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The Policy Strategy for the Development of Housing and Settlements in Disaster-Prone Areas after the Earthquake Disaster in Majene Regency, West Sulawesi

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Abstract*—According to Majene Regency's BNPB data, the early 2021 earthquake resulted in 105 fatalities and 92,075 people being forced to leave their houses, leading to their displacement. As many as 7,240 dwelling units were damaged, of which 3,005 were severely damaged, 1,727 were moderately damaged, and 2,508 were mildly damaged. The large number of earthquake-related houses damages reveals a lack of housing and settlement development policies. Therefore, the purpose of this study is to design appropriate policy strategies for housing and settlement development based on information regarding the degree of damage to residential hoses following the earthquake and the zones of Majene Regency's disaster-prone locations. In order to map the locations of residential buildings that sustain heavy, moderate, and low damage and to zone disaster-prone areas based on fault fault maps in Majene Regency, a quantitative descriptive analysis method with a spatial approach through map overlay is used. Then, in order to reinforce the strategic formulation of housing and settlement development policies in earthquake-prone areas, a policy study on spatial use directions as well as standards for the building of earthquake-resistant housing and settlements was conducted. The analysis's findings indicate that the level of residential houses damage falls into the medium and extremely high categories. A number of residential neighborhoods and settlements were found to have residential building structures that did not adhere to earthquake-resistant building requirements and were situated in restricted and forbidden zones. As a result, the best housing and settlement development policy strategy to minimize the damage of residential houses after the earthquake is to forbid new construction for residential functions and important facilities in restricted zones. Additionally, residential construction must be strengthened in accordance with The relevant specifications are SNI 1762 (Procedures for Planning Earthquake Resistance for constructions) and technical guidelines for earthquake-resistant constructions.

Keyword—Earthquake, Housing, Settlement Development Policy Strategy, Zoning disaster-prone areas,.

I. INTRODUCTION

According to Law No. 1 of 2011 Concerning Housing and Settlements, a "HOUSE" is a building that is both a place of habitation and a means of providing for a family. In accordance with government policies and plans for the implementation of housing and settlements, housing is one of the fundamental human needs, alongside food, clothing, education, and health. This shows that as the population increases each year, so does the need for housing.

As the need for housing increases, more unsuitable land is being used for settlements, which increases the amount of disaster-prone areas being used as residential zones. As a result, there is extensive home damage and a high mortality toll when natural disasters occur.

West Sulawesi is one of the areas with a high level of earthquake risk due to its vicinity to the Mamuju Upswing fracture, which is found on the Mamuju coast close to Polewali Mandar Regency. The fault has caused at least nine earthquakes since 1915, some of which were accompanied by tsunamis. The Majene Meteorological Station in West Sulawesi recorded 479 earthquakes in 2021, according to BMKG data. There are three different types of earthquakes: destructive, undetectable, and those that are felt. There were 469 earthquakes, of which 2 were damaging and 15 were felt. The records show that there are more dangerous earthquakes than there are earthquakes that are felt, yet the West Sulawesi BMKG reported that the earthquake's losses in 2021 were Rp. 1,020,373,580 The devastating earthquake completely destroyed everything, including buildings used for government, businesses, residences, and hospitals.

According to the results of the West Sulawesi disaster risk research, Majene Regency has a larger potential risk and hazard of earthquake and tsunami disaster than other districts in West Sulawesi.

A tsunami that surged as high as 10 meters in Majene was caused by an earthquake with a magnitude of 6.9 on February 23, 1969, which claimed 63 lives. On January 14–15, 2021, a 5.9 SR earthquake that was the most recent one occurred. 13 hours after the initial earthquake, a stronger one with a magnitude of 6.2 SR took place. There were very huge material and human losses even though a tsunami did not follow. Homelessness was claimed to affect 92,075 people, and 105 people died as a result (Source: BNPB West Sulawesi, 2021). A considerable number of dwellings have been damaged, according to data on the number of refugees

brought on by home losses. Up to 7,393 residential units were damaged, with specifics indicating 3,005 seriously damaged, 1,727 moderately damaged, and 2,508 lightly damaged homes. Five sub-districts, namely: Ulumanda District, Malunda District, Tameroddo District, Tubo Sendana District, and Sendana District, were responsible for the reported house damage (Source: Data, Information, and Public Relations of the West Sulawesi Province Earthquake Emergency Transition Command Post).

Houses are usually damaged by earthquakes because of strong earthquake vibrations in residential areas. A building is subject to structural impacts in its shear structure, particularly at the foot of the column and the building beams. As a result, the building structure becomes unstable and is vulnerable to sudden collapse in the event of an external impact. Housing and settlement construction must take disaster mitigation measures into account due to their locations in earthquake- and tsunami-prone zones. In order to decrease the impact of damage to dwellings caused by earthquakes, it is crucial to do research on the appropriate housing and settlement development policy measures, especially in earthquake-prone areas in Majene Regency, West Sulawesi.

II. THEORETICAL REVIEW

A. Housing and Settlements

According to Law No. 1 of 2011 Concerning Housing and Settlement Areas, the following are the definitions of houses, housing, settlements, and residential areas:

1. HOUSE: A structure that serves as a livable place to live, a place to raise a family, a symbol of the dignity of those who live there, as well as a resource for the owner.
2. HOUSING: A group of homes that are a part of settlements, both urban and rural, and that are outfitted with public amenities, infrastructure, and facilities as a consequence of efforts to provide livable housing
3. SETTLEMENT: A portion of an urban or rural residential area with more than one housing unit that has infrastructure, facilities, public utilities, and other supporting activities.
4. SETTLEMENT AREA: Part of the living environment outside the protected area, either in the form of urban or rural areas, that serves as a residential area or residential environment and a location for activities that support livelihoods and livelihood.

House is the core of cultural life and a source of security for oneself as a human. originated and evolved into human beings with personalities inside the home and its surroundings. In a sense, a house is not merely a structure (structural), but also a place where people live who meet the standards of a respectable living as seen from numerous facets of social life. Locals learn about his life in this world for the first time in Inside the house. More than that, the house must provide peace, pleasure, happiness, and comfort in all of his life's events. A house must safeguard the interests of the family, namely that they develop and have the opportunity to get along with their neighbors.

Settlement is a system consisting of five elements, namely: nature, society, humans, protection and network. The settlement's "container" portion combines three elements: natural (soil, water, and air), security (shell), and networks (networks), while its "content" is made up of people and society. Natural is the fundamental ingredient, and it is nature that produces shelter (houses, buildings, and other structures) where people can live and perform other tasks.

B. Earthquake Natural Disaster

According to Law No. 24 of 2007 concerning Disaster Management, a disaster is an occurrence or series of occurrences that endangers and disrupts people's lives and livelihoods and is brought on by both natural and/or non-natural factors, as well as human factors, and results in fatalities among people, environmental harm, property loss, and psychological effects. The following categories of disasters can be distinguished:

1. Natural Disaster is a disaster caused by an event or series of events caused by nature, including: earthquakes, tsunamis, volcanic eruptions, floods, droughts, hurricanes/tornadoes and landslides.
2. Non-Natural Disasters, namely disasters caused by events or a series of non-natural events, including technological failures, modernization failures, epidemics and disease outbreaks.
3. A social disaster is one brought on by a human-caused incident or set of events, such as terrorism and social conflicts between groups or communities.

Natural disaster hotspots are places where natural catastrophes occur frequently or with a high likelihood. Earthquakes are tectonic earthquakes, which are rapid releases of energy owing to tectonic activity, and fissures brought on by rising fluids (magma, gas, and other vapors) from deep inside the earth to the surface. Earthquakes are vibrations of rock particles or shocks to the crust of the earth. Depending on what caused them, there are three categories of earthquakes:

1. Tectonic earthquakes are those that are brought on by rapid movements in tectonic plates with strengths ranging from very small to very large..
2. Volcanic Earthquake is an earthquake that occurs as a result of volcanic activity.
3. Earthquake collapse (Sudden Ground Shaking), also known as sudden ground shaking, is an earthquake that happens as a result of the cave roof collapsing, the mine roof collapsing, the soil collapsing, the rocks collapsing, etc.
4. Earthquake collision, occurs as a result of the fall of an asteroid to earth.
5. Artificial Earthquakes, caused by human activity itself, such as dynamite, nuclear and bomb explosions with enormous power.

C. Earthquake Disaster Management Policy for Housing and Settlements

Law No. 24 of 2007 contains the disaster management policy. According to this Law, implementing disaster management entails a number of tasks, such as creating development policies that are vulnerable to catastrophes,

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engaging in disaster prevention initiatives, responding to emergencies, and providing rehabilitation. The following are the goals of catastrophe management:

1. Provide protection to the community from the threat of disaster;
2. Align existing laws and regulations;
3. Ensuring the implementation of disaster management in a planned, integrated, coordinated and comprehensive manner;
4. Appreciate local culture;
5. Building public and private participation and partnerships;
6. Encouraging the spirit of mutual cooperation, solidarity and generosity; And
7. Creating peace in the life of society, nation and state.

Disaster mitigation for housing and residential areas is carried out to reduce damage that occurs to the structure of the house, as well as to facilities, infrastructure, and public utilities, according to Article 9 Paragraphs 1, 2, and 4 of Public Housing Regulation No. 10 of 2014 (the Regulation). Identifying and mapping the locations of housing and residential areas that are vulnerable to earthquakes according to earthquake prone zones is how earthquake disaster mitigation is carried out in the housing and settlement sector. At the very least, disaster mitigation is accomplished by:

1. Planning for the placement of housing and residential areas to reduce the level of occupancy density in disaster-prone areas
2. Construction of housing and residential areas with structural strengthening and vibration/earthquake resistant building construction
3. Utilization of the application of zoning of disaster-prone areas and regulation of land use
4. Maintenance of housing and residential areas by involving the role of the community and training in earthquake rescue and alert programs

III. PREVIOUS RESEARCH REVIEW

This chapter will explain previous research studies related to this research. Sushanti, I.R., Ridha, R., Yuniarman, A. and Hamdi, A.I. (2021), conducted a study on Damage Management Strategy Post-Earthquake Disaster in North Lombok Regency, West Nusa Tenggara Province. The research aims to formulate strategies for dealing with post-earthquake damage to residential houses in residential areas. The results showed that the strategies for dealing with post-earthquake damage to residential houses in residential areas were: 1) strengthening the capacity of residents and community groups as disaster management from the pre-disaster, disaster and post-disaster stages, 2) establishing disaster response community institutions as a forum for the community and community groups to synergize and collaborate with external parties, both government and non-government regarding disaster information and its management, 3) collaboration with relevant parties who are competent to identify and analyze land suitability levels, 4) earthquake resistant housing technology based on land suitability levels and 5) integrated and sustainable disaster management in information, technical and administrative terms from the planning, implementation and control stages during the pre-disaster, disaster and post-disaster phases.

Previous research provides an overview of the strategy for housing construction policies in conditions of heavy damaged houses after the earthquake. Therefore, in this study, the housing building policy plan was analyzed more spatially to propose a policy strategy based on zoning of disaster-prone areas as observed from the condition of the dwellings being lightly damaged, moderately damaged, and badly damaged. So that the strategy formulated is adjusted to housing and settlement development standards in disaster-prone areas in order to minimize the impact of damage houses due to earthquakes in the future.

IV. RESEARCH METHODOLOGY

A. Data Collection

This study used a variety of data collection techniques, such as observation, interviews, surveys, and document gathering. The objective of a survey is to gather specific items or samples from a population that can accurately reflect the population in order to facilitate research. In order to construct the initial description of the research field, observation is attempted. Data collection through conversation with informants is the goal of interviews. Studies aim to gather data or knowledge from published works. Both quantitative and qualitative data types were used in this investigation. Quantitative data is collected through surveys of study locations and agency visits, as opposed to qualitative data, which is obtained through interviews with affiliated agencies. Quantitative data takes the form of statistical or numerical data.

Utilizing a stratified sample selection technique, study locations are chosen through a selection procedure with two or more phases of selection. According to Sugiyono (2016), the population is a broad group made up of items or people who have been picked by researchers for examination and subsequent drawing because they have specific qualities and traits. Depending on where the study will be conducted, a certain demographic will be sampled. The selection of study locations for the sample of earthquake-damaged homes went through a variety of stages and considerations in order to accurately portray the state of housing and settlements after the earthquake. These are the phases and elements that lead to references:

1. The location of the damage to houses was recorded from five sub-districts, namely: Ulumanda District, Malunda District, Tameroddo District, Tubo Sendana District, and Sendana District, according to BNPB data from Majene Regency.
2. The Malunda District was chosen as the sub-district for sampling the damaged homes in light of this. The chosen sub-district was chosen due to its high rate of home damage when compared to other sub-districts.

B. Data Analysis

This study uses a quantitative descriptive analysis method

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with a spatial approach through map overlay using ArcGIS to map the locations of residential buildings that suffered heavy, moderate, and light damage after the earthquake and to identify disaster-prone areas based on a map of fracture in Majene Regency. Based on the results of this analysis, this research also uses descriptive analysis with studies of policies and regulations as well as recommendations for developing settlements and housing that are earthquake-resistant, with the aim of strengthening the formulation of appropriate policy strategies in settlement development in earthquake-prone areas of life to reduce the risk of damage to homes and the risk of injury to people during future earthquakes.

The steps of analysis ini this study are :

1. Identify and map residential units that are vulnerable to earthquakes using survey data and observations of the current conditions of the dwellings, which are grouped into three groups, namely: heavily, moderately, and lightly damaged.
2. Next, determine the zoning of disaster-prone areas in accordance with Presidential Decree No. 10 of 2018, by subdividing the regional zones into 4 zones: prohibited zones, restricted zones, conditional zones, and development zones. Zone classification in the Majene Regency based on the fault's radius.
3. After determining the extent of the damage to residential homes and disaster-prone locations, then analysis the appropriate policy strategy based on the damaged conditions of residential houses and disaster-prone areas by considering regulations and technical guidelines for earthquake-resistant buildings.

V. RESULT AND DISCUSSION

A. Housing and Settlement Conditions After the Earthquake

Based on surveys and observations of post-seismic housing and settlement circumstances at the sample location, specifically in Malunda District, it is known that 240 dwellings were destroyed as a result of the Majene earthquake in 2021. The severity of home damage is divided into three categories: heavy damage, moderate damage, and light damage.

Table 1.
House Damage Level Data

No.	Level Damage	Total Houses
1.	Heavy damaged	84
2.	Moderate damaged	138
3.	Light Damaged	18

Source : Survey, 2022

Houses that destroyed by an earthquake are classified as heavy damage, while buildings that can still stand but have sustained some damages are classified as moderate damage. Light damaged housing is defined as having only a few fractures in the structure. These data reveal that there is a significant amount of moderate and heavy damage houses, indicating that an earthquake will have a significant negative impact on houses or other community dwellings. As a result, steps must be taken to reduce damage earthquakes cause to houses.

Figure 1. Types of Damage to Residential Houses After the Earthquake Category Heavy Demage (Source : Survey, 2022)

Figure 2. Types of Damage to Residential Houses After the Earthquake Category Medium Demage (Source : Survey, 2022)

Figure 3. Types of Damage to Residential Houses After the Earthquake Category Light Demage (Source : Survey, 2022)

There are three different types building framework of houses: stone houses, wooden houses, and other houses (which are not made of stone or wood). 163 houses made up

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stone, 56 houses made up wooden and the other 21 houses made up of non-wooden or stone structures. According to data, stone houses, which are made of sturdy materials, make up the bulk of earthquake-affected houses. However, these houses are not able to withstand the seismic shocks that harm residential structures.

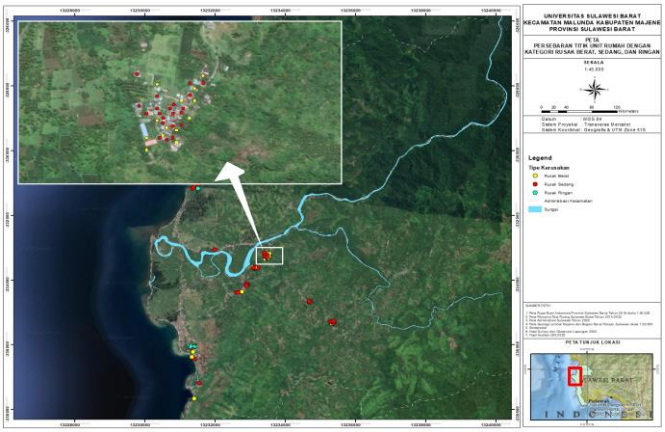

Figure 4. Map Distribution of House Unit Points with Categories of Heavy, Medium and Light Damage

B. Housing Zoning of Earthquake-Prone Areas

According to Presidential Instruction No. 10 of 2018, areas that are susceptible to earthquakes and tsunamis must have a zone of disaster-prone territory. The fault radius is one of the elements utilized to pinpoint these zones. The zone division is divided into four groups: development zones, conditional zones, restricted zones, and forbidden zones. The specifications or definitions for each zone are shown in the table below:

Table 1.
Criteria for Disaster-Prone Zones

Zona	Definisi/Kriteria
Forbidden Zone	• Active Fault Boundary Zone 0-10 meters • Zone prone to high ground movement after the earthquake
Restricted Zone	• 10-50 meter Active Fault Boundary Zone • Zone prone to high ground movement after the earthquake
Conditional Zone	• 50-100 meter Active Fault Boundary Zone • Zone prone to medium ground motion after the earthquake
Development Zone	• Active Fault Boundary Zone >100 meters • Zone prone to very low ground motion after the earthquake

Source: Ministry of ATR BPN's explanation on the Presidential Instruction No. 10 Years 2018

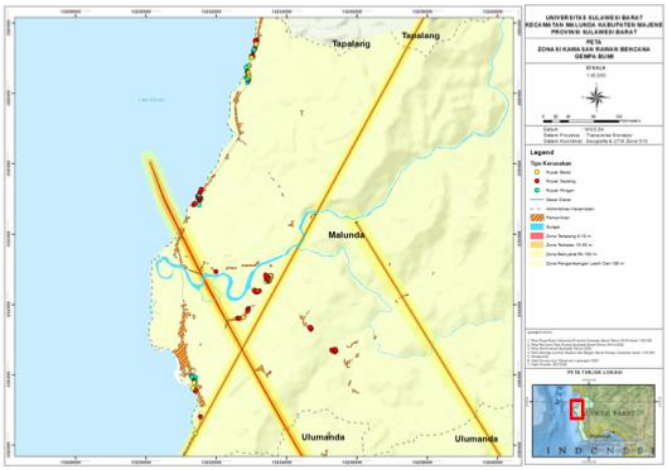

Figure 5. Zoning Map of Disaster Prone Areas

The majority of the housing and settlement areas are in the development zone, more particularly, the active fault border zone >100 meters away from the zone with the lowest earthquake ground movement susceptibility, according to the application of disaster-prone zones to the research area's map. Based on this, residential construction development is taking place in an area that is secure for habitations and settlements. According to the facts on the ground, the amount of damage to residential houses in disaster-prone areas in the development zone is very large, falling into the heavy and moderate damage categories. It was required to undertake measures to enforce standards or recommendations connected to earthquake-resistant buildings in order to limit the damage that the earthquake caused to homes. This explains why residential buildings sustained damage after the earthquake since the building's structure did not exceed the requirements for earthquake-resistant structures.

C. Policy Strategy for Post-Earthquake Housing and Settlement Development

The primary cause of the extremely high level of residential property damage, especially in the category of moderate and heavy damage, is the construction of housing and settlements without paying attention to the application of regulations or guidelines related to earthquake-resistant buildings. These facts demonstrate the need for sound housing and settlement policy efforts, especially to decrease the amount of damage done by the earthquake to residential buildings that did not meet the standards for earthquake-resistant construction.

By considering the above, it is important to pay attention to the technical guidelines for earthquake-resistant buildings, which refer to SNI 1762 regarding Procedures for Planning Earthquake Resistance for Buildings, SNI 2847 regarding Procedures for Planning Concrete Structures for Buildings, RSNI 2003 regarding Procedures for Planning for Indonesian Timber Construction, SNI 1729 regarding Procedures for Planning Steel Structures for Buildings, and SNI 6816 concerning Concerning Concerns for Buildings.

In light of the previous explanation, the following are a few housing and settlement development strategies that can be created:

1. In order to meet the technical requirements for earthquake-resistant constructions, new shelters and renovated homes must be fortified.
2. Technical guidelines for earthquake-resistant constructions must be extensively disseminated to the general population in order to reduce the danger of home damage. This will guarantee that all residential buildings can withstand earthquakes.

VI. CONCLUSION

The status of house damage is in the modare and heavy category, according to the findings of the conversation and the discussion in the previous description. This demonstrates that, in addition to the distribution of houses that were destroyed by the earthquake, the influence of the earthquake on the damage to houses or community dwellings is very significant. It is vital to adopt extensive remedies in the earthquake-affected areas because earthquakes happen seldom, indicating that all locations have equal levels of damage. Residential buildings structures do not adhere to earthquake-resistant building requirements, which results in damage to residential buildings that falls into the high category.

In light of the foregoing, the following is the appropriate housing and settlement development policy strategy, particularly to minimize damage to residential houses following an earthquake that occurred in residential units of buildings that did not comply with earthquake-resistant building standards:

1. New shelters and redeveloped dwellings must be strengthened in compliance with the technical standards for earthquake-resistant structures.
2. To lower the risk of home damage, technical recommendations for earthquake-resistant buildings must be widely communicated to the general public. This will ensure that all residential buildings can survive earthquakes.

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