The impact of disaster risk reduction information on the change of spatial pattern of Padang City

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Abstract. Padang City is disaster-prone area thanks to its location amongst four major tectonic plates of the world. As a disaster-prone area, both the central government and local governments keep attempting to reduce the disaster risk, which make people living in the West Coast Area of Padang City realize that they live in disaster prone areas. Spatial planning is important in disaster prone areas because it reduces of damage and victims when disaster strikes. This awareness not only brings positive impacts, but also the negative ones—one of which is the desire to move to a location they think safe. The objectives of the research is to analyze the influence of the desire to move the population in West Coastal area of Padang City that influence spatial planning, especially the spatial pattern contained in the 2010-2030 Padang City Spatial Plan (hereinafter called RTRW Kota Pandang 2010-2030). Data analysis techniques used to answer the objectives of the study is the overlay analysis of disaster-prone maps and the desire to move as well as the spatial pattern of Padang City. The results of the analysis show that: 1) The desire to move of people in the West Coastal Area of Padang City has the potential to change the spatial pattern of Padang City in RTRW Kota Pandang in 2010-2030; and 2) the location of new settlement that became the destination of the movement was prone to landslide, earthquake, and flood.

1. Introduction

Indonesia is one of the most disaster-prone countries in the world, regularly experiencing earthquakes, tsunamis, landslides, volcanic eruptions, flooding, and drought. Padang is one of the most disaster prone areas in Indonesia. Padang City is the capital of West Sumatra Province, located along the West Coastal Area of Sumatra Island. Geographically, geologically, and demographically Padang City is a disaster prone area because: 1) it is located at the meeting of four major tectonic plates of the world thus prone to earthquake and landslide disaster [1]; 2) it is located along the West Coast Coastal Area of Sumatra Island with 68,126 km of coastline with topography of ramps that are prone to tsunami disasters; and 3) the coastal areas are highly densely populated [2]. As a disaster prone area, the central government and local governments have undertaken DRR measures. They include the dissemination of tsunami prone maps, evacuation route maps, evacuation simulations, earthquake and tsunami alert letters and early warning systems, and others, which caused people realize that they live in disaster prone areas, especially earthquake and tsunami. However, many obstacles were found. It relates to capacity, resources, communication and coordination barrier due to sectoral ego [3].
The community awareness that they live in disaster prone areas, on the one hand, gives impacts of community capacity building on disaster especially on earthquake and tsunami disasters, yet on the other hand raises an excessive public concern. The excessive concerns of the population caused the resident to move to get the area in the residence they thought safe. It shows significant desire of people along the West Coast area of Padang City to move as a result of the increasing public awareness of tsunami and earthquake [4].

Spatial planning presumes to anticipate and prepare, make preparations, and plan for future land use development, for example related to city development, business areas, housing and communities. Indonesia spatial planning is the form of spatial structure and spatial pattern [5]. There are four possible roles of spatial planning for disaster risk reduction (hereinafter called DRR) are [6]: a) making differentiated decisions on land use; b) keeping areas free of development; c) following recommendations for legally binding land use or zoning plans; and d) undertaking hazard modification. It means that land use is one of the key elements for DRR. A large-scale population movement has the potential to change spatial pattern. Spatial pattern is the distribution of space allocation in one area that covers space allocation for conservation and cultivation (National Law of Spatial Management Number 26 year 2007). Changes in the spatial pattern will cause losses to the city government of Padang. This is because the spatial pattern is closely related to the development of supporting facilities and infrastructure that involves huge investment. This research will analyze the extent of the desire to move of the community in West Coastal Area of Padang City after the dissemination of DRR that involves the installation and dissemination of disaster prone maps, governor's circular on earthquake and tsunami disaster, and others that affect the spatial pattern as stated in the RTRW Kota Padang 2010-2030.

2. Method
The study area scope are seven sub-districts prone to tsunami disaster in Padang City [7]: Koto Tangah Sub-district, North Padang, Nanggalo, West Padang, South Padang, Lubuk Begalung, Bungus and Teluk Kabung Sub-district. The data collection techniques used are questionnaires, field observations, and documentation.

2.1 Sample and Population Determination
The population is the 527,308 residents in the seven districts of tsunami prone areas. The large number of population led to the research conducted on the sample. The number of samples determined by Isaac and Michael equation [8]. The sampling technique used is purposive sampling technique, with the criteria of the people living in the red zone on the Padang City Tsunami Hazard map made by Padang City Disaster Management Agency (hereinafter called BPBD Padang City) 2010. BPBD has the mandate and accountability of coordinating, planning and implementing any aspect of DRR [9].

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S = \frac{\lambda^2 N.P.Q}{d^2(N-1)+\lambda^2 P.Q}
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S = \frac{1^2 (527308)(0.5)(0.5)}{0.663^2 (527308-1)+1^2 (0.5)(0.5)} = 223\text{ respondents}
\]

2.2 Analysis Techniques
Overlay analysis techniques using GIS software used to identify the extent to which people's willingness to move that triggered by the fear of earthquake and tsunami disaster in the West Coastal Area of Padang City influences the changing of spatial pattern in RTRW Kota Padang 2010-2030. There are four potential big disasters in Padang City: earthquake, tsunami, landslide and flood [10]. Earthquake and tsunami disasters are the focus of research because the earthquake and tsunami are the greatest threats from other disasters. The high level of disaster risk in Padang City prompted both central and regional governments to prepare disaster risk reduction plans such as preparing Padang City plan of DRR, tsunami disaster map, tsunami evacuation plan, early warning, and so forth.
- Tsunami Hazard Map and Tsunami Evacuation Map. One of the DRR efforts are the creation of a disaster-prone area map prepared in 2010 by the BPBD of Padang City. The evacuation route map is one of the efforts of BPBD of Padang City in cooperation with Merci Corp., GTZ, Indonesian Red Cross, Volunteer Corps unit in reducing the risk of tsunami disaster in 2010.
- Simulation and Early Warning System. Padang City works with NGOs, academics, communities and others to develop community-based early warning systems. BPBD of Padang City periodically conducts disaster evacuation simulation so that people can evacuate according to planned evacuation route properly and correctly to minimize the number of casualties.
- West Sumatera Governor's Letter on Earthquake and Tsunami. The circulation of West Sumatra Governor's letter, published by several mass media in April 2012, made people in West Coast of Padang City feel afraid and anxious. Some people reactively desired to move. Earthquake disasters are different from such other disasters as floods, landslides and erupted volcanoes that can predict to occur, which causes people to become more anxious.

In this research, map overlay analysis used to create disaster potential map based on fault map, landslide map, tsunami prone map and flood prone map in Padang City. Figure 1 shows disaster-prone areas in Padang City, showing that almost 70% of the area is prone to disaster. Table 1 and Figure 1 show that the greatest disaster potential in Padang City is earthquake with 95,31 km² spreading in Bungus Teluk Kabung Sub-district, Lubuk Kilangan, Kuranji, Pauh, Nanggalo and Koto Tangah Sub-district. While the lowest disaster potential is landslide disaster that is 35,34 km² spreading in South Padang City Sub-district, Bungus Teluk Kabung, Lubuk Begalung, and Pauh Sub-district.

![Figure 1. Map of Potential Disaster of Padang City](image)
| Disaster Potential | Regional Distribution                                                                 | Coverage (km²) |
|--------------------|----------------------------------------------------------------------------------------|----------------|
| Tsunami            | Koto Tangah Sub-district, North Padang, Nanggalo, West Padang, South Padang, Lubuk Begalung and Bungus Teluk Kabung Sub-district. | 75.31          |
| Flood              | Koto Tangah Sub-district, Nanggalo, North Padang, West Padang, East Padang, Kuranji, Lubuk Begalung and Kec. Bungus Teluk Kabung Sub-district. | 57.22          |
| Landslide          | South Padan Sub-district, Bungus Teluk Kabung, Lubuk Begalung, Kuranji and Pauh Sub-district. | 35.34          |
| Earthquake         | Bungus Teluk Kabung Sub-district, Lubuk Kilangan, Kuranji, Pauh, Nanggalo, and Koto Tangah Sub-district. | 95.91          |

*Source: [12]*

3. Discussion and Result

3.1 The Impact of Dissemination in The Disaster Risk Reduction

Disaster prone area maps are one of the common DRR efforts. Padang City has made various maps prone to disaster. The maps were mounted onto billboards and positioned along the city’s coastal road. Basically, the installation of tsunami-prone maps on the main roads is intended to provide warnings yet potentially cause anxiety for the community if not followed by comprehensive dissemination process. Dissemination of disaster-prone maps not followed by comprehensive dissemination process information can cause fear for the community (Figure 2). Communication in DRR aims to prevent and mitigate harm from disasters, prepare the population before a disaster strike, disseminate information during disasters and aid subsequent recovery. In addition, incomplete information and inadequate understanding of the population may trigger a desire to move.

*Figure 2. The installation of Tsunami-prone area map on road segments*

*Source: [13]*

Post-earthquake in 2009 and the circulation of the issue of the earthquake and tsunami caused people in the West Coast Area of Padang City to experience fear. This causes the emergence of the desire to move of the population. The desire to move of the society followed by the decline in land and housing prices around the West Coast Area of Padang City [4]. In general, there are 6 (six) factors that influence the selection of a person's location: the distance to workplace, land price, information, family structure,
home ownership, education [11]. This study shows that improper of DRR plan can change people’s housing location preference. It has potential to change the spatial planning specially spatial pattern.

Based on a survey of 223 respondents, it identifies that 38.8% of the West Coast Area of Padang City declared their desire to move (Figure 3). This is due to the fear and trauma to the earthquake and tsunami disaster. Dissemination of disaster-prone maps that are not accompanied by a proper and adequate socialization process can cause distortion of information to the public. It needs to interpret hazard related to information accurately. Table 2 shows the origin and purpose of the desire to move of the people living on the West Coast Area of Padang City associated with the fear of earthquake and tsunami.

Table 2. Origin and Destination Movement

| No | Origin                        | Destination                  |
|----|-------------------------------|------------------------------|
| 1  | Bungus Teluk Kabung Sub-district | A1 = Limau Manis Village     |
|    |                               | A2 = Kampung Baru Village    |
| 2  | Koto Tangah Sub-district      | B1 = Kuranji Village         |
|    |                               | B2 = Koto Baru Village       |
| 3  | Lubuk Begalung Sub-district  | C1 = Limau Manis Village     |
|    |                               | C2 = Kuranji Village         |
| 4  | Nanggalo Sub-district        | D1 = Padang City Besi Village|
|    |                               | D2 = Cengkeh Village         |
| 5  | Padang City Barat Sub-district | E1 = Kapalo Koto Village    |
|    |                               | E2 = Limau Manis Village     |
| 6  | Padang City Selatan Sub-district | F1 = Koto Baru village     |
|    |                               | F2 = Kuranji Village         |
| 7  | Padang City Utara Sub-district | G1 = Lubuk Minturun village |
|    |                               | G2 = Kuranji Village         |

Figure 3 shows that the direction of community movement from seven sub-districts including Koto Tangah Sub-district, North Padang, Nanggalo, West Padang, South Padang, Lubuk Begalung and Bungus Sub-district of Teluk Kabung tends to move to five other sub-districts namely Koto Tangah Sub-district, Kuranji, Pauh, Lubuk Kelangan, Lubuk Begalung, and South Padang City Sub-district. The moving pattern by communities is not the right solution as they actually move to new disaster sites (B1, B2, C2, F1, and G2). This condition indicates that further understanding of disaster knowledge is need especially on disaster prone maps. It aims to make people understand what actions to be taken and what decisions to be chosen in order that reduce the level of anxiety and loss.

3.2 Overlay Analysis on Disaster-Prone Maps and the Desire to Move

The determination of the spatial pattern is a non-structural mitigation countermeasure of DRR (Mark, 2008). The spatial pattern is generally defined as conservation areas, whose main function is to ensure environmental sustainability, which is consist of natural and artificial resources [5]. Conservation areas are classified into land use categories, such as disaster-prone areas, natural reserves (wildlife sanctuaries and cultural heritage sites), and locally protected areas (mangroves, rivers, riverbanks, open spaces, and the seashore). Cultivation areas are classified into the following areas: residential, agriculture, mining, industrial, tourism, and trading and service areas [5]. Figure 5 is the spatial pattern of Padang City, it seems that the disaster-prone areas (Figure 1) are designated as a cultivation area, tsunami disaster prone areas (red color) are designated as trade and service area (orange color) and settlement (yellow). This condition is very dangerous for the community.
Figure 3. Map of the Orientation Direction Settled

Figure 4. Settlement orientation change & potential disaster map.

Figure 5. Spatial Pattern Map of Padang City

Source: [7]

The overlay of Figure 1 and Figure 3 shows that the movement of people in areas considered safe is not exactly safe against disaster. On the one hand, they are safe against earthquake and tsunami disasters
because they live on the West Coast area of Padang City. But, at the newly chosen residential location they are not safe against landslide and flood disaster as what happened to the community that choose to move in Kuranji Sub-district, South Padang City sub-district, and Pauh sub-district (Figure 4). Based on disaster potential map of Padang City (Figure 1), potential disaster of Kuranji sub-district is earthquake and landslide prone area; potential disaster of South Padang City Sub-district is flood, earthquake and tsunami; while Pauh sub-district is prone to landslide and flood disaster. This is shows that people still do not comprehensively comprehend the problem of disaster vulnerability. This condition is one of the causes why the community is very reactive to DRR efforts that undertaken by the government. Resident movement (Figure 3 and Figure 5) triggered the change of spatial pattern of Padang City, because of the West Coastal Area of Padang City abandoned by people. Population movements to other areas will cause land-use changes in the areas where the population moves. This condition will trigger a land-use deviation.

4. Conclusion
The overlay analysis shows some conclusions related to the desire to move of society because DRR dissemination process, which are:

- The information provided by the government in DRR is not always positive because it causes people to move. The desire to move can lead a land-use deviation and changes in spatial pattern, which also means loss to the government.
- The result of overlay of several disaster-prone maps in Padang City indicates that the spatial pattern of RTRW Kota Padang 2010-2030 has not accommodated sufficient DRR. Disaster prone areas are still design as a cultivation area that is harmful to the community. Areas prone to disaster should be design as conservation areas.
- New settlement areas selected by the community are not safe against disasters, especially floods and landslides, so the need for more in-depth study and evaluation related to the delivery of disaster information so that society is wrong in responding to the information that has been making by the government.

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