Spatial plan based on disaster mitigation in the city of Mukomuko, Bengkulu

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Abstract: Many cities in Indonesia are located in area that is actually not safe from the threat of natural disasters, one of them is the city of Mukomuko in Bengkulu province. How should a settlement area be built in vulnerable city to natural disasters especially an earthquake and tsunami. This study is intended to provide an overview of what factors are considered in development based on disaster mitigation, one of which is through its spatial planning which categorizes zone in the study area. Research begins by understanding the location, character of the disaster that threat the location, mapping and finally producing prioritize spatial plans which respond to natural hazard and definitelly integrated with the spatial plan in the hierarchy above. The main objective is clearly creating a sustainable settlement area for the community.

Keywords : spatial planning, disaster mitigation, sustainable development

1. Introduction
As an archipelago country (17.058 islands) located in Pacific ‘Ring of Fire’ and is located at the confluence of three active tectonic plates of the world (Indo-Australian Plate, the Eurasian and Pacific), Indonesia has the potential to face a variety of Natural Disaster threats. Volcano eruptions and Earthquakes are familiar in Indonesia territory. Other natural disaster such as whirlwinds, extreme rain, floods, landslides and drought must also be faced by Indonesia since it has been in the tropic with its hydrology condition.

Figure 1. Natural disaster in Indonesia last 10 years
(image source : https://bnpb.go.id//home/sejarah, date accessed : 9 August 2019 )
Looking to Figure 1, it is actually not only natural disasters are as a threat, but also non-natural disasters often hit the country such as bushfires, social conflicts, and technological failures. As a country on ring of fire with about 129 active volcanoes and lies on three active tectonic plates, earthquake is a natural disaster that has potential to cause disaster. Moreover, since the growth of many settlements spread in various regions of the islands in Indonesia.

Refer to Indonesian National Board for Disaster Management, there have been earthquake : 115 times, tsunami : 4 and both of them : 1, since 2014 till August 2019 in Indonesia with varying strength. Seeing these adverse events, threats to natural hazards must be anticipated so that the impact of disasters can be minimized. How? one of them is development based on disaster mitigation. It is appropriate for Indonesia to be developed based on this aspect, to reduce the impact of disasters, especially for areas close to faults such as along the west coast of the Sumatra island that face the threat of earthquake and tsunami at any time. Nugroho [1] there are two efforts to mitigate tsunami, through structural measures and non-structural measures. Structural measures are technical efforts aimed to reduce tsunami wave energy that propagates to coastal areas, while non-structural measures involve adjustments and regulation of human activities, so that they are in line with structural mitigation measures and other efforts. Gaffar [2] focuses on the role of mangrove forests in the coastal area of Bengkulu city to minimize the tsunami wave and the design of buildings in the coastal area which has two functions, first is the main function of the building and second is the function as an evacuation site in the event of an earthquake which is then followed by a tsunami alert.

Mukomuko is one district on the west coast of the island of Sumatra, which is vulnerable to the threat of natural hazards, especially earthquakes and tsunami. Having a city named Mukomuko (the same name as the district) with urban activities that continue to grow, how will the settlement is being developed in this vulnerable area? Of course the settlement must be responsive to avoid major disaster if an earthquake and tsunami occur. This study took a case area in the city of Mukomuko, this area near the Mukomuko airport. At the time of this study (2018), this area already grew into a residential area (housing and cropland). In addition, another factor that should be considered is the presence of an airport that is nearby, where the actual settlement must also consider other hazards related to flight activities. Then the result of the study is a spatial plan that respond to natural and man made hazard in this location.

2. Methodology
This study is a further step of district and sub-district spatial plan that already made by the Government. Refer to the plan, the area around the airport is directed to become a subdivision of the city, planning is carried out at a more detailed and priority scale. In this study, the method used is to overlay basic data such as the physical character of the area (including disaster prone data) with existing spatial plan. Then from the results of the overlay, it can be identified which zone are high potential for disaster, moderate and low with the plan of its spatial function above. Then, each zone is analyzed to find out what strategies need to be taken in order to be able to respond to the threat of danger, especially earthquake and tsunami.

The data used consist of: primary and secondary data. Secondary data was acquired through map or documents that focus on such as: natural disaster especially earthquake and tsunami and spatial planning of Mukomuko. The physical characteristic of mukomuko is also overviewed. This data was gathered from different sources, such as government office, previous research and historical data. Whereas primary data were mainly taken from field surveys and interviews to confirm existing data with current conditions in the field.

3. Analysis and discussion
3.1 General description of Mukomuko City
The City of Mukomuko is the Capital of Mukomuko Regency in Bengkulu Province. This regency is northern part of Bengkulu and have border line with West Sumatra Province. Mukomuko Regency has an area of around 4,146.52 square kilometers
The city of Mukomuko is about 240 km distance from the city of Bengkulu (the capital of Bengkulu province). It takes about 6 hours by car from Mukomuko to capital city of Bengkulu, but if using a plane (ATR type), only takes 40 minutes. However, although the city of Mukomuko is near to border of West Sumatra Province, to reach Padang (the capital city of West Sumatra Province) is also far (about 240 km) and takes around 7 hours by car, but if using a plane is only 40 minutes. Location of Mukomuko is in the middle between the distance of two provincial capitals (Bengkulu and Padang).

Looking at the physical condition, the topography in the Mukomuko Regency area is basically divided into 2 categories. The first category is flat land, located in the western part that stretches from north to south (elevation varies between 16 - 160 m above sea level) on which the city of Mukomuko is located., and the second category is land that is hilly in the east with elevation above it.

Mukomuko City (in the Mukomuko City District) has an area of 227 km². In terms of land use, most of the land is plantations (owned by communities) and oil palm plantations. Actually, only a small part is a developed area (housing, commercial and service). Fortunately, the west side bordering the sea is still dominated by mangrove forest land. Mukomuko City has a population of 18,796 people (2016). If we look at the ratio between area and population, it can be said that this city has a low density because most of the land is still empty as plantations. But, as a capital city of Mukomuko Regency, a government office complex with various supporting facilities, housing and commercial areas has been established here. It's fortunate that Mukomuko also has an airport with a long runway 1.400 metres. Referring to the Mukomuko City Spatial Plan, the center of the city is directed to become a Government zone and a trade service with supporting facilities. While the airport which is located about 5 km from the city center and its surrounding is directed as a sub-section of the city which is directed to become a residential area, trade services and supporting facilities. On one hand, a settlement will keep growing but on the other hand, the location is on highly threat of disaster. This situation is potential to cause disaster. Purwana [3] state that disaster is a manifestation of the combination of danger (which was originally only potential) with humans (or other objects that concern human interests)

If we look at the plan, it is necessary to immediately make more spatial detail plan to regulate how the residential area and supporting facilities will be developed here, since it is located in a disaster-prone area (especially the earthquake and tsunami). This spatial detail plan is portion of Local Government. Mention that attention is focused on the local government level since at this level the detail spatial plan is formulated and the responses to disaster risks is sought at first [4].

3.2 Potential Disaster

Refer to Indonesian National Board for Disaster Management, Geographically, Indonesia is an archipelago located at the confluence of four tectonic plates, the Continent of Asia, the Continent of Australia, the plate of the Indian Ocean and the Pacific Ocean. In the south and east of Indonesia there is a volcanic arc that extends from Sumatra - Java - Nusa Tenggara - Sulawesi, whose sides are old volcanic mountains, and lowlands, and dominated by swamps. These conditions are very prone to disasters such as volcanic eruptions, earthquakes, tsunamis, floods and landslides.

The coastal areas in Indonesia are prone to tsunami disasters, especially the west coast of Sumatra, the southern coast of Java Island, the north and south coasts of the Nusa Tenggara islands, the islands
in Maluku, the north coast of Irian Jaya and almost the entire coast of Sulawesi. Maluku Sea is the most tsunami prone area.

In 2004, there was a megathrust earthquake that registered has a magnitude 8.9 SR. This earthquake was epicentre off the west coast of Northern Sumatra then followed by tsunami which devastated the city of Banda Aceh and several cities / villages on the west coast of Aceh province. This disaster claimed more than 200,000 lives. In the Mukomuko area, several earthquakes, some of which were recorded as quite strong, occurred in 2007 and 2016 which resulted in hundreds of houses being damaged.

The study area is located in the city of Mukomuko with an area of 30 ha. The location is right on the East side of the Mukomuko airport. When viewed from its position, it can be said that this area is the 'front' area if the tsunami occurs due to its location only about 1 km from coast line (tsunami waves in Aceh reach a distance of up to 6.5 km inland).

Moreover, there is another potential disaster threatened to this study area. The existence of Mukomuko Airport has the potential for disaster since the area is adjacent to the runway is growth become housing area. Although currently the Mukomuko airport can be categorized only as a small airport (runway length 1.400 m, and currently can only be landed by ATR type aircraft) but it still has a risk related to flight accidents.

The position of the city of Mukomuko, which is relatively far from other cities, makes the presence of this airport very helpful for people accessing / entering the city of Mukomuko rather using by car, but the airport can turn into a source of disaster if aviation accidents occur since the area around the airport is filled with housing. The potential for this disaster will increase, in line with the government's desire to expand the airport so that larger planes can land, so there is an opportunity for more and more aircraft to fly up and down every day. Therefore the area around the airport also needs to be regulated in relation to aviation/ flight safety factor. Both general physical characteristics and its potential disaster is actually to measure risk assessment. This assessment is mainly a determination based on scientific and technical findings [5]. Fortunately, local government already has this assessment represented in spatial planning include the map of vulnerability prone area. Then this map is become basic data in this study.

3.3 Analysis and Mitigation

Refer to some conditions mention above, basically there are 2 main issues relate to the study area:

- High potential natural hazard, especially earthquake and tsunami (natural hazard)
- The study area is directed become sub-city center dominated by housing, however, due to its location near the airport, the area has strict limitation relate to aviation safety regulation (man-made hazard)

![Figure 4. Area of Study in Limited Zone](image_url)
Scenario to respond Natural Hazard (Earthquake and Tsunami) relate to landuse:

A. Basically, the area that could potentially be affected by a tsunami is divided into three zones:
   (1) Protection Zone,
   (2) Limited Zone,
   (3) Development Zone

B. Refer to Ihsan [6], landuse in the protection zone can be a forest with a thickness of approximately 1,000 m.

Based on the distance, the study area is in the limited zone (Figure 4) and it is more than 1,000 m away from the shoreline. The land use is explained as follows:

| Table 1. The zone land use |
|---------------------------|
| Zone | Landuse (level 1) | Landuse (level 2) |
| --- | --- | --- |
| PROTECTION (High Risk Zone) | Conservation | Mangrove Forest |
|  | Agriculture | Plantation |
|  | Fish pond | Fish pond |
|  | Recreation | Recreation facilities |
|  | Evacuation Facilities | Elevated Shelter |
| LIMITED USE (Moderate Risk Zone) | Agriculture | Cropland, farm |
|  | Medium density housing | Settlement and support facilities |
|  | Commercial & Service | Shop, Stay Accomodation |
|  | Recreation | Recreation Facilities |
|  | Evacuation Facilities | Evacuation : Building, Shelter, |
|  | Housing (low – middle density) | |
| DEVELOPMENT (Low Risk Zone) | Public Facilities | Housing |
|  | Government Area | Public Service Building |
|  | Commercial Area | Government Building Complex |
|  | Education Facilities | Shopping building, market. |
|  | Industrial | School |
|  | Recreation | Factory, Industrial Estate |
|  | Evacuation Facilities | Recreation Facilities |
|  |  | Public Open Space, shelter evacuation |

C. Based on its natural disaster hazard characteristics, some strategies in the study area are:

| Table 2. The characteristics of natural hazard and the planning strategies |
|---------------------------|
| Hazard | Characteristics | Strategies |
| --- | --- | --- |
| Natural Earthquake | unpredictable | Earthquake resistant building |
|  |  | Provide Assembly Point |
|  |  | Low - Medium Density |
| Natural Tsunami | predictable | Alert system to give more time for people to evacuate |
|  |  | More Open space |
|  |  | Low – Medium Density |
|  |  | Building design |
The building is quite strong in construction
• Using the stilt building type, where the ground floor is left empty without walls (in the event of a tsunami, water waves can flow through the building)
• Building/house is detached building type
• Providing Evacuation Route
• Providing Vertical Shelter
• Conserv existing forest along the coast as a green 'Bufferzone'
• Conserv existing river/creek

D. Based on its man-made disaster hazard characteristics, strategy in the study area are:

Table 3. The characteristics of manmade hazard and the strategies

| Hazard Characteristics                  | Strategies                  |
|----------------------------------------|-----------------------------|
| Man-Made : Flight activities (Takeoff/Landing) | Adopt Flight Operation Safety Area Regulation |

The area around the airport is subject to building height regulation. This is set up to provide safety not only for the interests of aircraft landing/take off at the airport, but also for the people who live around the airport.

4. Conclusion
Planning in this study area is actually a spatial plan in priority areas and is more detailed in the existing spatial plan. This plan is based on disaster mitigation, especially earthquake and tsunami as the most natural hazards in this area.

Based on the overlay between the spatial map and disaster hazard map: Area of study is in limited zone, it means that a housing can still be built here but with several requirements such as medium Density and building type: detached building and if possible is stilt building. Settlement in this study area must be provided Open Space with an attainment radius of < 5 minutes walk/run (emergency situation), provided vertical shelter. Also provided by a clear Evacuation route and leads away from the shoreline. Moreover, related to man-made disaster hazard, the area should provide: Open space at area near both ends of the runway, plant here should have a height not exceed the provisions by Flight Operation Safety Area Regulation including buildings that are not only a certain distance along the runway but also around the airport.

5. References
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