natural disasters caused by human activities, earthquakes and high tidal waves or tsunami are the two most dangerous disasters that have frequently occurred in Indonesia in the last 20 years since the 2004 Aceh tsunami. Therefore, these two disasters then become the focus of the discussion in this paper. Tsunami disasters generally occur on the coast or coastal area, while earthquake disasters can occur anywhere. However, the setting for this earthquake location or consideration is on a slope that can trigger the next danger, namely landslides. In recent years (2025 and 2026), flash floods caused by deforestation have also occurred in Indonesia. Sumatra was one of the worst-affected areas, with the provinces of West Sumatra, North Sumatra, and Aceh reporting thousands of fatalities and tens of thousands of displaced. This research is also expected to serve as a reminder of the importance of more disaster-responsive settlement planning.

Regarding the location setting, what is meant by the edge of the beach or coast is a flat, sandy land on the beach or at the edge of the sea, which consists of west coast or the area between the coastline at low tide and the coast at high tide, as well as dry coast or the area between the coastline at high tide and the highest coastline that can be reached by the sea when a typhoon hits (https://kbbi.kemdikbud.go.id/). From the same source, it is stated that what is meant by slope is the side (field, land) that is sloping. In general, this research focuses on these two location settings, namely coastal areas, and slope areas.

In addition, generally housing construction built by the community, government and private sector continues to grow in various locations in urban Indonesia. However, most of the housing that is built is more oriented towards business efficiency and not attention to the environment or even resilience to disasters. This then becomes the urgency of the research carried out by the author. The locations selected by the researchers are areas across Indonesia in general. However, several areas frequently at risk of disasters or that have experienced them are the focus, such as the slopes of Sumatra, coastal areas on the South Coast of Java, and so on. In terms of level, this research examines the general conditions in Indonesia. Further discussions can be conducted at more specific locations, such as a specific region as an example of how to anticipate potential disasters.

3. Results and Discussions

From several studies of conditions in the field, finding results that can be found and proposed consist of responses to building technology-physics aspects, micro-scale housing and landscape design characteristics, macro-scale housing and landscape planning considerations, and environmental support features. The categorization into these aspects is not strict and is only intended to facilitate discussion. This categorization is further reinforced across additional dimensions in approaching resilient housing. The framework of disaster-resilient housing design needs to be integrated with site assessment, climate-adaptive construction, and community participation, (Harun-Or-Rashid et al., 2022; Effiong et al., 2024) while also considering the affordability of materials (Adeyemi et al., 2024), alongside the role of communities in disaster education as a form of mitigation (John et al., 2023). In addition, the implementation of 3D technology can serve as a cost-effective simulation tool for planning disaster-resistant housing (Iyoha et al., 2024).

The technological and physical aspects of the building consist of, among other things, safety and responsiveness, while micro-scale housing and landscape design characteristics include building units, clusters and vegetation variety. Macro-scale housing and landscape planning considerations comprise land zoning and green proportions. The features of environmental support contain aspects of environmental utilities, accessibility and protective landscaping. All of these aspects are then analyzed, especially for the two types of natural disasters mentioned above that occur more frequently, namely earthquakes and high tidal waves (tsunami). For earthquakes, the preferred location is on a sloping area, while for high tidal waves (tsunami), a location on the coast is chosen.

3.1 Responses to the technological-physical aspects of buildings

In general, safe building standards are non-negotiable requirements. In terms of response to disasters, this standard increases because efforts are needed to anticipate the impact of disasters, in addition to the need for efforts to see the conditions or context/location where disasters occur. From a safety perspective, the thing to consider is the need for building users or residents to feel safe when carrying out activities in the room or residence they occupy. This has been evidenced by several studies indicating that disaster risks may arise from the presence of old buildings in urban areas, thereby necessitating consideration of appropriate safety systems (Hwang & Choi, 2025). Similarly, in residential areas, safety is closely related to public awareness regarding the structural feasibility of their houses in the context of disaster preparedness, as reflected in the existence of inadequate habitable housing practices (Mushar et al., 2021). This condition highlights the relevance of project management, which can be supported, among others, through the application of Building Information Modeling (BIM) technology (Baarimah et al., 2021).

Several aspects that need to be ensured consist of the safety of the building structure, certification of its functional feasibility, and regular maintenance or assessment of the strength of the structure. As for the landscape, if it is related to the presence of protective trees or tall trees with dense leaves, the grip of the tree trunk or roots on the ground below needs to be ensured. The steeper the slope, the more necessary trees that protect against soil erosion with strong roots are. As shown in Figure 1a and 1b, villages located near rivers have built embankments or reinforcements in several areas, in addition to maintaining distance by establishing river boundaries. This approach is implemented naturally, taking the landscape into account, while also artificially mitigating potential risks. Sometimes, it can be supported by man-made structure to ensure safety as shown in figure 1b with the building of riverbanks.

Figure 1a. Kampong along riverfront with natural landscape in Bajawa (Author's personal documentation, 2022)

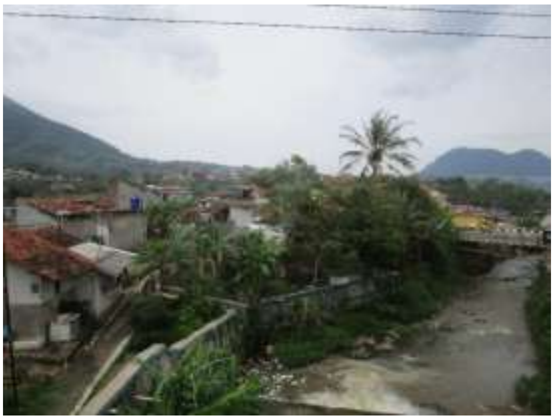

Figure 1b. Kampong along riverfront with artificial riverbank in West Java (Author's personal documentation, 2026)

On the other hand, anticipation is also needed if something undesirable happens in the context of a disaster, for example if an earthquake, landslide or tsunami occurs. This then underlies the need for responsiveness aspects in the design or planning of housing and landscape environments related to consideration of basic prerequisites and/or anticipation of disaster risks. In this case, apart from the structural aspects being adapted to the surrounding situations, the landscape condition also needs to be considered. For example, residences in coastal areas need to anticipate the potential for sea breezes and/or the possibility of a tsunami. Likewise, the protective trees in the surrounding area need to be adjusted, for example in the form of low plants such as mangroves or deterrent trees such as coconuts, prawn cypresses and so on. Logically, the closer to the coast, the more low-fill plants are needed to prevent abrasion and/or as an initial buffer against a potential tsunami. Figure 2a and 2b shows a village located around a valley, where natural reinforcement was achieved by planting or placing numerous trees around the area. Like the previous illustration, this treatment was implemented naturally, considering the existing landscape. Sometimes, to mitigate potential risks, artificial reinforcement can also be built to minimize erosion as shown in figure 2a by creating stepping platform surrounding or towards the settlement.

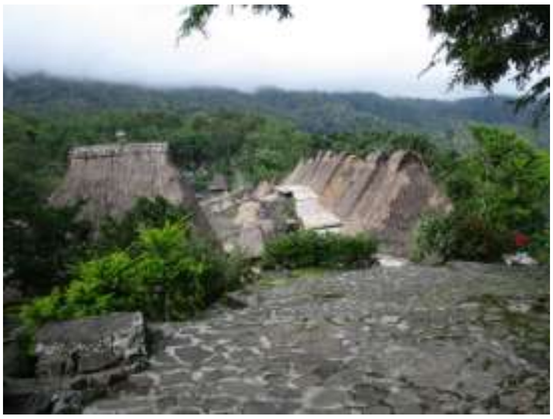

Figure 2a. Trees in slope area in traditional settlement in Bajawa (Author's personal documentation, 2022)

Figure 2b. Trees in slope area in village in West Java (Author's personal documentation, 2026)

3.2 Micro-scale housing and landscape design

In general, aspects of micro-scale housing and landscape design are related to the condition of building units, type of clusters and variety of vegetation. In terms of the condition of building units, it is proposed that there should be a distance between buildings to create gap that separates the structural masses. The goal is if something happens or there is a risk of disaster in a unit, it will not have an impact on the nearby buildings.

As for the cluster type aspect, the residential environment that is formed should generally be formed in a closed situation because it is more oriented towards land efficiency. Under these conditions, on the one hand, the residential area will be exclusive and private, but on the other hand, there will be no attachment with surrounding situation. Here, it is necessary to ensure that the mass composition of the building or enclosure can enable occupants to escape quickly. The partial clusters condition is more proposed than the strong one. Likewise, a mixture of strong elements such as walls with softer filler plants is recommended to reduce the potential risk of being hit by continuous material. Furthermore, housing designs in the form of clusters are generally made uniform. This is collectively beneficial because it emphasizes the identity of housing and the similarity of type and shape that can facilitate material and financing efficiency. However, regarding this uniformity, consequently it poses the same risk. This is because each residential unit has the same probability if a disaster occurs. Therefore, it is proposed to have mixed types or mixed building heights or something else.

From a landscape perspective, it is recommended that a variety of vegetation be presented as an effort to strengthen mitigation with a mixed logic such as clusters. Logically, the more diverse the type, height, and character of the vegetation, the greater the opportunity for natural elements or structures to strengthen each other. Figure 3 shows a village located in a coastal area, where the existing vegetation types typically vary as a natural reinforcement. Short plants such as mangroves are typically placed in areas near water or currents, while taller plants are placed closer to settlements. Figure 4 shows the clustering of settlements along riverbanks, where denser clusters are recommended to be located farther from the river. On the other hand, as local wisdom can be found in coastal areas, the use of stilt houses in waterfront settlement clusters is generally carried out to minimize the risk of inundation, flooding, or even tsunamis. The use of vertical embankments, terraces, breakwaters, and so on as artificial elements is recommended as a last effort and not as the primary treatment.

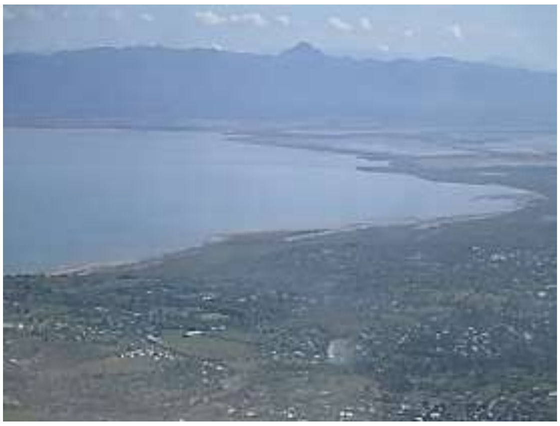

Figure 3. Variety of vegetation in coastal area in Southern Coast of Java (Author's personal documentation, 2022)

Figure 4. Housing cluster in coastal area in Sulawesi (Author's personal documentation, 2022)

3.3 Macro-scale housing and landscape planning

In general, macro-scale housing and landscape planning is related to land zoning conditions and green proportions. In terms of land zoning, the more diverse the land uses, the stronger the existing disaster mitigation efforts will be. Logically, mixed land use will lead to different types and intensities of activities. Thus, the various types of resilience of existing buildings will also be different, with the assumption that each unit will strengthen each other and not vice versa. For example, if the conditions are monotonous or of one type, then in the case of the worst scenario, if it turns out that one is not strong enough to withstand the load, then the others are assumed to have similar impact because the resistance conditions are the same.

On the other hand, in relation to zoning aspect, residential areas generally have a relatively small proportion of undeveloped land. Generally, land is maximized as built-up land for housing units, and undeveloped land is designed with pavement. Under these conditions, the principle of environmental drainage where rainwater comes/falls and can be absorbed by the ground becomes unequal or unbalanced. In this case, from a landscape perspective, it is necessary to have a more balanced proportion of green between the built land and the vegetation that surrounds it. The argument is that the building structure itself will not physically be able to withstand the burden of disaster alone, no matter how strong the structures, forts or walls are built. Natural elements or structures are needed to soften and/or maintain its natural resistance. It is assumed that this can only be realized if there are empty spaces that are deliberately created to anticipate potential disasters. For example, in the form of vegetated retention ponds, small infill gardens, higher Green Basic Coefficients, and so on. In addition, the green proportion of housing that is formed is sought to be more oriented towards environmental or group green planning and not the vegetation of individual or house units. In this way, for example, if there is limited open land, especially in the context of a residential environment, uneven vegetation can be avoided in a housing unit which can later affect the surrounding area system and have a wider impact.

Figure 5a and 5b shows mangrove planting as a natural reinforcement method, typically located in coastal areas or in river mouths. Generally, existing zoning is differentiated between high-risk areas (at the water's edge), medium-risk areas (farther away), and so on. Thus, the proportion of plants to built-up areas will also change depending on the location, with the higher risk areas leading to a higher proportion of plants. This is also demonstrated in Figure 6a and 6b, which shows the proportion of houses or settlements. Ideally, the proportion of plants is recommended to be greater than the built-up area. This is done to prevent disasters due to a lack of environmental carrying capacity, such as water absorption capacity. However, if the opposite condition is found (the increasing of built-up areas), empty spaces in the form of vegetated retention ponds, small infill gardens, and other areas, as mentioned previously, are recommended to minimize the risk.

Figure 5a. Mangrove in a coastal area in Bajawa (Author's personal documentation, 2022)

Figure 5b. Mangrove in a river mouth area in Kalimantan (Author's personal documentation, 2023)

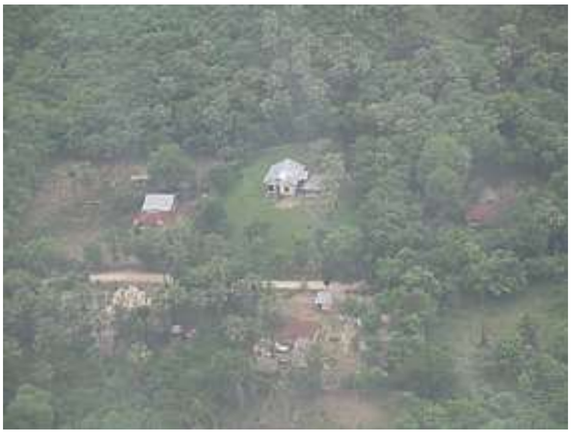

Figure 6a. Green proportions in a kampong in Kalimantan (Author's personal documentation, 2022)

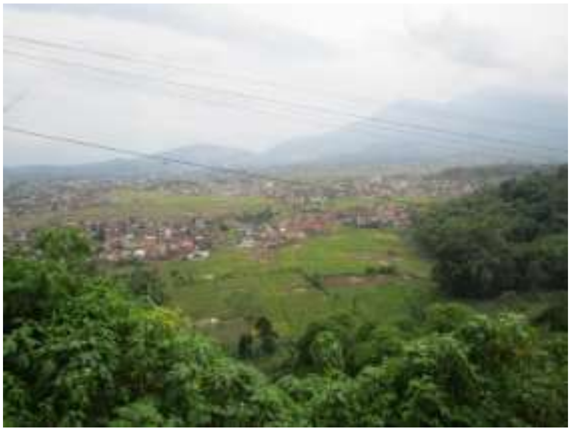

Figure 6b. Green proportions in a kampong in West Java (Author's personal documentation, 2026)

3.4 Environmental support

In general, environmental support is related to environmental utility, accessibility, and protective landscape conditions. In terms of environmental utility, the support of surrounding conditions for aspects of housing and landscape elements can be seen from the amenity attributes that form the space. For example, a room with supporting equipment such as an assembly point or evacuation area will better support anticipation when a disaster occurs. Allocation for building halls in large buildings and/or providing fields around residences, for example for sports rooms, will strengthen the resilience of the area. On the other hand, it is proposed to have communal spaces, such as shared parking spaces, social interaction spaces, and so on. These amenities will function as anticipatory spaces if needed in a disaster emergency.

As for accessibility, in general, a housing is generally closed with only one or two entrances, taking into consideration the efficiency and internal security of the environment. However, this can eliminate dialogue between environmental needs and the conditions surrounding them. Here, the ease of reaching safe locations, and not just a function of gathering points, is needed to strengthen disaster mitigation and anticipation efforts. For example, space with easy access to high places (upper floors) or to steeper slopes or to places further from the coast, will provide better possibilities in reducing the impact of a tsunami disaster. In addition, wide evacuation routes can be created to facilitate rescue efforts.

From a protective landscape perspective, residential areas generally have a certain concept in terms of orientation. According to design principles, generally the view towards the open sea or the valley below is the preferred orientation of the building mass compared to other directions. However, because of the potential danger of disasters, this orientation needs to be adjusted to anticipatory prerequisites. In general, housing needs to be built at a certain distance from potential disaster locations, such as in coastal areas, and needs to be equipped with protective vegetation. This equipment is more proposed than creating a massive and expensive dam structure. On the other hand, filler trees can act as barriers and reminders of safe area boundaries, for example on slopes.

Figure 7. Pedestrian walk along water/oceanfront in Bali (Author's personal documentation, 2022)

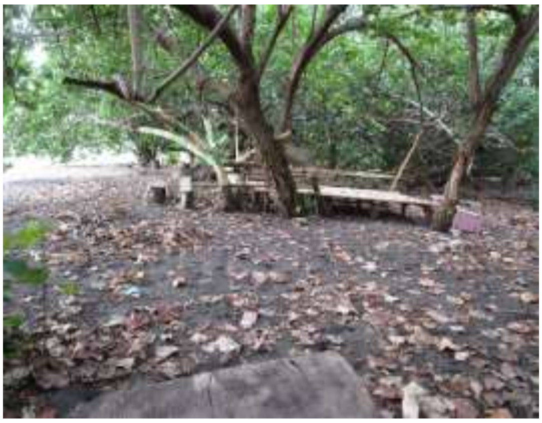

Figure 8. Natural amenities in water/oceanfront n Bajawa (Author's personal documentation, 2022)

The illustration above demonstrates environmental support efforts related to environmental utility, accessibility, and protective landscape conditions. Figure 7 shows the placement of a pedestrian walkway that also acts as a barrier against coastal waves. Thus, in addition to its useful reinforcement function, this pedestrian walkway can also serve as an inspection route and indicator of coastal water erosion. Figure 8 shows efforts to create amenity elements that can support social activities. This space can serve as a monitoring area and as an assembly point or evacuation area in anticipation of a disaster.

3.5 Summary

From analysis, findings that can be found and proposed are responses to the technological-physical aspects of buildings (i.e. safety and responsiveness), micro-scale housing and landscape design (i.e. building units, clusters, and variety of vegetation), housing and landscape planning at the macro-scale (i.e. land zoning and green proportions), as well as environmental support (i.e. environmental utility, accessibility, and protective landscape). Below is the table explaining the summary.

Table 1: Summary of Residential Environment and Landscape Planning for Disasters Anticipation

	Coastal area	**Slopes area**
Responses to the technological-physical aspects of buildings	– Safety standards for waterfront building structures – The existence of tsunami-protecting trees such as mangroves and coconut trees	– Safety standards for building structures in slope areas – The existence of trees with strong grip of the trunk or tree roots
Micro-scale housing and landscape design	– The change in building mass and/or enclosure makes it easier for occupants to escape quickly – The partial clusters condition is more proposed than the strong one – Variety of vegetation	– There should be a distance between buildings – Mix strong elements such as walls with softer filler plants – Mixed types or mixed building heights or others
Housing and landscape planning at the macro-scale	– Land uses are increasingly diverse both in terms of type and intensity of activity – There are empty spaces that are deliberately created, for example in the form of vegetated retention ponds, small gardens, etc.	– Natural elements or structures are needed as softeners and/or guardians of resilience – The green proportion that is formed is sought to be more oriented towards environmental or group green planning and not individual
Environmental support	– Housing is made at a certain distance from potential disaster locations – Allocation for making halls in large buildings and/or fields around the residence – There are communal spaces, such as shared parking spaces and social interaction spaces	– There are space-forming amenity elements such as assembly points or evacuation areas – The residence is equipped with erosion-resistant vegetation – The presence of infill trees can act as a buffer and reminder of safe area boundaries

Source: Author's Analysis, 2024-2025

4. Contribution to Broaden Condition

Based on the findings from the discussion above, the authors propose several suggestions that are expected to be beneficial for broadening conditions. These suggestions are as follows. Regarding responses to the technological-physical aspects of buildings, safety standards for waterfront building structures are proposed in coastal areas, including functional feasibility certification and regular structural maintenance. For landscapes, the presence of tsunami-protecting trees, protective trees, or tall trees with dense leaves is encouraged to ensure the tree trunk or root's grip on the ground below. For example, plantations of mangroves and coconut trees are recommended. This condition can be found in water areas with strong winds in various locations in Indonesia, such as coastal areas of islands and archipelagos where many people live. For slope areas, safety standards are proposed for building structures, both those using local materials and artificial technologies. For example, the use of steps or terracing principles for areas with relatively gentle slopes. In addition, the presence of trees with strong grip of the trunk or tree roots is recommended in hilly landscapes to naturally buffer the risk of erosion.

For micro-scale housing and landscape design, variations in building mass and/or enclosure are proposed in coastal areas, with partial clusters being preferred over strong ones. Both objectives aim to facilitate quick escape for occupants in the event of a disaster. This condition is often encountered in dense coastal settlements in Indonesia, where emergency exits are often lacking. In terms of landscaping, a variety of vegetation is encouraged to be used as natural reinforcement, particularly as wave breakers. For slope areas, it is recommended that buildings be spaced apart to minimize the risk of a domino effect in the event of a disaster due to the free spaces between houses. Furthermore, a mix of strong elements, such as walls with softer filler plants, and mixed building types or heights, is proposed. The goal is to provide greater opportunities for natural elements or structures to reinforce each other, given the diverse type, height, and character of the vegetation. This condition can be applied in many residential or village locations in mountainous areas or with hilly landscape conditions in Indonesia.

Regarding macro-scale housing and landscape planning, coastal areas are proposed to have more diverse land uses. This applies both to the type and intensity of activity. These various natural elements or structures are needed to soften and/or maintain their natural resilience. For example, a mix of built-up and open spaces, a mix of high-intensity and low-intensity spaces, etc. Furthermore, there should be deliberately formed empty spaces, such as vegetated retention ponds, small gardens, etc. The goal is to have a more balanced proportion of green between the built-up land and the surrounding vegetation, to be able to withstand the burden of disasters. For slope areas, natural elements or structures are proposed as softeners and/or guardians of resilience. For example, a mix of tall trees and filler plants, strong-trunked trees with densely leafy plants, etc. In addition, the green proportion that is formed is sought to be more oriented towards environmental or group green planning, rather than individual. For example, it is recommended to have public or communal spaces in the context of shared green open spaces, green corridors, etc. These spaces can be transitions and/or barriers between land uses, for example between the private function of a house and the public function supporting settlements, which are usually found in dense villages located on slopes or hills.

For environmental support, it is proposed that housing groups be established at a certain distance from potential disaster locations in coastal areas. For example, it is proposed to create intermediate spaces between low-density and high-density uses. Furthermore, it is proposed to allocate open spaces or halls in large buildings and/or fields around the residence, as well as the creation of communal spaces, such as social interaction spaces. Both objectives are to strengthen the area's resilience, serving as an assembly point or evacuation area when a disaster occurs, and as anticipatory spaces in a disaster emergency when needed. These locations can be relatively safe from inundation, the risk of high tides, the threat of tsunamis, etc. These places, for example, can be located at higher up or further from the coast. For slope areas, it is proposed to have space-forming amenity elements such as assembly points or evacuation areas. The goal is the same as the interstitial space in coastal areas. Furthermore, it is proposed that the residence be equipped with erosion-resistant vegetation. For example, a tall, strong-rooted trees, dense fill plants, etc. Additionally, the plantation of infill trees is proposed to act as a buffer and reminder of safe area boundaries. For instance, certain local plants can be used as a boundary between the settlement and the surrounding forest, such as vegetation with deep, strong, and spreading roots that can function as a binder for soil structure on slopes or cliffs, reduce the impact of rainwater, and prevent landslides. Examples include mahogany, teak, strong-rooted fruit trees, etc., which are usually locally-planted vegetation in each location.

5. Conclusions

From empirical discussions in the field and comparisons with similar conditions with studies in previous cases, there are several discourses on residential environment and landscape planning principles that are more anticipatory of disaster risk. These design and planning principles include:

1. It is necessary to pay attention to the standard requirements of a design or plan and adapt them to conditions in the field related to disaster risk.
2. It is necessary to integrate efforts with the environment around the residence and its landscape, both in terms of design, movement, environmental utility, aspects of carrying capacity, vulnerability to disasters and so on. This is intended to reduce the impact of disasters, both directly and indirectly

3. Details are needed that can provide additional information, to complete pre-existing requirements, for example regarding the frequency of disasters, risk coverage, and so on

In addition, further research that is more technical in nature and/or adding examples that can be applied in the field is important to complete this research. Wider and/or specific research areas can also be proposed to obtain more diverse results.

6. Acknowledgment

The authors would like to express their gratitude to the parties who have assisted in this research, including the Faculty of Engineering, Gadjah Mada University (Cooperation Institute of the Faculty of Engineering or *Lembaga Kerjasama Fakultas Teknik* / LKFT), the Department of Architecture and Planning, the assignor of the spatial planning study in Bontang City, Bajawa Regency, West Manggarai Regency, and Merauke Regency, as well as to the surveyors and research assistants who have worked hard so that this paper can be completed.

References

Adeyemi, A. B., Ohakawa, T. C., Okwandu, A. C., Iwuanyanwu, O., & Ifechukwu, G.-O. (2024). Affordable housing and resilient design: Preparing low-income housing for climate change impacts. *Research in International Journal of Applied Research in Social Sciences*. https://doi.org/10.51594/ijarss.v6i9.1585

Baarimah, A. O., Alaloul, W. S., Liew, M. S., Kartika, W., Al-Sharafi, M. A., Musarat, M. A., … Qureshi, A. H. (2021). A Bibliometric Analysis and Review of Building Information Modelling for Post-Disaster Reconstruction. *Sustainability 2022, Vol. 14, Page 393*, *14*(1), 393. https://doi.org/10.3390/SU14010393

Datola, G. (2023). Implementing urban resilience in urban planning: A comprehensive framework for urban resilience evaluation. *Sustainable Cities and Society*, *98*, 104821. https://doi.org/10.1016/J.SCS.2023.104821

Davlasheridze, M., & Miao, Q. (2021). Natural disasters, public housing, and the role of disaster aid. *Journal of Regional Science*, *61*(5), 1113–1135. https://doi.org/https://doi.org/10.1111/jors.12534

Effiong, T., Esen, U., Aniefiok, A., & Peter, J. (2024). THE ARCHITECTURAL DESIGN OF DISASTER RESILIENT HOUSES AS THE DETERMINANT OF BUILDING SUSTAINABILITY AGAINST ENVIRONMENTAL HAZARD IN AKWA IBOM STATE. *UNIVERSAL ACADEMIC JOURNAL OF EDUCATION*, *6*.

Ghanbarzadeh Ghomi, S., Wedawatta, G., Ginige, K., & Ingirige, B. (2021). Living-transforming disaster relief shelter: a conceptual approach for sustainable post-disaster housing. *Built Environment Project and Asset Management*, *11*(4), 687–704. https://doi.org/10.1108/BEPAM-04-2020-0076

Harun-Or-Rashid, G. M., Castro, J. J., Chakrabartty, M., & Kamruzzaman, M. (2022). Proposal of Resilient Housing Features for the Disaster Affected Community of Bangladesh. *Sustainability 2022, Vol. 14, Page 14061*, *14*(21), 14061. https://doi.org/10.3390/SU142114061

Hutchings, S. J., & Mooney, W. D. (2021). The Seismicity of Indonesia and Tectonic Implications. *Geochemistry, Geophysics, Geosystems*, *22*(9), 1–42. https://doi.org/10.1029/2021GC009812

Hwang, S., & Choi, M. (2025). Integrative building safety evaluation to mitigate disaster risks: a case study on public-use buildings in Seoul. *Journal of Asian Architecture and Building Engineering*, *24*(3), 1625–1639. https://doi.org/10.1080/13467581.2024.2329360/ASSET/4DF6B83A-1481-4D03-90C3-268A58B4012C/ASSETS/GRAPHIC/TABE_A_2329360_F0009_OC.JPG

Iyoha, P., Nejat, A., & Mostafavi, S. (2024). *A SYSTEMATIC REVIEW OF LITERATURE ON THE UTILIZATION OF 3D PRINTING TECHNOLOGIES FOR DISASTER-RESILIENT HOUSING*. https://doi.org/10.2139/SSRN.5139855

Jephcott, P., & Robinson, H. (2023). Homes in High Flats: Some of the Human Problems Involved in Multi-Storey Housing. *Homes in High Flats*. https://doi.org/10.4324/9781003317883

John, G., Gustavo, P., & Rakuasa, H. (2023). Disaster Education and the Role of Geographers: A Step Toward a Disaster Resilient Ambon City: A Review. *Journal of Education Method and Learning Strategy E*, *1*(03), 183–192. https://doi.org/10.59653/jemls.v1i03.238

Kamthonkiat, D., Leelawatthanaphong, T., Unapumnuk, K., & Vu, T. T. (2023). Recovery Assessment of Permanent Housing after the 2004 Tsunami in Thailand toward Sustainable Planning. *Sustainability (Switzerland)*, *15*(5), 1–22. https://doi.org/10.3390/su15054627

Komarudin. (1997). *Menelusuri pembangunan perumahan dan permukiman*. Jakarta Yayasan Realestat Indonesia. Retrieved from https://lib.ui.ac.id

Kuswartojo, T., Rosnarti, D., Effendi, V., K, R. E., & Sidi, P. (2005). *Perumahan dan Permukiman di Indonesia*. 211.

Marmin, H. (2022). A Concept of Housing and Settlements based Sustainable Spatial Articulation for Indonesian Cities. *International Journal of Scientific Research and Management*, *10*(10), 928–939. https://doi.org/10.18535/ijsrm/v10i10.ec01

Moghayedi, A., Awuzie, B., Omotayo, T., Le Jeune, K., Massyn, M., Ekpo, C. O., … Byron, P. (2021). A critical success factor framework for implementing sustainable innovative and affordable housing: A systematic review and bibliometric analysis. *Buildings*, *11*(8), 1–31. https://doi.org/10.3390/buildings11080317

Mushar, P., Samppebulu, V., Nasruddin, Hartawan, Imriyanti, S, T. I., … T, Y. R. F. (2021). Kesadaran Masyarakat Mengenai Pentingnya Keamanan Konstruksi Bangunan Rumah Tinggal terhadap Bencana (Badai Angin, Banjir, dan Gempa). *Jurnal Tepat (Teknologi Terapan Untuk Pengabdian Masyarakat)*, *4*, 207–219.

Nagami, K., Miyano, T., & Sediqi, M. N. (2025). Medium to long-term impacts from in-situ housing reconstruction: Insights from post-disaster surveys of the indian ocean tsunami and Nepal earthquake. *International Journal of Disaster Risk Reduction*, *117*(December 2024), 105175. https://doi.org/10.1016/j.ijdrr.2024.105175

Ochiai, C., & Saito, K. (2024). How the establishment of community organizations can help improve newly resettled residential sites: A case study from the post-tsunami disaster in Japan. *International Journal of Disaster Risk Reduction*, *115*, 105022. https://doi.org/10.1016/J.IJDRR.2024.105022

Pezzica, C., Cutini, V., & Bleil de Souza, C. (2021). Mind the gap: State of the art on decision-making related to post-disaster housing assistance. *International Journal of Disaster Risk Reduction*, *53*(November 2020), 101975. https://doi.org/10.1016/j.ijdrr.2020.101975

Pranantyo, I. R., Heidarzadeh, M., & Cummins, P. R. (2021). Complex tsunami hazards in eastern Indonesia from seismic and non-seismic sources: Deterministic modelling based on historical and modern data. *Geoscience Letters*, *8*(1). https://doi.org/10.1186/s40562-021-00190-y

Sari, A. R. (2023). *Housing Development for Low-Income Communities (Mbr) in Indonesia*. *5*(2), 75–82.

Sen, M. K., Dutta, S., & Kabir, G. (2021). Development of flood resilience framework for housing infrastructure system: Integration of best-worst method with evidence theory. *Journal of Cleaner Production*, *290*, 125197. https://doi.org/10.1016/J.JCLEPRO.2020.125197

Sen, M. K., Dutta, S., Kabir, G., Pujari, N. N., & Laskar, S. A. (2021). An integrated approach for modelling and quantifying housing infrastructure resilience against flood hazard. *Journal of Cleaner Production*, *288*, 125526. https://doi.org/10.1016/J.JCLEPRO.2020.125526

Setyonugroho, G. A., & Maki, N. (2024). Policy implementation model review of the post-disaster housing reconstruction in Indonesia case study: Aceh, Yogyakarta, and Lombok. *International Journal of Disaster Risk Reduction*, *100*, 104181. https://doi.org/10.1016/J.IJDRR.2023.104181

Silva, K. D., & Ballinger, B. T. (2021). Sustainable Rehousing after Disasters: Learning from Post-tsunami Resettlements in Sri Lanka. *International Journal of Mass Emergencies & Disasters*, *39*(1), 120–172. https://doi.org/10.1177/028072702103900106

Sukhwani, V., Napitupulu, H., Jingnan, D., Yamaji, M., & Shaw, R. (2021). Enhancing cultural adequacy in post-disaster temporary housing. *Progress in Disaster Science*, *11*, 100186. https://doi.org/10.1016/J.PDISAS.2021.100186

Suparji, S., Nugroho, H. S. W., Sunarto, S., & Prayogi, A. S. (2024). Disaster preparedness culture in Japan and Indonesia: cultural perspectives and practical implementation (a commentary). *PAMJ-One Health*, *15*. https://doi.org/10.11604/pamj-oh.2024.15.2.45129

Thiri, M. A. (2022). Uprooted by tsunami: A social vulnerability framework on long-term reconstruction after the Great East Japan earthquake. *International Journal of Disaster Risk Reduction*, *69*(November 2021), 102725. https://doi.org/10.1016/j.ijdrr.2021.102725