



## Review of Zoning Regulations for Seismic Area on the Southwest Coast of Sumatra, Indonesia

Akhmad<sup>1</sup>; Sinung Mufti Hangabei<sup>2</sup>

<sup>1</sup>Faculty of Law, Universitas Bengkulu

<sup>2</sup>Faculty of Law, Universitas Muhammadiyah Bengkulu

Corresponding author's email: [amuslih@unib.ac.id](mailto:amuslih@unib.ac.id)

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### Abstract

The Indonesian region is one of the countries with high seismicity because it is located on the Ring of Fire. This article describes and analyzes regulations regarding earthquake-prone areas on the southwest coast of Sumatra Island, especially in Bengkulu. Data related to earthquake and disaster was taken using the literature method from several previous research results and disaster reports from government agencies. The results of the study show that the potential for earthquake hazard is dominating Bengkulu City. Several policies and regulations regarding urban land use were issued, but they must be further aligned with the objective of earthquake disaster mitigation. Almost all areas are located in moderate seismic hazard areas, so general rules and parameters are needed for classification structures; this is a must to ensure that in the event of an earthquake, human life is protected. Detailed spatial plans and zoning regulations become important documents that can regulate spatial use in detail, accompanied by calculations related to the density and environmental conditions of the area given spatial provisions.

## I. Introduction

As explained in the Regulation of the National Disaster Management Agency Number 2 of 2012 concerning Disaster Risk Management, Indonesia has a threat of disasters, such as earthquakes; Tsunamis; Flood; Landslide; Volcanic eruptions; Extreme Waves and Abrasion; Extreme weather; Drought; Forest and Land Fires; Building and Housing Fires; Epidemics and Outbreaks of Disease; Failed Technology; and Social Conflict. Bengkulu is an area on the southwest coast of Sumatra which is very vulnerable to the threat of earthquakes. One way to reduce the impact of earthquakes is to analyze potential based on microtremor data and statistical weighting methods to analyze the potential based on microtremor data (Hadi et al.,2021)

Indonesia has made global headlines on several occasions, especially over the past 20 years, due to devastating natural disasters, especially earthquakes which have caused heavy loss of life and property. It has also been found that earthquakes are the most significant threat in terms of natural disasters in the country. Indonesia is one of the countries with high seismicity in the world because it is located on the Ring of Fire. Seismic waves are usually generated by plate tectonics, active faulting and shallow backgrounds, so engineering structures in the country must be designed with seismic forces in mind. However, every time an earthquake occurs, several buildings in the affected zone usually suffer significant damage or even collapse, resulting in loss of life, disruption of public services, and expenditure of billions of rupiah in rehabilitation and reconstruction ([Nugroho et al., 2022](#)).

Junior Researcher at the Bengkulu-Kapahiang Meteorology, Climatology and Geophysics Agency (BMKG), Sabar Ardiansyah, said the damage caused by the 2007 Bengkulu-Mentawai earthquake was not as bad as in 2000 because the 2000 earthquake destroyed tens of thousands of buildings and killed 94 residents. Then what should be watched out for is the potential for a large earthquake that is still stored on the west coast of Sumatra. Especially in the waters of Simeulue (Aceh), Mentawai and Siberut (West Sumatra), and Enggano (Bengkulu) to the west of Lampung. The government of Bengkulu city must respond to disasters by making clear spatial guidelines and building structures in earthquake-prone areas while ensuring the functioning of monitoring equipment networks, such as GPS and seismometers. Likewise survey activities and mapping of active faults and fracture zones must be carried out; the most important thing is outreach to the community ([Supardi, 2019](#)).

Bengkulu City is the capital city of Bengkulu Province which is located adjacent to the subduction zone between the Indo-Australian and Eurasian plates. This area is also bordered by the large Sumatran fault, there are Musi fault and Manna section ([PusatStudi Gempa Nasional, 2017](#)). In many cases, government institutions do not consider traditional land use in community areas in their spatial planning policies ([Sulistiyawan et al., 2018](#)).

Based on the provisions of Article 76 Letter b Regional Regulation of Bengkulu Province Number 2 of 2012 concerning the Regional Spatial Plan (Rencana Tata Ruang Wilayah - RTRW) of Bengkulu Province for 2012-2032, which states "development of residential areas that have been built in areas that are geologically protected and prone to natural disasters must be limited and stipulate building codes (building code) under potential hazards/natural disasters, and equipped with evacuation routes".

There are several policies and regulations on urban land use in Indonesia, but these need to be more cohesive in terms of their objectives. It is not surprising that these regulations and policies are inefficient, inconsistent, and sometimes even conflicting ([Firman, 2004](#)). Land use decision-making is basically a multilevel process ([Myers et al., 2015](#)). Regional Spatial Planning Policy is a legal umbrella in regional development. However, these policies are sometimes based on other things other than the actual conditions on the ground, so that they are out of sync with the directions for spatial use.

In addition, they stipulate building regulations to realize orderly building governance that ensures the technical reliability of buildings in terms of safety, health, and comfort. Sjoerd Nienhuys, in his report, states that Indonesia uses a model code that was developed together with building regulations by the government. National regulatory systems are the most common among APEC economies, with variations in the degree of freedom of local (local) governments to modify, adopt, and enforce regulations. In China and Indonesia, the central government develops rules and codes of conduct, and local governments are free to adopt or reject these codes and regulations. In Chile, Chinese Taipei, Japan, Korea, Peru, and Vietnam, local governments have little or no authority to change codes and regulations ([Nienhuys, 2017](#)).

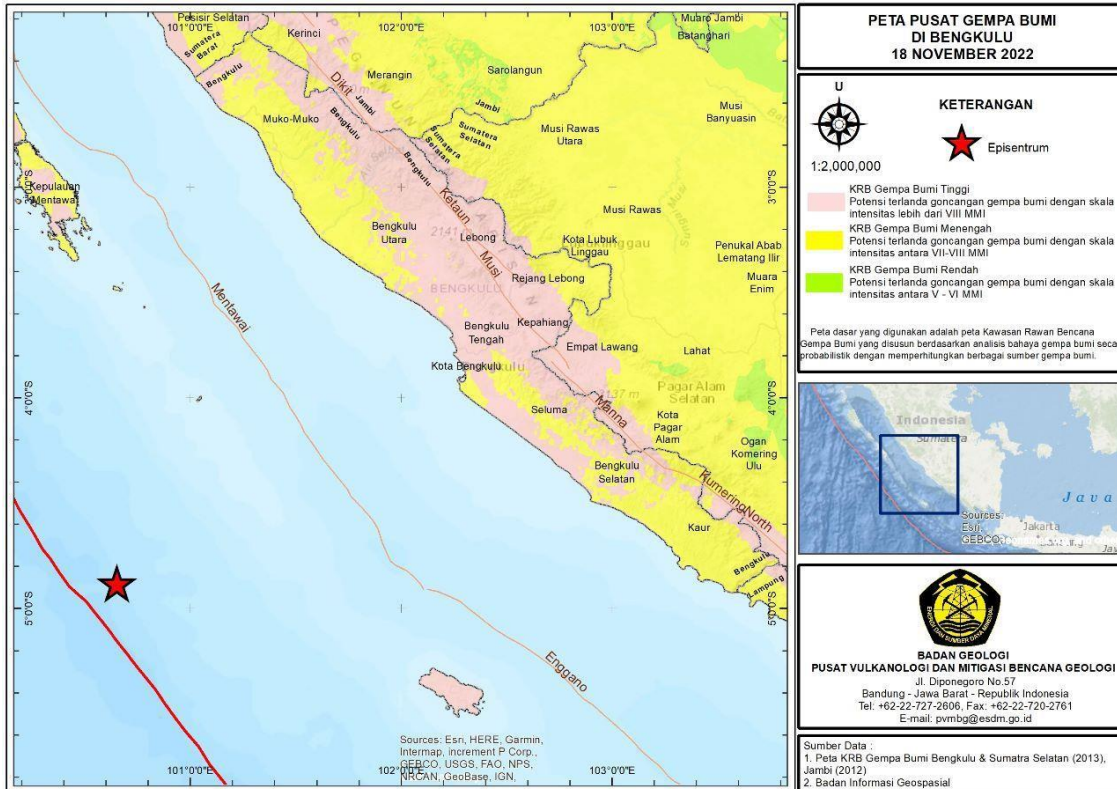
The author uses a literature and statutory approach to describe and study regulatory policies for the development of earthquake-prone areas. Earthquake and disaster data are taken using the library method from several previous research results, as well as disaster reports from government agencies that have the authority to submit disaster data, such as the National Disaster Management Agency, the Meteorology, Climatology and Geophysics Agency. As well as related agencies in disaster studies. Data regarding statutory regulations can be accessed through the official websites of the Regional Government of Bengkulu Province, the Regional Government of Bengkulu City, and other state institutions. With a critical review of the regulations studied, regulatory policies for the development of earthquake-prone areas are analyzed and concluded as a form of spatial planning that is more comprehensive and can be implemented effectively in realizing safe, comfortable, productive and sustainable spatial planning.

## **II. Earthquake Vulnerability in Bengkulu City**

Earthquakes frequently hit Bengkulu Province. The major earthquake that hit the Bengkulu region was first recorded in 1833 with a magnitude of 8.8 MAG. The vibrations were felt as far as Palembang, Singapore, and Malaysia, which were ten major world earthquakes in the 19th century, then in 1914 with an epicenter of 4.50 LS-102.50E with a depth of 33 KM and a magnitude of 7 MAG. In 1940 the strength was almost 8 MAG, and in 1980, the power was nearly 8 MAG. The 5th earthquake in 2000, with a magnitude of 8 on the Richter scale, was the biggest disaster ever; the most significant impact was felt by residents on Enggano Island, where buildings collapsed. In 2000,

the aftershocks lasted for three weeks from the main earthquake that occurred. And in 2007, the earthquake reached a magnitude of 7.9 on the Richter scale. In 2007 the earthquake occurred 61 times (Bengkulu Climatology Station, 2008).

**Figure 1.** Earthquake Center Map in Bengkulu 18 November 2022 ([Badan Geologi Pusat Vulkanologi dan Mitigasi Bencana Geologi, 2022](#))



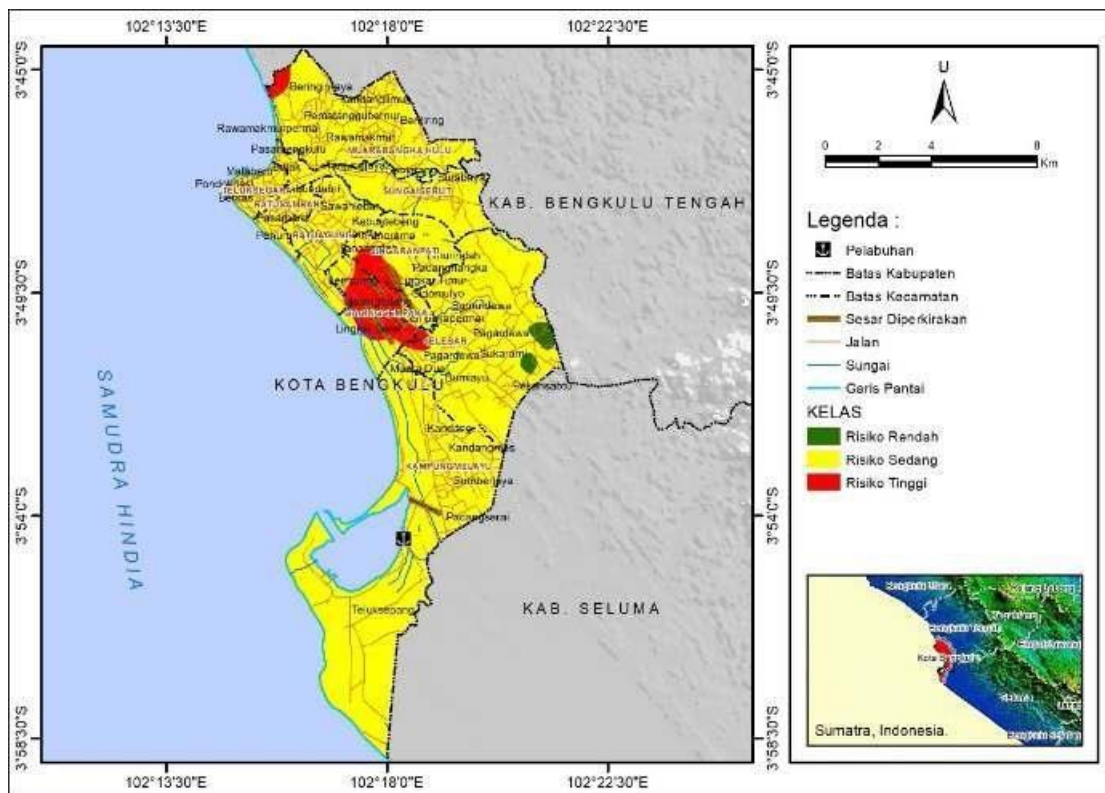
*Source:* <https://vsi.esdm.go.id/index.php/gempabumi-a-tsunami/kejadian-gempabumi-a-tsunami/4019-analisis-geologi-kejadian-gempa-bumi-di-provinsi-bengkulu-tanggal-18-november-2022>, 20 Dec 2022

Based on the earthquake hazard potential map (Figure 1), the level of risk of an earthquake threat in Bengkulu City, Bengkulu Province is divided into three classes, namely low risk, medium risk and high risk. Bengkulu City is dominated by medium-risk earthquake-prone areas, and only a small portion of low-risk earthquake hazards is located to the east of the center of Bengkulu City, while the high-risk threats are located in the middle of the study site and to the northwest of the center of Bengkulu City ([Hadi et al., 2021](#)).

Figure 2 explains that the very high intensity level of earthquakes that occurred in Bengkulu caused the Bengkulu region to often experience natural disasters, especially earthquake disasters, so action was needed in the form of dissemination of disaster mitigation in understanding regional disasters ([Citra et al., 2020](#)).



**Figure 2.** Map of potential earthquake vulnerability in Bengkulu City, Bengkulu Province based on microtremor data and the *Analytical Hierarchy Process method* (Hadi et al., 2021)



Source: <https://ppjp.ulm.ac.id/journal/index.php/f/article/view/9479/7276>

### III. Zoning Regulation in Bengkulu City

Related to Spatial Planning, spatial planning arrangements are needed that are more comprehensive and can be implemented more effectively in realizing safe and comfortable spatial planning (Niravita & Wahanisa, 2019). The Government formulates and implements policies and technical standardization in the field of spatial planning in accordance with laws and regulations. In addition, the regulation of activities in disaster-prone areas with spatial plans to anticipate development and activities around disaster-prone areas or areas is still growing. In applying its zoning regulation still need time for this zoning regulation to become more known to the public and local Government (Korlena et al., 2010).

In every preparation of the Spatial Plan, at least four things must be considered, there are: (1) population and society; (2) economy; (3) environment, and (4) technology (Direktorat Jenderal Tata Ruang Kementerian Agraria dan Tata Ruang, 2022). In the social sector, population numbers and future population projections affect many things, including providing housing and other facilities (schools, markets, hospitals). Regarding the economy, each region has different economic potential. The development of various economic prospects has different

infrastructure needs. In the environmental sector, development is expected to be more planned so that environmental conditions can be better maintained. In addition, it should always be remembered that Indonesia is located in the *Ring of Fire* area, so each region has different disaster characteristics. Therefore, additional disaster mitigation is required for different types of disasters. In terms of technology, spatial planning pays attention to technological developments in the sense of causing changes in human behavior and mobility in the regions or areas.

Zoning regulations are a set of rules on a block scale that are commonly used in developed countries because existing regional spatial patterns are based on regional block development patterns (Pratama & Shita, 2021). This condition is different from Indonesia because of its diverse geographical environment, so that the zoning regulations must be adapted to the needs of developing spatial patterns which generally use administrative delineations.

Zoning regulations consist of basic rules and techniques. Basic rules are mandatory material that must be provided in the document planning process, while zoning management techniques are optional material that is not mandatory or can be attached if needed. This is following Ministry of Agrarian Affairs and Spatial Planning/National Land Agency Regulation Number 11 of 2021 concerning Procedures for Compiling, Reviewing, Revision, and Issuing Substance Approval of Provincial, Regency, City and RDTR Substances. There is a difference in the zoning regulation content based on the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency Regulation Number 16 of 2018 and Ministry of Agrarian Affairs and Spatial Planning/National Land Agency Regulation Number 11 of 2021 (Pratama & Shita, 2021).

Law Number 26 of 2007 concerning Spatial Planning mandates that every spatial planning arrangement, whether at the national, provincial, or district/city levels, must pay attention to the carrying capacity of the environment. The aims to guarantee the preservation and continuity of human life and pay attention to the interests of future generations.

The essential policies related to the environment's carrying capacity in spatial planning include establishing protected areas and cultivation areas. Referring to the provisions of the Elucidation of Article 5 paragraph (2) letter d Law 26 of 2007 concerning Spatial Planning, protected areas include: areas prone to natural disasters, including areas prone to volcanic eruptions, areas prone to earthquakes, areas prone to landslides, areas prone to tides, and areas prone to flooding.

Zoning is derived from the word "zone", which means part of an area that is separate from other areas based on the type of land use or allotment. The use of Zoning in urban planning is intended as a legal regulation in the use of land as an effort to maintain order to protect the community and support the necessities of life in urban areas. Zoning regulations also contain provisions for the use, ownership, and determination of building coverage boundaries within urban space (city land) (Catanese & Snyder, 1988; Wahyuningtyas & Utami, 2015). Additional devices are needed as development control instruments that can not be applied with spatial plans (Dwinanto, 2006)

The function of area management and building regulation aimed to implement a just and prosperous society that evenly distributed materially and spiritually. This function aimed at administrative and technical supervision of buildings. In considering Law Number 28 of 2002 concerning Buildings, it is explained that facilities are essential for humans to carry out their activities to achieve various goals that support the realization of national development goals. Arrangements regarding buildings and areas were tried to be harmonized in Bengkulu Province Regional Regulation Number: 02 of 2012 concerning the Regional Spatial Plan of Bengkulu Province for 2012-2032, in preamble considering number 2 it was stated, that the development of development, especially the use of space in the Bengkulu Province is organized to improve the welfare of the community through the utilization of potential natural resources, man-made resources, and human resources while taking into account the carrying capacity, capacity, and environmental sustainability.

Spatial pattern plans, based on the provisions of Article 33 of the Bengkulu Province Regional Regulation Number 02 of 2012, two categories are determined, there are protected area spatial patterns; and patterns of cultivated areas. Areas prone to natural disasters fall into protected areas (Article 34 letter f), but Article 35 paragraph (6) does not mention that earthquakes fall into the category of natural disaster-prone areas, as described below, "Disaster-Prone Areas as referred to in Article 34 letter f consist of areas that frequently and have a high potential to experience natural disasters, such as fires Forest (Seluma Regency, Kaur Regency, North Bengkulu Regency, Mukomuko Regency, Lebong Regency, and Central Bengkulu Regency), floods (spread in Bengkulu City, Mukomuko Regency, Seluma Regency, and Kaur Regency)."

Areas prone to natural disasters in the provisions of earthquake natural disasters, are regulated in Article 34 letter e concerning geological protected areas and Article 56 concerning spatial use in the framework of realizing spatial patterns. In the provisions of Article 35 paragraph (5) it is stated, the geological protected area as referred to in Article 34 letter e consists of Landslide areas (Lebong Regency, Rejang Lebong Regency, Kepahiang Regency, Seluma Regency and Kaur Regency), Earthquake, Tsunami and Waves High tide (along the coast of Bengkulu Province); Volcano (Rejang Lebong Regency).

The protected area management plan along the coast of Bengkulu Province, including the Bengkulu City area with densely populated settlements in 3 (three) sub-districts, namely Teluk Segara sub-district, Ratu Samban sub-district, and Ratu Agung sub-district, is an area included in a geological protected area. It has a high level of earthquake vulnerability coupled with a relatively high post-earthquake tsunami potential.

Based on the results of Arif Ismul Hadi's research, areas that have the potential to experience earthquakes are mapped based on microtremor data and the Analytical Hierarchy Process method in Bengkulu City, Bengkulu Province. In general, the dominant threat potential in the region is in the medium risk category, followed by the high risk category and then the low risk category. However, the high risk category is not dominant. High-risk areas are in Gading Cempaka District, Singaranpati District, Selebar District, a small part of Ratu Agung District, and Muara Bangkahulu District. Low-risk areas are only found in Selebar District, while other areas have moderate potential ([Hadi et al., 2021](#)).

The preparation of spatial plans forms the basis for the rehabilitation and reconstruction of settlements in handling potential natural disasters such as earthquakes, tsunamis and tidal waves. Zoning arrangements are another provision from conventional zoning that were developed to provide flexibility in the application of zoning rules and are intended to overcome various problems in applying basic zoning rules, taking into account the contextual conditions of the area and the direction of the spatial plan. Zoning regulation techniques can be in the form of transfer of development rights (TDR), bonus zoning, conditional use, and others. The application of zoning regulation techniques can be carried out as needed. Cadwallader stated that the government's role in managing cities and regions can be realized through various activities and policies, among others ([Cadwallader, 1985](#)):

- a. Suppliers of public goods and services;
- b. Regulating and facilitating the running of a market economy in order to create the best allocation of resources;
- c. As social engineering in directing society to achieve the goals or values desired by the nation and state. The allocation of resources is left to the market, but the government is obliged to correct socio-economic imbalances and protect the weak and minority economic groups;
- d. As an abiliter in conflicts between community groups

There are seven principles in planning and designing for tsunamis as referred to in the National Tsunami Hazard Mitigation Program NOAA, USGS, FEMA, NSF, Alaska, California, Hawaii, Oregon, and Washington, namely the principle of recognizing tsunami risk, danger, helplessness, and damage; avoiding new construction in tsunami-affected areas to reduce future casualties; arranging for new development in tsunami-affected areas to reduce future casualties; design and build new buildings to reduce damage; protect already underway development from tsunami losses through rebuilding,



planning and land reuse projects; take special precautions to locate and design critical infrastructure and facilities to reduce damage; evacuation planning ([National Tsunami Hazard Mitigation Steering Committee, 2001](#)).

The criteria in this principle determine that zoning regulations and building codes are essential tools in disaster management policies, especially the earthquake and tsunami in the Bengkulu City area. Law Number 28 of 2002, in the elucidation section, states that buildings are a form of physical use of space. Therefore, in the regulation of buildings, they still refer to spatial planning arrangements following applicable laws and regulations. In order to guarantee legal certainty and order in the management of buildings, each building must meet the administrative and technical requirements of the building and be managed in an orderly manner. Even if regulations did not explicitly formulate order as an aesthetic ideal, they did perform create regularity, standardization, and structure ([Colombijn & Coté, 2015](#)).

#### **IV. Buiding Codes of Preventive Measures for Fictims of the Earthquake**

In order to realize an orderly building code that guarantees the technical reliability of the building in terms of safety, health, comfort and convenience, several provisions in the KPI, IRC and KIEBC are intended so that the structure can adequately withstand earthquake forces when an earthquake occurs. . These seismic provisions are the best available guide on how facilities should be designed and constructed to limit seismic risk ([Federal Emergency Management Agency, 2022](#)).

The seismic code in Spain is called "*Norma de Construcción Sismorresistente*" The first Mexico City building code was issued in 1942; since 1966, it has contained a complete set of regulations for structural design and has served as a reference for municipalities across the country. 1976 the code adopted a coherent format for all materials and structural systems based on limit states design philosophy. In February 2004, a new set of seismic codes was issued ([Ordaz & Meli, 2004](#)). In Indonesia, there are no special regulations regarding earthquake-resistant buildings. Several regulations, particularly specifications regarding facilities, require building structure standards against the effects of earthquakes.

Based on the provisions of Article 29 of Government Regulation of the Republic of Indonesia Number 16 of 2021 concerning Regulations for Implementing Law Number 28 of 2002 concerning Buildings that:

- (1) Provisions on the capacity of Buildings to load loads as referred to in Article 28 paragraph (2) letter a include technical provisions concerning:
  - a. provisions for the building structure system;
  - b. loading provisions on the building structure;
  - c. provisions on structural and construction materials; and
  - d. provisions on the feasibility of the function of the building structure.

- (2) Building structures must be planned to be strong, stable and meet *serviceability requirements* in carrying loads for the planned service life taking into account building functions, location, durability and ease of construction.
- (3) Technical provisions regarding the building structure system standards as referred to in paragraph (1) letter a include:
  - a. building superstructures; and
  - b. the lower structure of the building.
- (4) The provisions for loading on the building structure as referred in paragraph (1) letter b take into account the ability of the structure to carry loads that may work during the service life of the structure.
- (5) In addition, to the load effect as referred in paragraph (4), structural planning takes into account the effects of corrosion, fungus and destructive insects so that the structure can reach its service life.
- (6) In planning the structure of a building against the effects of an earthquake, the structure of a building must take into account the effects of the planned earthquake in accordance with the level of earthquake risk and the level of structural performance.

Referring to the provisions of Article 2 of Law Number 28 of 2002 concerning Buildings that buildings are managed based on the principles of benefit, safety, balance, and harmony between buildings and their environment. In the explanation of the law, it is explained that:

1. The principle of expediency is used as a foundation, so that buildings can be realized and implemented in accordance with their assigned functions, as well as as a forum for human activities that fulfill just human values, including aspects of decency and appropriateness.
2. The principle of safety is used as the foundation for buildings to meet building requirements, namely technical reliability requirements to guarantee the safety of building owners and users, as well as the surrounding community and environment, in addition to administrative requirements.
3. The principle of balance is used as a foundation so that the existence of sustainable buildings does not disturb the balance of the ecosystem and the environment around the buildings.
4. The principle of harmony is used as a basis so that building management can create harmony and harmony between the building and the surrounding environment.

Article 18 (1) Law Number 28 of 2002 concerning in the buildings requires that the ability of a stable and robust building structure to support the load, as referred to Article 17 paragraph (2), is the ability of a durable and strong building structure to the top condition loading to support live loads and dead loads, as well as for specific areas/ zones is ability to support loads arising from natural behavior. (2) The amount of load is calculated based on the function of the building at maximum loading conditions and

variations in loading so that in the event of a collapse, the building occupants can still save themselves. (3) Provisions regarding loading, resistance to earthquakes and winds, as referred to paragraph (1) and paragraph (2), are further regulated by Government Regulation.

Criteria regarding the Building Code, in Article 57 paragraph (3) Government Regulation of the Republic of Indonesia Number 16 of 2021 in terms of Prototype Design Provisions, it is explained that "In preparing the prototype design as referred to paragraph (2), Ministries/agencies, Regional Governments, or Society must be based on: a. fulfillment of Technical Standards; b. fulfillment of basic provisions on earthquake resistance; c. consideration of geological and geographical conditions; d. review of the availability of building materials; e. fulfillment of design criteria in accordance with development needs; and f. consideration of ease of construction implementation.

Based on the provisions of the Bengkulu City Regional Regulation Number 1 of 2022 concerning Retribution for Building Approvals in the preamble it is stated that in order to comply with the provisions of Article 347 paragraph (2) Government Regulation Number 16 of 2021 concerning Regulations for Implementing Law Number 28 of 2002 concerning Buildings, it is necessary stipulate a Regional Regulation concerning Retribution for Building Approvals.

Implementation regarding the Building Approval, as referred to in Article 1 point 7, is described that the Building Approval, hereinafter referred to as the Building Approval, is a permit granted to the building owner to build a new building, change, expand, reduce, and maintain the facility under Building technical standards.

Article 252 paragraph (4) of Government Regulation Number 16 of 2021 explained about regarding the technical specifications or technical planning of Buildings, which reads: In the case of a Building in the form of a single 1 (one) floor residence with a maximum floor area of 72 m<sup>2</sup> (seventy two meters square) and Buildings in the form of 2 (two) floors single dwelling houses with a maximum floor area of 90 m<sup>2</sup> (ninety square meters), technical plan documents can be provided by the Applicant himself with the following conditions:

- a. uses the basic provisions of earthquake resistance;
- b. using building prototype/prototype design; or c. planned by the planning service provider.

The disaster management policy is regulated technically in Government Regulation Number 16 of 2021, in the Bengkulu City Regional Regulation Number 1 of 2022 following the technical planning for technical buildings in the provisions of Article 252 paragraph (4). This is stated in Article 3 paragraph (1) to paragraph (4) of Bengkulu City Regional Regulation Number 1 of 2022, namely:

- (1) The object of Retribution as referred to Article 2 is the issuance of Building Approvals and Certificates of Functionality.

- (2) Issuance of Building Approvals and Certificates of Functionality as referred to paragraph (1) includes consulting services for compliance with technical standards, issuance of Building Approvals, inspections of buildings, issuance of Certificates of Functionality and Proof of Building Ownership, as well as printing of certificates Eligible Function.
- (3) Issuance of Building Approval and Certificate of Eligible Function is given for application for approval of: a. new development; b. Buildings that have been constructed but do not yet have building approvals and/or certificates of proper function; c. Approval of building changes for: 1. changes in building function; 2. changes in building the layers; 3. changes in building area; 4. changes in the appearance of buildings; 5. changes in specifications and dimensions of components in Buildings that affect safety and/or health aspects; 6. Strengthening Buildings against medium or heavy damage levels; 7. protection and/or development of cultural heritage buildings; or 8. repair of buildings located in cultural heritage areas.
- (4) Approval of building changes are not required for maintenance work and maintenance work.

## V. Disaster-Based Spatial Planning Policy Strategy

As understood in the provisions of laws and regulations, Spatial Pattern is the distribution of spatial allotment in an area which includes the allocation of space for the protection function and the allocation of space for the cultivation function. This condition follows the proper direction of national development policies following the provisions of laws and regulations. The accuracy of development and spatial planning policies is measured from the development towards the suitability and optimization of the potential of natural, human, and physical (artificial) resources, as well as the particular strategies are needed for disaster-prone areas. Development policies that are not based on the potential of these resources will be challenging to say as sustainable development ([Budigusdian, 2012](#)). Ineffective development also can be experienced if the aspect of human resources as part of the social aspect is not considered. Traditional values, technological capabilities, and human resource potential must be aligned with the pace of development.

Detailed spatial plans and zoning regulations become essential documents that can regulate spatial use in detail, accompanied by calculations related to the density and environmental conditions of the area given the spatial provisions. In other words, zoning regulations are one of the essential instruments in controlling the use of space. These zoning regulations can serve as a reference for licensing, applying incentives/disincentives, maintaining space, serving as a bridge in preparing spatial plans that are operational, and can serve as a technical guide in land development/utilization.

The determination of disaster-based spatial planning or spatial planning is to provide zoning according to the scale or scope of areas likely to be affected by the earthquake followed by a tsunami. On the scale of the Bengkulu City area as a whole, a strategic step that can be taken is the development of a safe area zoning route followed by the development of activities in that route or area. In coastal areas, the settlements of people who make a living as fishermen can be maintained by structuring and planning regional



development that pays attention to aspects of safety against earthquakes and tsunamis in the development policies for the coastal areas of Bengkulu City. Planning for the development of breakwaters and tidal canals in residential areas along the coast. Disaster risk is the potential loss caused by a disaster in an area and a certain period of time which can be in the form of death, injury, illness, threatened life, loss of sense of security, displacement, damage or loss of property, and disturbance from community activities.

Integration and alignment of the direction of disaster management in a region requires a solid foundation for its implementation. This requirement is answered by a disaster risk assessment. Disaster risk assessment is a tool to assess the possibility and magnitude of losses due to existing threats. By knowing the potential and importance of losses, the focus of planning and integration of disaster management operations becomes more effective. It can be said that disaster risk assessment is the basis for ensuring alignment of direction and effectiveness of disaster management in an area (Regulation of the Head of the National Disaster Management Agency Number 02 of 2012 concerning General Guidelines for Risk Assessment, 2012).

If seen from the purpose of preparing the General Guidelines for Disaster Risk Assessment, it is intended to:

1. Provide sufficient guidelines for each region to assess the risks of each disaster in their area.
2. Optimize the implementation of disaster management in an area by focusing on treating several risk parameters on a clear and measurable basis.
3. Align the policy directions for the implementation of disaster management between the central, provincial, and district/city governments in a unified goal.

One of the ways to reduce the main risk factors for disasters is to apply indicators in settlement planning and management that contain elements of disaster risk reduction, including enforcement of requirements and building permits for public safety and health (enforcement of building code).

There is no more important factor in reducing a community's risk from an earthquake than the adoption and enforcement of up-to-date building codes. Evaluating older buildings and retrofitting structural and non-structural components are also critical steps. To survive and remain resilient, communities should also strengthen their core infrastructure and necessary facilities to withstand an earthquake or other disaster and continue to provide essential services ([Federal Emergency Management Agency, 2022](#)). The characteristics of the coastal area of Bengkulu City are occupied by residents who mostly still rely on the sea as their livelihood. So, settlement management in the context of reducing disaster risk is urgently needed, especially in coastal areas (Figure 3).



One of the long-term mitigations is to prepare yourself by building houses that comply with earthquake-resistant regulations. With earthquake predictions that are difficult to predict, earthquake-resistant houses are an alternative to reduce the negative impact of earthquakes; where for small and medium earthquakes, earthquake-resistant houses still provide a sense of security, while for large earthquakes, they still provide an opportunity for residents to save themselves. By leaving the house, the house can still survive with less severe damage ([Supriani, 2009](#)).

Furthermore, Fepy Supriyani explained several activities that can be carried out in the building code implementation policy; In addition to setting rules, the government can carry out several activities, including preparing earthquake-resistant housing modules that can be understood by the general public, providing counseling to the public about the importance of understanding the principles of earthquake-resistant housing; Provide training to masons and supervisors; Suggested that the principles of earthquake-resistant houses should be a guideline and followed when residents are going to build/renovate a house; The government must play an active role by continuing to remind the public of earthquake mitigation by continuously conducting good socialization with posters, banners, simulations, and counseling ([Supriani, 2009](#)).

## VI. Conclusion

It is important to establish zoning regulations to control the development and operationalization of spatial plans in disaster management and mitigation both in regional growth and development as well as in formulating disaster policies. The next strengthening of disaster mitigation is establishing building codes in construction and determining specifications for new building structures and building repairs. In Bengkulu City, almost all sections are in moderate seismic hazard areas, so general rules and parameters are needed for the classification structure; this is a must to ensure that in the event of an earthquake, provide for and follow up on aftershocks and tsunamis, human life is protected, damage to buildings is minimal. Establishment of regulations regarding this matter is urgently needed as part of disaster mitigation policies.

## VII. Acknowledgments

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