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SPATIAL MODELING FOR LEARNING MEDIA OF TSUNAMI RISK REDUCTION IN THE FIELD OF EDUCATION

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Abstract: This research aims at reducing the risks of tsunami by (1) optimizing the learning media of earthquake and tsunami disaster mitigation, (2) designing Disaster Risk Reduction (DRR), and (3) applying community-based disaster risk management through spatial modeling to students. Through the activities, the students are expected to comprehend the early detections of tsunami and mitigation efforts that need to be made. The methods employed are conducting survey at lowland areas in Pacitan which are vulnerable to tsunami disaster, mapping tsunami-prone areas, constructing the map of tsunami disaster risks. By applying Geospatial Information Technology a tsunami model and its impacts are created at the lowlands in Pacitan. The preliminary data are taken by using either remote sensing imagery or aerial photography in which the image processing has been conducted before. The results of this application will be used to train teachers in the Teacher Networks (*MGMP—Musyawarah Guru Mata Pelajaran*) of Geography and Guidance and Counseling (BP) subjects. This research will be carried out in three stages, comprising the identification of DRR media, the practice of DRR using spatial information technology, particularly spatial modeling, and the simulation of tsunami disaster mitigation.

Keywords: *spatial modeling, tsunami, instructional media*

1 INTRODUCTION

Indonesia is a country of which regions are potential to tsunami hazards. Tsunami is caused by earthquake, volcanic eruption, and avalanche area. The high frequency of tsunami in Indonesia deals with the tectonic setting of its archipelago. The region of Indonesia, especially the east region, is a triple junction of three main plates, comprising Eurasian and Indo-Australian plates moving to the north and Pacific plate moving to the west.

Tsunami moves out of the source area as a series of waves. Its speed depends on water depth, so that the waves either accelerate or decelerate when passing through different depths. The process causes the change of wave direction, and therefore the wave energy becomes more focused. Tsunami with the height of 1 meter in the sea such as in Indian Ocean can elaborate to be dozens of meters at the coastline. In areas near coast, the energy concentrates to vertical direction due to the reduced water depth and the wavelength shortening because of wave motion deceleration.

As a branch of science which studies the similarities and differences of geospheres phenomena (environment, area complexity, etc.), Geography attempts to study and to give contribution related to the natural phenomena which frequently occur in Indonesia.

Communities' lack understanding on disaster aspects effects on their lack understanding on tsunami prone areas. As a concrete example, many people build settlements, tourism objects, and hotels in the tsunami prone areas, and therefore it leads to the loss of life. In addition, their lack understanding on the signs of tsunami causes them less-likely to recognize and not to be ready for evacuation efforts when the disaster occurs.

In Indonesia, the remote sensing technology has been applied mostly for the purpose of inventory of natural resources and living environment, while its intensity is still low and inequitable to all areas. Referring to the satellite imagery which can give depiction of earth surface, imagery can be used as a tool to map disaster-prone areas.

This introduction program will be socialized to students and schools. Schools as educational institutions are believed to be able to accept

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scientific thoughts which later can be made into learning materials for the students.

2 LITERATURE REVIEW

Indonesia is one of disaster-prone countries. For more than the last four years, it has experienced a series of disasters which killed human and influenced its economy. The aforementioned disasters included a tsunami at Aceh in December 2004, an earthquake at Nias in March 2005, an earthquake at Yogyakarta and Central Java in May 2005, and earthquake and tsunami at Central Java in July 2006. The country also has high potential to explosive eruptions with 128 active volcanoes (31 among them are monitored) of 600 volcanoes throughout the Equator. The disasters gave great impacts to the country's economy. The damage caused by tsunami was estimated about 4 million US dollars, and the earthquake at Yogyakarta and Central Java 3 million US dollars. Natural disasters threaten human resource development in Indonesia and result in the damage of facilities serving as the achievement of national welfare.

The efforts to protect and to prepare communities living in the disaster-prone areas, and those to increase government capacity in responding to the state of emergency can help reduce the risks significantly when the disasters occur and encourage people to implement safety habits. In order to increase the national and regional resilience in reducing disaster risks and to help the transition from the habits of responding and asking help to be a comprehensive and integrated risk-reduction habit referring to the main roles of the all levels of governments and those of private sectors, and the organization of civilized citizens, several efforts are made, including:

1. providing policy advice and increasing the capacity to reduce and analyze the disaster risks into the framework of policy, law, regulation, and planning;
2. enhancing the capacity in conducting self-preparation in coping with the state of emergency and responsiveness system in national, provincial, and regional levels, and helping community-based disaster risk management. To improve the regulation related to the DRR efforts in Indonesia, instructional strategies and policy advises need to be provided for the formulation of the bill and disaster mitigation regulation. The bill was legitimated in 2007. It is very important to increase the capacity of both central and local government to prepare and manage disasters and provide the further recovery in disaster-prone and centralized-government country like Indonesia. The capacity of DRR and its operation require knowledge, system, information, equipment, and resource to deal with disasters;
3. The effective capacity in reducing the disaster risks requires DRR integrated to the national plan and budget in national, provincial, and local levels. The formulation and distribution of National Action Plan on DRR and DRR action plan in regional levels are required. Planning is important to enhance government capacity to reduce the disaster impacts, to manage the disaster hazards, and to decrease disaster risks. To do this, the planning of Disaster Risk Information System (DRIS) which helps provide the relevant information related to the reduction, prevention, and mitigation of disasters is required.

The awareness on the importance of DRR efforts has been started by the release of the book entitled National Action Plans on the Disaster Risk Reduction by The Bappenas (The National Development Planning Agency of Indonesia) and The Bakornas PB (The National Disaster Management Coordinating Board) and the Bill no. 24/2007 about Disaster Mitigation. The aforementioned publications have been a milestone for the efforts of disaster risk reduction in Indonesia, followed by the regulation of their release, and the establishment of the BNPB (The National Board for Disaster Management).

In reference to the results of World Conference on Disaster Reduction held on 18-22 January 2005 in Kobe, Hyogo in Japan and in order to adapt Framework for Action year 2005-2015 under the theme of "Building Nation's Resilience and Community to Disasters", an opportunity to initiate a strategic and systematic

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approach to reduce vulnerability and disaster risks to hazards is given. The conference emphasized on the significance of identifying the strategies to build nation and community's resilience to disasters. They can be reduced in case that the community has adequate information and is motivated by prevention and resilience custom to disasters. This at last requires searching, collecting and spreading both relevant knowledge and information on hazard, vulnerability and capacity. For that reason, several efforts need to be made, including:

1. initiating knowledge on DRR as a relevant part to be added in the curriculum of all education levels and making use of other formal and informal ways to reach youngsters and children with information; as well as establishing integration of DRR as an intrinsic element during decades of 2005-2015 for United Nations Decade of Education for Sustainable Development;
2. promoting the implementation of expertise of local risks and disaster preparedness program in schools and further education institutions.
3. promoting the implementation of schools' programs and activities related to the learning on the strategies to minimize the hazard effects.
4. enhancing training program and learning on DRR. They are targeted to certain sectors including development planners, emergency response managers, local government officials, etc.
5. initiating community-based training by considering role of volunteers as appropriate to increase local capacity to mitigate and cope with disasters.
6. ensuring equitable access to appropriate training and education for women and vulnerable individuals.
7. promoting trainings on gender and culture sensitivity as inseparable parts of education and on DRR.

3 RESEARCH METHOD

This research will be conducted at Pacitan lowland, an area around Pacitan. This area is selected as research location since it is located in funnel-shaped Pacitan bay which is prone to tsunami. The research targets include educated communities since they play appropriate role as propaganda agents of DRR to broader communities.

This research consists of a set of activities which will be gradually conducted. They include:

1. Field Survey
   Terrestrial survey is applied after a survey is conducted by using remote sensing images (either satellite or aerial photography images). It aims to determine the accuracy level of sample data of remote sensing images in field. Moreover, it is conducted in order to collect the field data comprising contour, settlement, land use, population, public facilities, rivers and network of transportation exposed to disaster impacts.
2. Mapmaking
   The field data will be then analyzed by using Spatial Information Technologies to make map of tsunami-prone areas, tsunami risks, and tsunami disaster mitigation.
3. Spatial Modeling
   Based on the maps, spatial modeling is made. It creates spatial model in case that tsunami occurs with models of the magnitude of earthquake and the height of tidal waves.
4. Application and Workshop
   In order to be more applicable in the field of education, the spatial modeling needs to be comprehended by teachers of the relevant subjects. Furthermore, they are able to simulate and add significant things adjusted to the school condition

4 DISCUSSION

4.1 Earthquake-Prone Areas in Pacitan Regency

Earthquake is one of disasters of which occurrence is difficult to predict. Based on the location, almost all areas in Pacitan regency are potential to tectonic earthquake. Areas vulnerable to the hazard include those with high population. This is because areas with high population are extremely potential to result in tragic loss of life if a great earthquake occurs at any time.

Almost all areas of Pacitan regency are potential to the earthquake. However, the areas

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along faults have higher earthquake hazard level than the other areas. Meanwhile areas with no faults have moderate potential of earthquake hazard. This fact is illustrated by the distribution map of earthquake-prone areas in Pacitan regency below.

Map 1. Earthquake Hazard in Pacitan Regency

4.2 Tsunami-Prone Areas in Pacitan Regency

Areas in Pacitan regency prone to tsunami commonly are those with shore morphology. All coastal areas generally have lower elevation and therefore lead to tsunami hazard potential. Based on tsunami hazard map in Pacitan regency, two areas with high tsunami hazard potential include Pacitan bay and Taman bay.

If approximately 7-km-straight line from coastline is made, areas of Pacitan bay are commonly 0-25 meters high above sea level. The cross section profile is shown in the image below.

Image 1. Cross Section Profile in Pacitan Bay

As illustrated by the image, it can be seen that most areas in Pacitan bay are less than 15 meters high above sea level. This results in great potential to the tsunami hazards. If measured by making 3.75-km-straight line from coastline, the areas are considered prone to tsunami. However, if a straight line is pulled through the flow of Grindulu River to Pacitan Bay, the areas having potential of tsunami hazard are about 7 km from the coastline. This is surely dangerous and leads to great loss since areas in Pacitan bay are included as administrative area of Pacitan district. It is the most densely populated district in Pacitan regency with population of 63,042 and population density of 818 people per square kilometer.

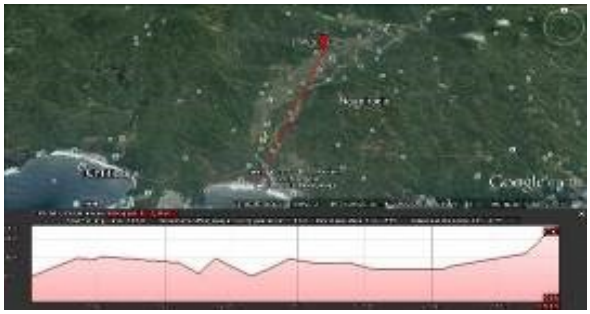

Image 2. Cross Section Profile in Taman Bay

The second area with quite high tsunami hazard potential in Pacitan regency is Taman bay. The bay has the same topography characteristics as Pacitan bay. They have low elevation and are included as estuary areas. The cross section in Taman bay is illustrated by the image 2 above.

From the above image, if a 6-km-straight line is made from the coastline, it can be seen that areas in Taman bay are 0-27 meters high above sea level. Most areas in the bay are less than 15 meters above sea level. Those having height of less than 15 meters above sea level are approximately 5.25 km from coastline. Those areas are prone to tsunami hazard and have high potential of leading to the loss of life if tsunami occurs.

In addition to those two areas with great potentials to tsunami hazard, there are some other prone-tsunami areas belonging to moderate and mild levels. Those areas are generally administrative coastal areas of several districts along Pacitan regency coastal zones, including some villages like Watukarung, Candi, Pringkuku

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and Jlubang in Pringkuku district, Worawari in Kebonagung district, Sidomulyo in Ngadirojo district, and Samberrejo in Sudimoro district. Tsunami-prone areas are displayed in the following vulnerability map.

Map 2. Tsunami Hazard in Pacitan Regency

4.3 Evacuation Route Direction

Evacuation routes in Pacitan bay in Pacitan district are divided into some routes based on the access ways around Pacitan bay. The first route is the evacuation route located in the west of Pacitan bay. This route is the main road from Pacitan to Solo. It is used by people in some villages including Sidoharjo, Ploso and Bangunsari. This evacuation route is the main road of Pacitan – Solo to Pringkuku district through Dadapan village. It is selected since the village has higher elevation than Pacitan bay does, and it is the nearest place to access from those three villages.

The second evacuation route in Pacitan bay is situated in the north of Pacitan bay. It is used by villagers in the nothern areas of Pacitan district, including Sumberharjo, Pucangsewu, Pacitan, Tanjungsari, Baleharjo, Nanggungan, Widoro, Purworejo, Semanten, Menadi and Banjarsari. This evacuation route uses inter-district connecting route of Pacitan and Arjosari districts. The evacuation direction of this route goes north to Arjosari district.

The third evacuation route in Pacitan bay is the route situated in the east of Pacitan bay. This is the inter-district connecting route of Pacitan district and Kebonagung district. This evacuation route can be accessed by villagers in Kembang, Sirnoboyo, Sukoharjo, Arjowinangun, Kayen, Menadi and Mentoro. The evacuation route direction goes east to Kebonangun district through Wonogondo village in Kebonagung district.

The next evacuation routes are in Taman bay in Ngadirojo district. In this area, evacuation routes are divided into two, evacuation route for villages in the northern and in the southern Taman bay. The northern evacuation route can be accessed by people in Tanjungpuro, Wiyoro and Ngairojo villages. This route uses the inter-district connecting route of Ngadirojo and Tulakan districts. This evacuation route direction goes either north to Tulakan district or Cokrokembang, Bodag and Tanjunglor villages.

The second route in Taman bay is the route situated in the southern area of Taman bay. This route can be accessed by people living in Hadiluwih and Hadiwarno villages. This evacuation route uses the inter-district connecting route of Ngadirojo and Sudimoro disctricts. The evacuation route direction goes east to Sudimoro district through Pagerkidul village or goes to the eastern area of Hadiwarno village which is not affected by tsunami because it has higher elevation than areas in Taman bay prone to tsunami hazard. The illustration of evacuation route in Pacitan regency is displayed below.

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Image 3. Tsunami Disaster Evacuation Route in Pacitan Regency (1)

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Image 4. Tsunami Disaster Evacuation Route in Pacitan Regency (2)

4.4 Learning Media Story Board

Multimedia for tsunami disaster mitigation in Pacitan regency is developed with the following specification:

1. Developed with Adobe Flesh CS 6
2. Developed with Script 2

Here is the illustration of disaster mitigation multimedia development.

No	Face Multimedia	Explanation
1		**INTRODUCTION** Media development is begun with the introduction of developing institution's logo using UNS logo
2		**OPENING** This part facilitates multimedia user with a button to enter HOME, SETTING OR EXIT menus from multimedia program Background: Picture of Beach
3		**SETTING** In SETTING menu, there are two setting options that can be done, including: a. Screen size display : the screen size can be displayed with either maximize or minimize b. Sound: it can be used to adjust sound, whether is set on or off.
4		**EXIT** In EXIT menu, there are some options to either enter or exit from the media.

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5		**HOME** In HOME menu: Background : Aerial Photo of Pacitan Bay HOME menu contains 6 main menus, including: a. Developer Profile Menu b. Pacitan Profile Menu c. Tsunami d. Modeling e. Mitigation f. MAP Gallery
6		**PROFILE MENU** PROFILE menu contains: a. Preface It is the preface from developer
		b. Developer Profile It contains biographical description provided by developer and pictures of them.
7	 	**PACITAN PROFILE** It contains 2 sub-materials, including: a. Profile of Indonesia It contains the profile of geographical and astronomical situation of Indonesia, as well as its disaster profile and videos describing Indonesia profile.
		b. Pacitan Profile It contains Pacitan profile dealing with is geographical and astronomical condition, and Pacitan disaster profile. This sub-material also contains videos on Pacitan regency profile.

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8		**TSUNAMI PROFILE** TSUNAMI menu contains several sub-materials: a. Tsunami History: this sub-material contains materials dealing with history and animation of tsunami.
	 	b. Tsunami causing factors It contains several factors contributing to tsunami, its animation and videos.
9	 	c. Disaster Map Profile, containing tsunami and earthquake vulnerability map.

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10		**MODELING** It contains animation of tsunami range modeling in Pacitan bay.
11		**DISASTER MITIGATION** Disaster mitigation menu contains two sub-materials, including: a. Phases in tsunami disaster mitigation containing materials and images of mitigation phases according to "DIRECTORATE OF COASTAL AREAS AND MARINE and NATIONAL BOARD FOR DISASTER MANAGEMENT (BNPB)"
12		b. Comic on tsunami disaster mitigation sourced from "DIRECTORATE OF COASTAL AREAS AND MARINE".
13		**MAP GALLERY** It contains several types of maps. a. Land-use Map b. Geological Map c. Administrative Map d. Earthquake Map e. Tsunami Map f. Evacuation Map g. Slope Map

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