Evacuation Route Simulation for Tsunami Preparedness Using Remote Sensing Satellite Data (Case Study: Padang City, West Sumatera Province, Indonesia)

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ABSTRACT... Tsunami disaster caused great damages and very large victims especially when occurs in urban area along coastal region. Therefore information of evacuation in a map is very important for disaster preparedness in order to minimize the number of victims in affected area. Here, information generated from remote sensing satellite data (SPOT 5 and DEM) and secondary data (administration boundary and field survey data) are used to simulate evacuation route and to produce a map for Padang City. Vulnerability and evacuation areas are determined based on DEM. Landuse/landcover, accessibility areas, infrastructure and landmark are extracted from SPOT 5 data. All the data obtained from remote sensing and secondary data are integrated using geospatial modelling to determine evacuation routes. Finally the simulation of evacuation route in Padang City for tsunami preparedness is provided based on the parameters derived from remote sensing data such as distances from shelters, save zones, city's landmarks and the local community experiences how they can survive with the disaster.

KEY WORDS: SPOT 5, DEM, Evacuation Route, Tsunami

1. INTRODUCTION

Indonesia is both blessed and threatened by nature. Due to its large size which extends over three time zones and more than 6000 km from east to west, Indonesia is the largest archipelago in the world with population over 200 million. Such large inhabitants together with the fact that Indonesia is the junction where Caroline of Pacific, Philippine Sea, Eurasian and Indian-Australian Plates are collided, make Indonesia very vulnerable to natural disasters (such as earthquake, tsunami and volcano eruption), even among its neighboring countries (Ristek, 2005).

In December 2004, tsunami caused very large casualties especially in Banda Aceh province (Sumatra Island). The tsunami also killed thousands of people in other countries such as Malaysia, Thailand, Myanmar, India, Srilangka, Bangladesh, Maldives and countries in Africa. More than 200,000 people were killed by this tsunami so that the tsunami is considered as the most catastrophic tsunami in the history of tsunami. Other areas considered as earthquake and tsunami risk areas are located along west part of Sumatra Island and south part of Java Island which two plates are collided. Especially some cities in coastal which have high population, such as: Padang, Bengkulu, Yogyakarta and Denpasar.

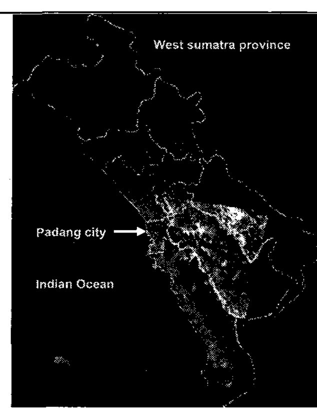
Base on this background, information of vulnerability area and evacuation route are very important as disaster preparedness to minimize the number of victims in affected area. These kinds of information can be produced using satellite remote sensing data and GIS technology. Satellite remote sensing data has a capability to identify landuse/landcover of earth surface and to generate topographic data (DEM: Digital Elevation Model). Landuse/Landcover and DEM are already known as main parameters to generate a model of vulnerability and evacuation area for some disasters such as Tsunami and flood (LAPAN, 2005).

Here, information generated from satellite remote sensing data (SPOT 5 and DEM) and secondary data (administrative boundary and field survey data) are used to simulate evacuation route map for Padang City in West Sumatra Province.

2. METHODOLOGY

2.1 Study Area

West Sumatra province boundary and Landsat ETM-7 data are shown in Fig.1. Padang City is located in coastal area of West Sumatra province of Indonesia. Almost entirely part of the city area has low topography and high densely populated. Therefore this area is predicted to be one of the highest risk areas in Indonesia when tsunami and earthquake occur. (Ristek, 2005)



(a) West Sumatra province using Landsat 7 image

(b) Padang city using SPOT 5 image

Figure 1 Study area of Padang City using SPOT 5

2.2 Methodology

Figure 2 shows a flowchart of data processing. Primary and secondary data were used. Primary data consists of landuse/landcover (included infrastructure –landmark- and accessibility area) extracted from SPOT 5 with 2.5 m spatial resolution and DEM SRTM (*Digital Elevation Model, Shuttle Radar Topography Mission*). On other hand, secondary data consists of adminitration boundary, street`s and building`s name and other information obtained from the field survey. Pre-processing was done by geometric correction, histogram matching and image fusion to obtain SPOT 5 image of Padang City as shown in Fig.1. Information of landuse/landcover, infrastructure and accesibility area were extracted by on screen digitation and visual interpretation method.

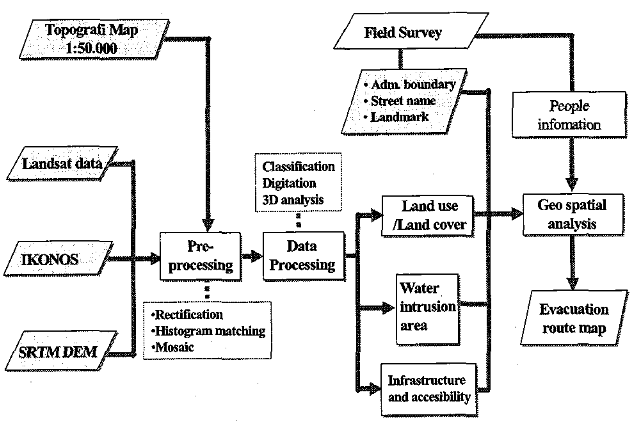


Figure 2 Flowchart of data processing

The next step, 3D view of Padang city was constructed by combining SPOT 5 image and DEM. Water inundation model was calculated by increasing water level toward 3D image, then vulnerability area and evacuation area are detrmined based on inundation model and other references. Field survey was conducted around Padang City to make verification of landuse/landcover, to collect street's and building's name, administration boundaries and other social economy data. And the coordination has been made with local community for tsunami preparedness (KOGAMI) in study area to determine evacuation route. Finally, all data were integrated using geospatial modeling to produce evacuation routes of Padang City. These routes have been produced in form of evacuation maps for the community preparedness.

3. RESULT AND DISCUSSION

SPOT 5 provides 2.5 m spatial resolution of fusion image (fusion between multi spectral and panchromatic image), so it can be used to identify objects on earth surface accurately. Figure 3 shows a sample of classification result, which consists of landuse/landcover, infrastructure (building) and accessibility (street) information.

Figure 3 Classification Result Part of Padang city

The types of landuse/landcover in current area are listed bellow:

1. Built area :
   1. Urban area
   2. Settlement
      Landmarks: Hospital, Air Port, Bus Terminal, Harbour, Mosque, Market, Station, Offices, Schools/Colleges, Meeting Buildings, Malls, Hotels, Banks,Industry, Sport Halls.
2. Vegetation :
   1. Paddy fields
   2. Mix garden
   3. Forest
   4. Other vegetation (bushes, etc)
3. Open area
   1. Open land
   2. Coastal sand
4. Water Body:
   1. Sea
   2. Lakes
   3. Rivers

Figure 4 shows inundation model by increasing water levels (0, 5, 10 and 15 m) toward 3D image of Padang city. Almost of the city is inundated by water when the water level rises until 10 m. Further, whole the city (except Pangilun hill, Padang Mountain) is under water when the water level rises more until 15 m. From the result of tsunami modeling (Case study: Aceh and west Sumatra Tsunami) done by other researcher, it is predicted that the max tsunami height at shoreline is around 3-6 m (Latief (2003) and Latief (2004)). Regarding to the result, Padang City can be classified into 4 zones based on topography of study area as shown in Figure 5. Those are zone 1 (0-5 m), zone 2 (5-10 m), zone 3 (10-15m) and zone 4 (>15m) respectively. This zone model is also adopted by other work for determining risk area in Padang (KOGAMI, 2005). Zone 1 is the highest risk area for tsunami disaster. The risk level decreases as increasing the number of zone. Zone 4 can be considered as save zone because tsunami can not reach until this area. Some areas belong to zone 4 are Pangilun hill and Padang Mountain (located near the coastal), and upland area (located in the east part of Padang city). Most of areas in zone 1 are covered by urban and settlement, on other hand, zone 4 are covered by forest and paddy field.

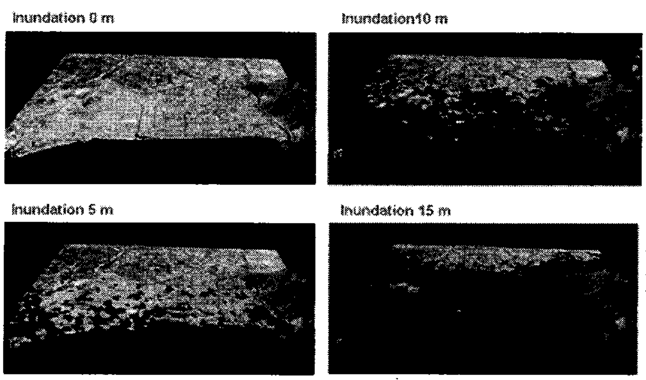


Figure 4 Inundation model in Padang city

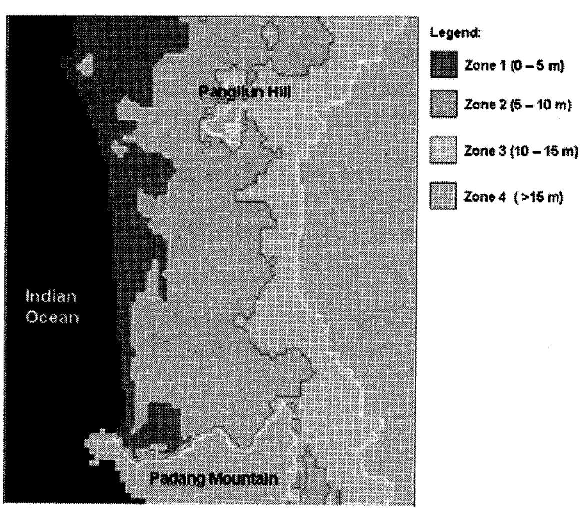


Figure 5 Tsunami risk zone based on topography

Field survey was conducted in Padang City to verify the information extracted from satellite data, and to identify some features which were difficult to be interpreted using satellite data. Beside that, administration boundaries were collected and as well as social economic data of the study area. This study also carried out a coordination with people through local community KOGAMI related to determination of tsunami risk area and evacuation route as shown in Figure 6.

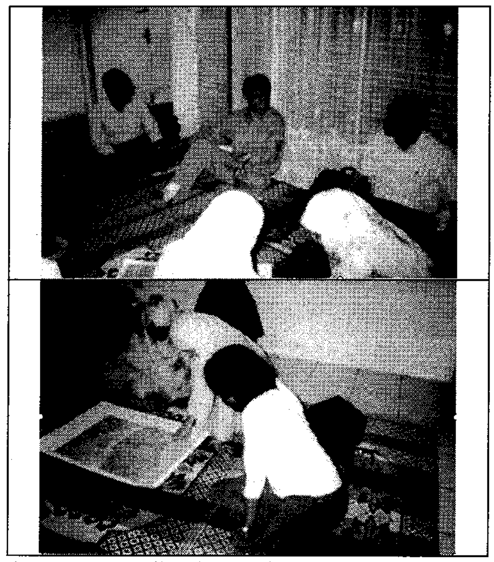


Figure 6 Coordination with people through local Community in Padang city

Finnally, all the data (primary and secondary data) were integrated and analyzed using GIS (Geographic Information Sistem). Then, the evacuation route was selected by considering some points:

1. Evacuation route is the shortest way toward shelters (such as building) and save zone,
2. Evacuation route is a way which can be through by vechicle (car and motorcycle)
3. Route is a vertical way to shoreline, and has the shortest distance to evacuation area (shelter and save zone).
4. Route selection considers information from local comunity experience

The evacuation route map can give route information in Padang city until level of subdistrict and village. The map provides route information as well as other information such as landuse/landcover, infrastructure and acessibility of Padang city. The information can be produced in a detil map with scale 1:10.000. Figure 7 shows an evacuation route map for North Padang sub-district of Padang city.

Even though, Coordination with the people through local community or local government is needed to improve a route map becoming an operational route map.

Other important thing is that, the map should be regularly updated to know the changes in the study area.

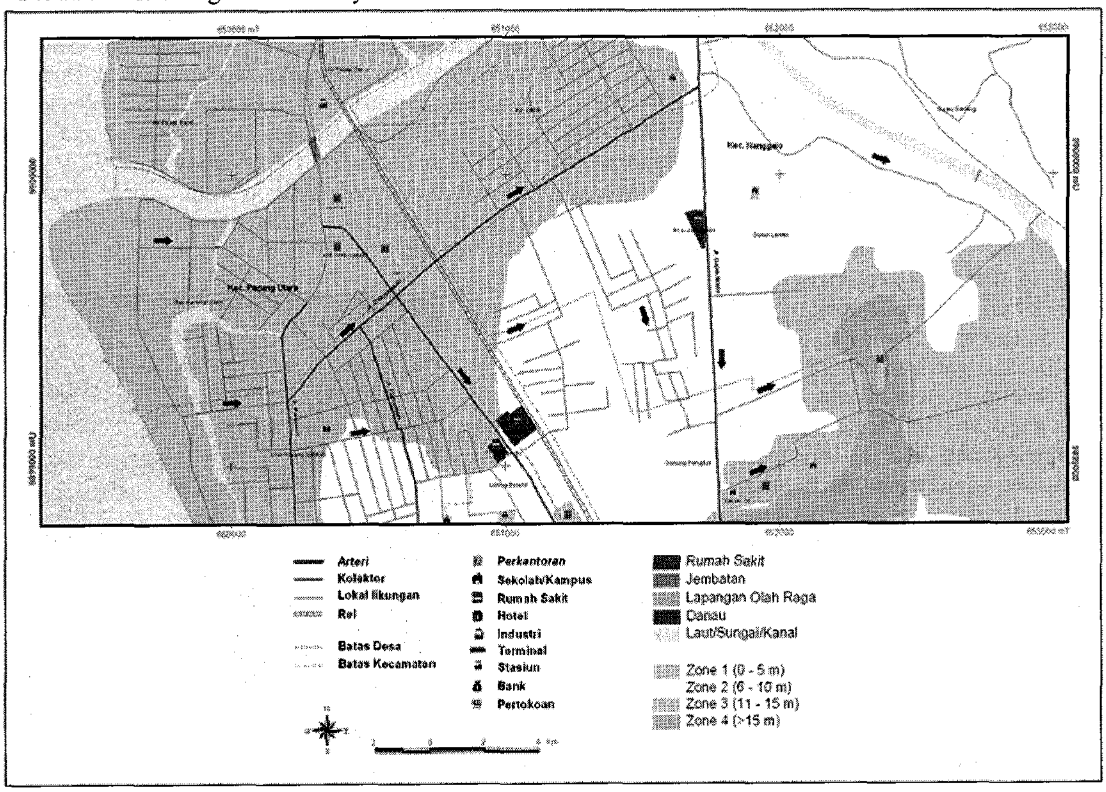


Figure 7 An evacuation route map for North Padang sub-district of Padang city

4. CONCLUSION

Information generated from satellite remote sensing data and secondary data from the field survey are used to simulate evacuation route map for Padang city. Some points can be concluded as follow:

1. Satellite remote sensing has a capability to provide important data for making tsunami vulnerability and evacuation route map
2. Padang has a flat topography, and it is considered as a high risk area to be affected by tsunami. But there are some places in the city with topography above 15 m, such as: Pangilun hill and Padang Mountain. This area can be used as evacuation area.
3. Coordination with the people through local community or local government is needed to improve a route map becoming an operational route map.

References

Tsunami Preparedness Community (KOGAMI), 2005, Proposal of Earthquake and Tsunami Disaster Mitigation for Padang city 2005, West Sumatra Province.

LAPAN, 2005, "Geo-spatial database and Tsunami evacuation information for supporting ITWS program", Report of ITWS 2005

Latief H., 2004,"Tsunami Aceh 2004", Tsunami Research Group-Bandung Institute of Technology (ITB), presented Power point.

Latief H, 2003, "West Sumatra Tsunami 1833 dan North Sumatra Tsunami 1935", Oceanography Research Center, Bandung Institute of Technology (ITB), Research report in http://tsunami2.ppk.itb.ac.id/

RISTEK, 2005, Grand scenario of Indonesia Tsunami Early Warning System (Indonesian-TEWS), version 190405