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Resilience Architecture in Post-Disaster Area: A Case Study of the West Mamboro Independent Housing Relocation Area

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Abstract: The earthquake, tsunami, and liquefaction disasters that hit Palu City, Central Sulawesi in 2018 had a major impact on people's lives, physically, socially, and psychologically. In the context of recovery, the practice of resilience architecture plays an important role in creating a built environment that is not only resilient to future disasters but also supports adaptation and sustainability of people's lives. The purpose of this study is to explore the experiences of the Palu City community in utilizing and interpreting post-disaster built space and to identify effective design elements that support community adaptation. A case study approach was used to explore the subjective experiences of affected communities through interviews, field observations, and descriptive analysis of daily life narratives. The focus of the research includes changes in housing design, public facilities, and open spaces, as well as the role of local cultural values in shaping interactions between communities and the built environment. Although the study results indicate that the application of participatory architecture has successfully supported the physical and social adaptation of communities, there are several challenges, such as the gap between standard designs and local needs. This study concludes that the lived experiences of communities after a disaster can provide a basis for developing a more comprehensive and contextual model of resilient architecture. The recommendations produced include integrating local cultural values into the design, providing flexible spaces that support community needs, and closer collaboration between planners and architects and communities during the rebuilding process. This research is expected to contribute to the development of resilient architecture that is not only responsive to disasters but also humane and focuses on the sustainability of life after a disaster.

Keywords: *Resilience Architecture, Post-Disaster, Community Adaptation.*

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I. INTRODUCTION

➢ *Background*

Indonesia, as a country located between several active tectonic plates, often experiences natural disasters such as earthquakes, tsunamis, and liquefaction. One significant event was the disaster that hit Palu City in 2018, causing damage to infrastructure and loss of homes for thousands of residents [1]. In response, many parties from various sectors such as the government, NGOs, and the community have carried out different kinds of aid initiatives and development movements. One of them is the movement

The earthquake, tsunami, and liquefaction disaster in Palu City in 2018 left a profound impact, not only on the physical area but also on the social and psychological aspects of the community [2], [3]. In the recovery effort, the practice of resilient architecture emerged as an important approach to creating spaces that support the adaptation and sustainability of community life.

In the context of post-disaster reconstruction, resilient architecture becomes crucial. Resilient architecture not only emphasizes the speed and accuracy of construction, but also the sustainability aspect to achieve a balance between economic, social, and regenerative growth of the community through architectural design [4], [5], [6]. The application of resilient architecture principles in post-disaster housing design includes aspects of efficiency and effectiveness, economy, eco-technology and sustainability, durability, and flexibility.

This study uses a case study perspective to understand how communities experience, utilize, and make sense of the post-disaster-built environment, and how resilient architecture practices are applied to support their lives. Research methods include:

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- Interviews with affected communities.
- Field observations to observe how the built space is used in everyday life.
- Descriptive analysis of narratives of community experiences, covering emotional, social and cultural aspects.

The uniqueness of the case study approach is that it focuses on subjective experiences, providing an in-depth dimension to the relationship between communities and the built environment. In addition, it is able to reveal personal narratives that are often missed in technical approaches. Consequently, it bridges the gap between standard-based design and specific local needs.

➢ *Formulation of the Problem*

The research location is the independent relocation housing area of West Mamboro, an area affected by the earthquake and tsunami disaster that has been rebuilt by disaster survivors assisted by the Community Architect (ARKOM) Jogja with assistance from various related parties. The focus of the research is on physical changes in the design of the built environment after the disaster; social community interaction with public and residential spaces; and the cultural role of local values and traditions in influencing the acceptance of design. The objects of study are residential buildings and public open spaces.

Fig 1 Research Location

The case study of the West Mamboro self-relocation housing area offers an opportunity to evaluate the extent to which the principles of resilience architecture are applied in the reconstruction process. This analysis is important to understand how post-disaster housing design can adapt to the needs of the local community and environment and increase resilience to potential future disasters. In addition, the evaluation of the Mamboro Barat self-relocation housing area can provide insight into the effectiveness of the reconstruction strategies that have been implemented, including aspects of community participation in the construction process and adaptation of housing after being occupied.

➢ *Research Purposes*

This study aims to analyze the application of resilience architecture in post-disaster reconstruction, especially in the West Mamboro independent relocation area, and its impact on social, cultural, and environmental sustainability. The results of the study are expected to be a reference for the development of more disaster-responsive architectural design policies and practices in the future.

If described in more detail, this research is expected to:

- Explore the life experiences of the people in the location by utilizing post-disaster development spaces.
- Reveal the role of resilience architecture in helping communities adapt and recover from disaster trauma.
- Identify local values that influence the success or failure of resilience architecture practices.

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The research questions prepared to achieve the desired objectives are:

- How do disaster survivor communities interpret and respond to post-disaster built environments?
- What elements of resilience architecture practice are considered effective or less successful by communities?
- How can people's lived experiences provide input for the development of resilience architecture in the future?

The contribution of this research is expected to provide new insights into how communities utilize and interpret post-disaster-built spaces, identify design elements that are appropriate to the psychological and social needs of post-disaster communities, and offer an approach based on community experience for the development of more effective resilience architecture.

The expected results of this research are:

- In-depth understanding of the life experiences of the community in the Mamboro Barat independent relocation area post-disaster, including the challenges and successes of their adaptation to the built environment.
- Experience-based design recommendations to support psychosocial resilience and recovery.
- A resilience architecture model that is relevant to the local context and can be adapted to other disaster-prone areas.

This title is relevant to connecting human experience with the practice of resilience architecture. The case study approach provides a framework for understanding how communities respond to built environment features designed to support post-disaster resilience.

II. LITERATURE REVIEW

➢ *Resilience Architecture in Post-Disaster*

Architecture is a design approach that aims to create buildings and environments that are able to adapt and survive changes and stresses, such as climate change, natural disasters, or pandemics. This concept emphasizes adaptability, sustainability, and resilience to ensure continued function under extreme conditions.

Resilience architecture is one of the important approaches in post-disaster built environment planning and design. This concept focuses on the ability of buildings and communities to survive, adapt, and recover from the impacts of disasters by minimizing losses and accelerating the recovery process [7], [8], [9].

In a post-disaster context, architectural resilience involves planning that is responsive to future disaster risks. Design strategies include the use of local earthquake-resistant materials, settlement layouts that avoid hazard zones, and the integration of supporting infrastructure such as drainage and emergency accessibility [10].

There are 3 parameters of resilience architecture [11] mentioned in the book "Resilience and Development - Positive Life Adaptations" (Glantz & Johnson, 2002), including:

- Design that allows the building to learn from the environment and adapt to various conditions including natural disasters [12], [13]
- Using discoveries and knowledge from previous design processes or master architects so that they can be applied to the next design.
- Involving all aspects of life in the area and environment where the design is carried out to answer problems, present needed programs and increase the utility value of the building [14].

According to [15], resilience is defined as the capacity of an urban system to absorb disturbances and transform while maintaining its primary functions and structures. In the context of architecture, resilience includes physical (buildings), social (communities), and ecological (environment) elements. [16] emphasize that resilient architecture must integrate the principles of risk mitigation, adaptability, and sustainability to create long-term post-disaster solutions.

The resilient design approach involves several strategies, including:

- Modular and Adaptive Design: The use of modular elements allows buildings to be rebuilt quickly. An example of its application can be found in the temporary housing project in Palu, Indonesia, after the earthquake and tsunami disaster [17].
- Integration of Local Materials: Utilization of local materials not only reduces costs but also supports sustainability and suitability to local geographic and cultural conditions [18].
- Community-Based Approach: Community involvement in planning and design ensures that reconstruction solutions are socially and culturally relevant [19], [20], [21].

Despite its great potential, the implementation of resilience architecture is often hampered by:

- Limited funds and resources.
- Lack of coordination between various stakeholders.
- Community resistance to changes in traditional design.

Resilience architecture is an important approach in post-disaster reconstruction that emphasizes sustainability, adaptability, and community engagement. This approach not only mitigates future risks but also supports faster social and economic recovery.

➢ *Community-Based Reconstruction Approach*

The community-based reconstruction approach has become one of the methods widely applied in post-disaster recovery. This approach emphasizes the active role of local communities in every stage of reconstruction, from planning, and implementation, to evaluation. This strategy aims to ensure sustainability, cultural relevance, and social acceptance of the reconstruction results.

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The community-based approach is based on the principles of active participation, community empowerment, and utilization of local resources [23], [24] According to [25], community participation not only increases the sense of ownership of the reconstruction project but also accelerates the social and economic recovery of affected communities. This is in line with research conducted by [26], which emphasizes the importance of building local capacity to support long-term sustainability.

The main advantage of this approach is its adaptability to local needs. Research conducted by [27] shows that high levels of participation can produce reconstruction solutions that are more effective and appropriate to local conditions. In addition, this approach also allows the transfer of knowledge and skills to the community, which is important for future disaster preparedness [28].

However, community-based approaches for post disaster recovery also face challenges such as Limited resources, conflicting interests among community members, and lack of government support often hinder successful implementation [29], [30], [31]. The success of community-based approach is highly dependent on effective coordination between stakeholders.

Several case studies have demonstrated the success of this approach. For example, reconstruction following the 2001 earthquake in Gujarat, India, showed that involving local communities in the redesign and construction of earthquake-resistant housing resulted in high levels of community satisfaction ([32]). In Indonesia, a similar approach was implemented after the Yogyakarta and Nias earthquakes, where communities were involved in the planning and construction of both temporary and permanent housing ([33]).

Community-based reconstruction approaches offer an inclusive and sustainable solution for post-disaster recovery. Despite its challenges, this approach remains relevant in the context of sustainable development and disaster risk mitigation. Further studies are needed to integrate this approach with modern technology and information systems to improve its efficiency and effectiveness.

➢ *Disaster Mitigation*

Disaster mitigation is an effort to reduce the negative impacts of disasters through planning, design, and technology approaches [34]. In the context of architecture, disaster mitigation involves developing strategies that focus on reducing physical and social risks through building and spatial design that is resilient and adaptive to potential disasters.

According to Global Assessment Report on Disaster Risk Reduction [35], disaster mitigation includes actions designed to minimize losses due to disasters, both in terms of humans, property, and the environment. In architecture, disaster mitigation is often associated with:

- Risk-Based Planning: Identifying and integrating disaster risks into the design process [36].
- Use of Disaster-Resistant Technology and Materials: Utilizing technological innovations to increase building resilience [37], [38].
- Nature-Based Solutions: Utilizing natural ecosystems to reduce the impact of disasters, such as the use of wetlands for flood mitigation [39].

- *Design Approach in Disaster Mitigation*

✓ Earthquake resistant building design includes the use of flexible structures, vibration-damping systems, and earthquake-resistant materials. An example is the base isolation system used in buildings in Japan [40].
✓ Drainage and Flood Management, Architecture and spatial planning can integrate sustainable urban drainage systems to reduce flood risk.
✓ Modular Design for Fast Recovery, Modular buildings enable rapid post-disaster reconstruction while increasing resilience to future disaster risks [17].

- *Challenges in Disaster Mitigation Implementation*

✓ Funding Constraints: Construction of disaster-resistant buildings often requires large initial investments.
✓ Lack of Awareness and Education: Many communities do not understand the importance of disaster mitigation, so resistance to design or spatial changes is common.
✓ Regulatory Constraints: Some areas have development regulations that do not integrate disaster mitigation principles.

Disaster mitigation is an approach that is not only preventive but also strategic in creating a safe and resilient built environment. Integration of technology, community participation, and nature-based approaches are the main keys to success in disaster mitigation in the architectural sector.

➢ *Participatory Architecture Design*

Participatory architecture refers to participatory design Participatory design is a design method that involves stakeholders in the creation and management of built and natural environments. A key advantage of this method is that it transcends professional and cultural boundaries; it is grounded in the principle that the design of built environments—including architectural products—functions effectively when all stakeholders are actively involved in the design process [41], [42]. This design approach involves non-designers—including building users—in various activities throughout the design process [43], prioritizing concepts of democracy and mutual learning [44].

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III. RESEARCH METHODS

This study uses a descriptive qualitative approach, which aims to understand the application of the principles of resilient architecture in the construction of permanent housing in the Mamboro Barat independent relocation area. This approach allows exploration of design, implementation, and its impact on environmental sustainability and local community empowerment after a disaster.

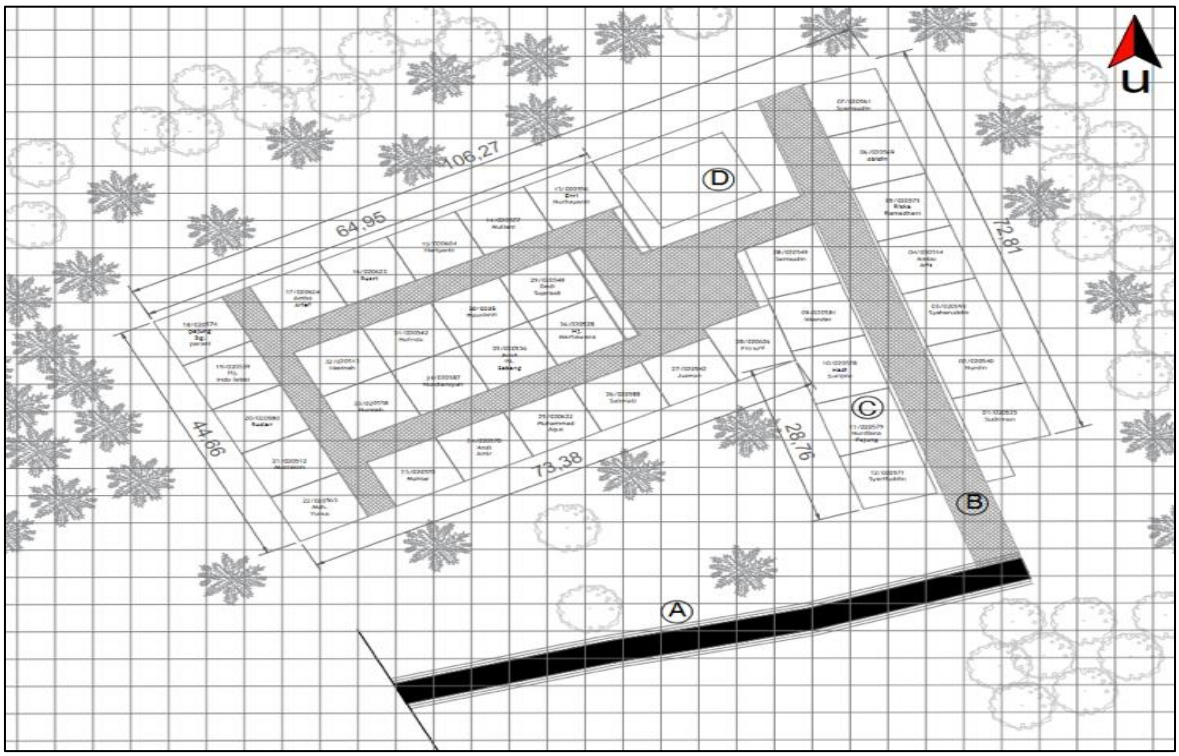

Fig 2 Research Location

The research focused on the West Mamboro independent housing relocation area, which is one of the reconstruction locations after the 2018 earthquake and tsunami disaster. The research subjects involved:

- The experience and level of satisfaction of the community receiving temporary housing with the temporary housing design are presented in Table 1 and Fig 3.

Table 1 Data on Huntap Recipient Communities

No.	Name	Age	Work	Number of Occupants	Comfort Scale (1-5)
1	Syamsudin	44	Fish drying	4	5
2	Ambo Aris	62	Fish dryer/ builder	6	5
3	Hadi Sucipto	39	Fish drying	4	5
4	Nurdiana Pajung	41	kiosk vendor	4	5
5	Sharifuddin	43	Civil Service (RT Head)	5	5

- Architects and project planners gain a technical perspective on the application of resilience principles.
- Local governments and related NGOs evaluate the role of policies and logistical support in the development of permanent housing.

Research data was collected through the following methods:

- Interviews were carried out for the community receiving the huntap, and the architect/project planner. The interviews focused on post-disaster experiences, adaptation to new housing, and housing sustainability.
- Field Observation: Directly observing the physical condition of the permanent housing, spatial design, and integration of resilience elements such as disaster-resistant materials, drainage systems, and accessibility. Visual documentation is used to support the description.

This study uses a resilience architecture framework based on three main aspects:

- Physical Aspects: The resistance of building structures to potential future disasters.
- Social Aspects: The level of community adaptation to the design of the permanent housing and the role of the community in reconstruction.
- Ecological Aspects: Environmental sustainability, including energy efficiency, use of local materials, and waste management.

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The results of the study are expected to provide recommendations for more resilient, adaptive, and sustainable housing designs. This study also aims to contribute new insights into the application of resilience architecture in the context of post-disaster reconstruction.

IV. RESULT AND DISCUSSION

A. *Participatory Architecture as a Framework for the Development of Independent Relocation Areas*

The earthquake, tsunami, and liquefaction disaster that hit Palu City in 2018 was one of the most complex disaster events in Indonesia. Its impacts were widespread in terms of infrastructure damage, loss of social assets, and disruption of the community's socio-economic order. In this context, post-disaster reconstruction in Palu, including the construction of Permanent Housing (Huntap), is a strategic step to ensure sustainable recovery.

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➢ *Based on the Research Questions Prepared, we can Draw the Following Analysis:*

- *How do Disaster Survivor Communities Interpret and Respond to Post-Disaster Designed Built Environments?*

Disaster survivors are placed as objects in post-disaster reconstruction planning. To ensure the community feels a sense of ownership and responsibility for their environment. The community can take the initiative, plan, and make decisions in the development of their new environment. The community can become heroes for themselves, their families, and their surroundings. The survivor community carries out planning and development through mutual cooperation.

- *What Elements of Resilience Architecture Practice are Considered Effective or Less Successful by Communities?*

In the planning and development process, good communication is established between residents and planners so that the needs of the house space and the environment are built according to needs, and also based on the needs of the survivor community. With a process that involves all related elements, the survivor community becomes more aware of disaster-prone zones (ZRB), earthquake-resistant houses, and more aware of disaster mitigation.

Conversely, this participatory development practice requires a fairly long process and small or fragmented groupings. To meet the needs of the community widely and quickly, there is also a permanent housing government program with several types of systems. Therefore, further research is needed to see the comparison between the independent community relocation Huntap and the local government Huntap.

- *How can People's Lived Experiences Provide input for the Development of Resilience Architecture in the Future?*

From the life experiences of the survivors, aspirations and participatory mapping can be conducted. Based on this, it can map the potential and the problems or conflicts that occur in the environment before and after the disaster, socio-cultural conditions, the community's economic potential, and the potential for existing environmental conditions that can be further developed so that they can have economic value and strengthen the community's social cohesion.

Resilience architecture does not only focus on technical aspects, but is also comprehensive, encompassing a multidimensional approach that includes physical, social, and ecological resilience. Its application in the Mamboro Barat independent relocation area provides important insights into resilience-based reconstruction in disaster-prone areas through mutual cooperation or participatory architecture.

The development movement in the independent relocation area of West Mamboro Housing was carried out in a participatory manner. The survivor community is the subject and not the object so the community becomes a hero for themselves, their families, and their surroundings. In post-disaster participatory architecture, the survivor community becomes the center that has the right or power to initiate, plan, and make decisions in development. The role of the architect community is as a companion and provide suggestions or ideas in the process that occurs.

The activity for participatory architecture design was prepared in six step (Fig 3) by the Arkom Indonesia Foundation (YAI) Palu City Volunteer Secretariat, with the following order:

- ✓ Assessment, persuasive communication was built with the survivor community in a relaxed manner.
- ✓ Organizing survivors, recording family, neighbors, profession, culture and culture, as well as the number of family members of the survivor community.
- ✓ Consultation, discussing collaborative work, reconfirming the number of survivors and remaining disaster materials that can be reused, and discussing disaster mitigation ideas at the micro (housing) and macro (environment) levels along with evacuation routes and distances between buildings.
- ✓ Survivor planning, determine the size, shape, and contents of the living space, as well as the structure and connection of the materials to be used.
- ✓ Survivor workshop, forming working groups, divided based on the structure of the house, also making a mock-up of the residence.
- ✓ Action, the development process is carried out through cooperation with a mutually determined deadline.

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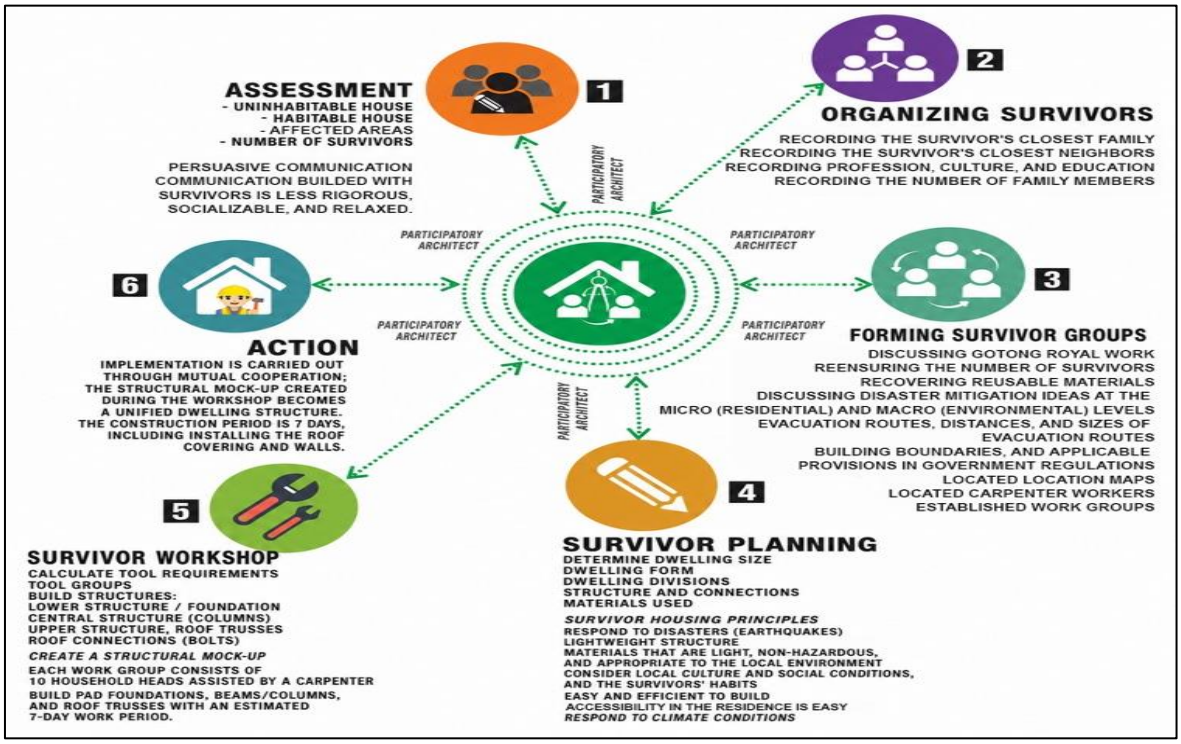

Fig 3 Participatory Architecture Workflow. (Palu City Volunteer Secretariat YAI Presentation, 2024)

B. Implementation of Resilience Architecture Principles in Research Areas

➢ *Physical Aspects: Infrastructure Resilience*

- *Strategic Location Planning*

The location of the Mamboro Barat independent relocation area was chosen based on a disaster risk assessment. This area is located in a location with good access to public facilities and is also close to the work location of local residents. This approach is based on a spatial study that ensures the location is safe from the threat of secondary disasters and also.

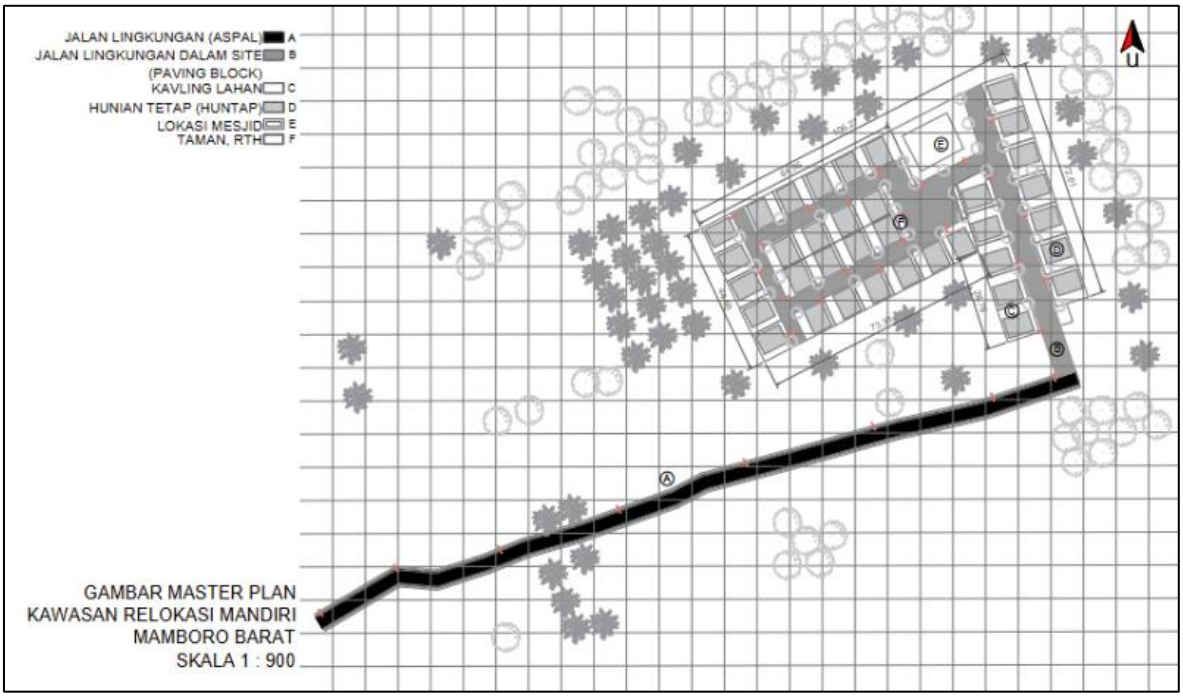

Fig 4 Research Location.
Source: (Yayasan Arkom Indonesia (YAI) Palu City Volunteer Secretariat, 2024)

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- *Building Design and Structure*

Disaster Resistant Materials: Use of local earthquake-resistant materials, such as RISHA panels and wood. The structural design also adopts seismic principles to ensure the building's flexibility against earthquakes.

Fig 5 RISHA Huntap Panel for the West Mamboro Independent Relocation Area (ARKOM Documentation, 2024)

- *Spatial Planning System*

✓ The building layout is arranged to ensure evacuation accessibility, with clear main routes and green open spaces that also serve as emergency gathering areas.

✓ The distance between buildings is regulated to prevent a domino effect of structural damage in the event of a disaster.

Fig 6 A Community-Based Approach to the West Mamboro Independent Relocation Area.
Source :(Dokumentasi ARKOM, 2024)

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➢ *Social Aspects: Community Sustainability*

- *Community Participation in Reconstruction*

A community-based approach is applied in the construction of Huntap. The community is involved from the planning stage to ensure that the building design is in accordance with their cultural and lifestyle needs. Participatory Consultation: Discussion sessions between planners and communities enable the transfer of knowledge on disaster mitigation. Skills Enhancement: Construction training for residents improves their skills, which also impacts the local economy.

Fig 7 A Community-Based Approach to the West Mamboro Independent Relocation Area. (ARKOM Documentation, 2024)

- *Adapting to a New Life*

Permanent housing reconstruction presents adaptation challenges, especially in terms of housing design that is different from traditional houses. To overcome resistance, a socialization approach is carried out by introducing modern facilities, such as a better sanitation system.

- *Social Infrastructure Improvement*

The provision of public facilities, such as schools, markets, and places of worship, supports social recovery and strengthens community ties. This increases the social resilience of communities in facing post-disaster challenges.

➢ *Ecological Aspects: Environmental Sustainability*

- *Nature Based Design*

✓ Sustainable Drainage: Drainage systems are designed to address stormwater runoff and prevent local flooding. Planting local vegetation in catchment areas helps reduce surface runoff.
✓ Energy Efficiency: The building design makes use of cross ventilation, natural lighting, and thermal insulation, which reduces the need for electrical energy.

- *Local Waste and Material Management*

The use of local materials, such as rattan and sustainably processed wood, supports the local economy and reduces the carbon footprint of material transportation. A community-based waste management system is also implemented to maintain a clean environment.

➢ *Evaluation and Reflection*

- *Success*

Safety and Resilience: Huntap buildings are proven to be safer than previous houses, especially from the threat of earthquakes. Community Adaptation: Most residents feel more comfortable and protected in their new homes. Local Capacity Building: Community involvement in reconstruction increases their sense of ownership and skills.

- *Challenges Faced*

Budget Constraints: Some public facilities are not yet available, such as multipurpose rooms and playgrounds. Limited budgets affect the quality of some design elements and materials. Long Term Maintenance: Challenges in managing and maintaining public facilities, such as drainage and roads. Public awareness of sustainable environmental management needs to be increased.

Based on the results of an interview with one of the community architect activists, it can be seen that mapping, participatory planning, and mutual cooperation in the independent relocation of Mamboro housing area, are one kind of methods for resilience and adaptation to natural disasters. The survivor community determines the location of the site (outside the disaster-prone zone) and selects the RTG (Earthquake-resistant House) technology of the Risha panel. The involvement of survivors in the planning and construction process of the permanent housing, directly, provides knowledge about how a resilient and adaptive built environment can be.

➢ *Implications for Future Reconstruction*

- Enhanced Risk Assessment: More in-depth risk mapping is needed to ensure that the location and design of Huntap are truly safe from future disasters.
- Integration of Local Technology: The combination of modern technology and traditional elements can increase community acceptance while strengthening cultural identity.

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- Public Education and Awareness: Educational programs on disaster mitigation and utilization of housing facilities need to be expanded.
- Multistakeholder Collaboration: Synergy between government, local communities, academics, and NGOs must be strengthened to ensure the success of the reconstruction program.

V. CONCLUSION

It takes good synergy between various parties to create a habitable and disaster-responsive area. So that we can live side by side with natural disasters that can occur at any time in our environment.

➢ *The Role of Government and Institutions*

The government as the highest policy holder of a region is expected to be able to involve various aspects and communities in its region. So that when a region is rebuilt, it can be used effectively and efficiently, and is also happily used by its people.

Through RTRW or PERDA, the government is expected to be able to provide control over the development or expansion of areas under its authority, including disaster-affected areas.

The government provides space for institutions to conduct related studies and research. So that it can produce new rules or systems in dealing with future disasters if they do not yet exist or are not yet appropriate.

➢ *Collaboration with the Private Sector and Communities*

The private sector is one of the hopes in the development of an area so that it can help the government from the economic sector. Likewise with the community, where through this community a space is created and becomes alive. Through the community, it can teach or educate the community regarding activities or policies that need to be carried out during or after a disaster occurs.

The creation of relationships between the various sectors above is expected to produce a good relationship that is able to build a space or area. First, the same goal is needed between sectors so that there is no overlapping of interests that will create new problems in society.

➢ *Education and Training*

Education and training need to be carried out continuously considering that we live in a disaster-prone area. With education and training that is repeated, it is hoped that it will be embedded in the community's memory. So that when a disaster occurs, the atmosphere is expected to remain conducive and can minimize the risk of the disaster.

A design of educational and training activities is needed that is appropriate to the age grouping of the community. This design can certainly be created from the results of studies by related institutions or communities that conduct in-depth research on communities in disaster areas.

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