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Analysis of tsunami disaster resilience in Bandar Lampung Bay Coastal Zone

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Abstract. The coastal area is an area that has potential diversity of natural resources and high economic value. The coastal area is influenced by changes in land and sea so that the coastal areas are highly vulnerable to tsunami. Bandar Lampung has the potential of coastal areas of considerable potential as it is located in the bay adjacent to the Sunda Strait. Based on the study of Heru Sri Naryanto (2003), Bandar Lampung ranks third from the level of vulnerability to tsunami. Therefore, the purpose of this study to determine the readiness of the region in facing tsunami and the magnitude of the potential risks of tsunami disaster in the Gulf Coast region of Lampung in Bandar Lampung; thus, it needs to make the model or concept of tsunami disaster mitigation appropriate in terms of vulnerability and danger in creating the resilience of the Gulf Coast region of Lampung in Bandar Lampung against tsunami. The methodology used in this study was the methods of primary and secondary data collection, and the data analysis method was quantitative analysis such as spatial analysis and descriptive analysis of the data obtained from the field. The results showed that the level of preparedness in the Gulf coast region of Lampung in Bandar Lampung in facing the tsunami was still low. There are still many developed regions or houses belonging to the community either fishermen or non-fishermen located in a tsunami hazard zone. Other than that, the level of education in the Gulf coast region of Lampung in Bandar Lampung is still low where the majority of inhabitants work as fishermen. Besides, the infrastructure is old and not well-maintained so that it becomes a slum area. Therefore, the development and planning to mitigate the natural disasters tsunami using technology of IOT (Internet of Things) is an embeded system with the use of sensor seismic as a means of pre-Earthquakes vibrations, placed both on the land and in the ocean, to read the vibrations and faults in the earth's crust under the sea. With the use of seismic sensors under the sea, the vibration of the earth's crust under the sea will be detected. The sensors then will be connected to a flare marker buoys as a means to inform the disaster mitigation center. The construction of hall disaster at some point will be helpful to give first aid to those who are difficult to pass through the evacuation place since it is far away from the Gulf coast. The hall mitigation can be designed anti-earthquake and anti-tsunami. The model and concept of mitigation used is combining the Spatial Plan of Bandar Lampung and the mitigation of tsunami disaster as an integrated system of pre-disaster, during disaster and post-disaster by making the city of Bandar Lampung has the resilience to tsunamis.

Keywords: Tsunami, Resilience, and Bandar Lampung

1. Introduction

The coastal area is an area that has potential diversity of natural resources and high economic value. Based on Law No. 27 of 2007 on the Management of Coastal Areas and Small Islands, coastal region is the transition between terrestrial and marine ecosystems which are affected by changes in land and sea"[1]. The transition between terrestrial and marine ecosystems in coastal areas raises the appeal to exploit the available wealth of resources in the region. It can result in disaster if it is not accompanied by the utilization of existing policy. In addition, the coastal regions are affected by changes in land and sea so that the coastal areas are highly vulnerable to the tsunami.

Indonesia as an archipelagic country has the longest coastline in the world after Canada with a length of 81,000 km and it is accompanied by abundant natural resources [2]. In the coverage area of Indonesia, there are some areas that have a coastline with similar characteristics to Bandar Lampung. Bandar Lampung is the capital of Lampung Province which is in the southern part of Sumatra Island with an area of 192.18 km2. Bandar Lampung has high potential of coastal areas as it is located at the base of the bay which is adjacent to the waters of the Sunda Strait connecting between Java Sea and Indian Ocean. Geographically, the Gulf Coast of Lampung is located between 104^{o}56'-105^{o}45 East Longitude and 5^{o}25'-5^{o}59' South Latitude covering the land with an area of 127 902 ha and 161 178 ha of water area. Lampung Bay shoreline is along 160 kilometers of Sunda Strait.

There are 110 tsunamis in Indonesia with 100 tsunamis were caused by an earthquake, 9 tsunamis by volcanic eruptions, and 1 tsunami by landslides [2]. Tsunami in Indonesia is dominated by tsunami originating from an earthquake. The centers of earthquakes are related to the subduction (subduction) plates, so that the path of the earthquake that occurred follows the subduction zone [4]. Lampung Province, including Bandar Lampung (west) which is near the Sunda strait subduction zones, has very high levels of seismicity due to movement of the plates in the zone. Based on the study by researchers from BPPT to the tsunami disaster in the Sunda Strait region, there are five (5) vulnerabilities zones, one of them is Bandar Lampung located in the third zone (Zone III) [5]. Bandar Lampung is as one of tsunami disaster vulnerability zones because the south coast of Bandar Lampung is a bay that is prone to tsunamis and the potential for earthquakes, flooding and environmental damage on very dense settlements along the coast.

Potential tsunami disaster in the city of Bandar Lampung is derived not only from the earthquake, but also from the participation Anak Krakatau eruption in the waters of Sunda Strait so that the potential of higher tsunami in Bandar Lampung increases. Of the various potential, a handling effort in the region through a mitigation is required by paying attention to the danger of disaster, vulnerability to disasters and disaster preparedness tsunami in Bandar Lampung.

2. Basic theory

2.1 Tsunami and causes

Tsunami comes from Japanese language meaning harbor where *Tsu* and *Nami* mean ocean waves, so it can be interpreted as the ocean waves that hit the Sea Port. Tsunami is one form of disaster caused by natural activity in utilizing vibration, cracks, as well as the movement under the ocean surface that can trigger the movement of the sea waves in terms of size, height, volume, and speed of the waves. Tsunami is a series of ocean waves with the spreading capability at speeds up to 900 km per hour, mainly caused by the earthquake which occurs on the seabed [6]. Tsunamis can occur by several factors which are as follows.

1. Volcano Eruption
   Tsunami caused by volcano is the most significant cause. By the time the volcano erupts, the vibration in the earth's surface is inevitable where earthquakes are one of the causes of tsunami. In addition, land subsidence due to the volcano and landslide can cause a tsunami. Therefore, tsunami caused by the volcanic eruption can be said as the main point of tsunami.
2. Landslide
   Avalanche is the reason for tsunami. Basically, the tsunami caused by the landslide requires amount of land to drive a new wave in the ocean floor. Tsunami caused by landslide is illustrated with the decreasing soil or permafrost of the land surface to the ocean floor. In addition, encouragement and a large movement trigger the formation of a new wave at the sea surface.
3. The Earthquake
   Tsunami struck by earthquakes is the most frequent cause in some areas of the world as an echo of the earth is to balance the state of the Earth. However, the earth movement can cause tsunami waves on the sea surface. Tsunami struck by earthquakes usually occur due to the shifting plates beneath the ocean surface and depths of less than 60 km.

2.2 The tsunami disaster resilience

The resistance level of tsunami in coastal areas is assessed through the level of tsunami risk and tsunami-prone areas. The risk of a disaster has three variables, namely: 1) aspect of the threat type, 2) aspect of planning and 3) the capability to cope with [7]. Disaster Management Law Number 24 Year 2007 describes a series of disaster mitigation efforts to reduce disaster risk, either through physical development as well as awareness and increased capacity to deal with the threat of disaster [8]. Not all disasters create disaster risk. Disaster risk comes from disasters that have vulnerabilities. Therefore, the risk of disasters is the convergence between hazard and vulnerability [2].

$$\text{Risk}=\text{Hazard}\times(\text{Vulnerability}/\text{Capacity})$$

The book of Managing Country Risk Maritime Disaster in Indonesia: Disaster of Earth, Oceans and Atmospheric discusses the analysis principles of tsunami risk, the stages of work required in determining the magnitude of tsunami hazard and the vulnerability, and the vulnerability of communities and infrastructure, namely 1) assessment of tsunami hazard; 2) assessment of vulnerability to tsunami hazard; 3) analysis of tsunami risk; and 4) tsunami disaster mitigation.

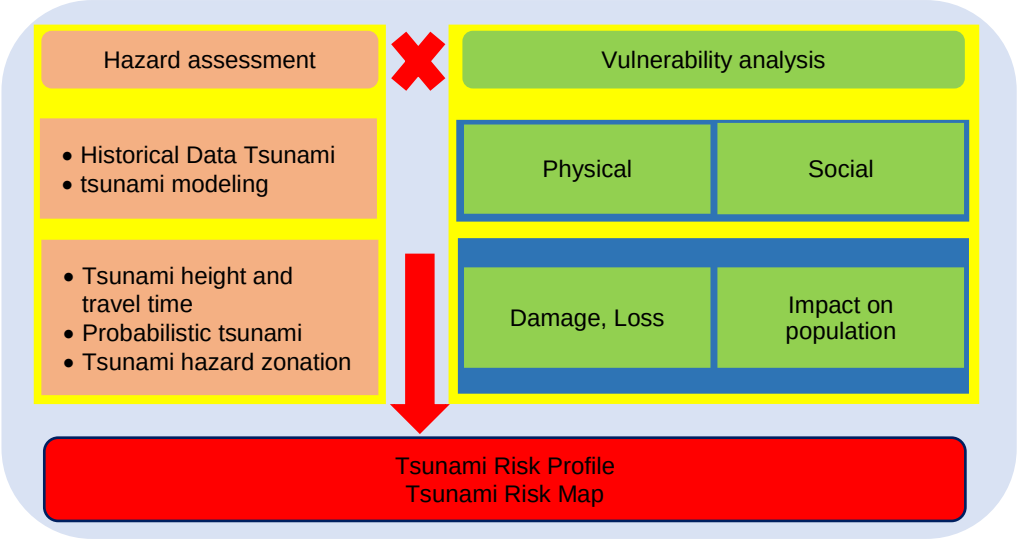

Figure 1. Framework for risk model [9]

Hazards are potential physical damage events/phenomena/human activity that may cause loss of life, property damage, social and economic disruption, or environmental degradation. Capacity is the combination of all the strengths and resources that exist within a community, society or organization that can reduce the level of risk or the impact of the disaster. Meanwhile, vulnerability is the condition and physical processes/social/economic/environment that boosts pressure and the impact of a disaster on the society or community. Then disaster risk is a potential destructive consequence that eliminates life, safety, property, livelihoods, economic activity, or the environment as the result of interaction between natural hazards and harm due to human action in conditions of vulnerability.

Coastal Community Resilience (CCR) Guide (TWCRG, 2007) is a reference guide tsunami warning center which attempt to identify, prepare, and recover tsunami and its impact [10]. Coastal Community Resilience (CCR) e is an approach done as a collaborative effort and participatory coastal communities, national government agencies and local, NGOs, private sector, and other key stakeholders to identify strengths, weaknesses, and opportunities to improve disaster resilience locally and nationally. This integral approach can be used systematically to determine the right program to increase the resilience of coastal communities in a region. The concept of coastal community resilience is applied to reduce the risk of coastal hazards and to avoid disaster and speed recovery in case of disaster. With the resistance, coastal communities can easily adapt to changes through the

experience and lessons learned from the previous disasters. The analysis of the level of risk or the tsunami can be done. Then, the elements of coastal community resilience can be grouped based on assessment criteria as follows:

Figure 2. Diagram elements of coastal community resilience [10]

A. ***Governance***: Leadership, legal framework and institutions provide the conditions that allow the resilience through community involvement with the government in which the government is as a facilitator and provides space for the coastal communities to withstand disasters and come forth back from disaster quickly. The community is able to adapt to the changes so that coastal community resilience can be enhanced periodically through the intervention of government, private and civil society in the community development and the management of coastal areas by implementing disaster management therein.
B. ***Society and Economy***: People involved in a diverse and sustainable living environment are resistant to the dangers. Society and economy are an important element of disaster resilience because they have a direct relationship between economic activities and social life of the community. The activities influence any changes that occur in local and regional.
C. ***Coastal Resource Management***: Management of coastal resources, which actively supports environmental services and livelihoods and reduces the risk of coastal hazards, provides a wide range of valuable resources and sustainable for society.
D. ***Land Use and Structural Design***: Land use and effective structural design are to complement the environment. The purpose of land use and an effective structural design in reducing the risk of danger will allow people to survive from tsunami and disaster..
E. ***Risk Knowledge***: The public is aware that the hazard and risk information is useful when facing disaster. If the public knows the risk level of the dangers, the public can adapt to reduce the impact of the disaster (reducing vulnerability).
F. ***Warning and Evacuation***: People can receive notifications and alerts coastal hazards and risk warning. The warning system and evacuation are an effective response to danger by providing the opportunity for the public to take action quickly and reduce the impact of disasters.. In a warning and evacuation system, there are three parts, namely early warning systems, evacuation plans and provision of information to the public effectively and accurately.

G. ***Emergency Response***: Mechanisms and emergency response network are established and maintained to respond disasters quickly and address immediate needs in coastal communities. The level of effective emergency response makes coastal become more resilient to withstand the impact of the tsunami and other disasters. The mechanisms and emergency response planning can provide the basis for people to back up quickly from the impact of a disaster (disaster recovery).
H. ***Disaster Recovery***: Plans are made to accelerate disaster recovery, engage communities in the recovery process, and minimize the negative environment, social, and economic impacts of recovery. To build community resilience can be done with approaches covering all the elements above which are integrated into disaster management, development communities, and coastal resource management.

From the level of resiliency against tsunami hazard, one of the tools used in the tsunami disaster mitigation in today's digital era is embedded systems referring to an electronic system that is part of a site system. Embedded systems are typically found in electronic devices which are often used every day such as TV remote control, digital clock, MP3player and many more. Embedded system can be considered as part of electronic devices components, but it lacks specificity on its use. Embedded will match if it can be translated means. Embedded is different from personal computer (PC), laptop, etc. in doing an activity. It needs an adjustment and matching between devices and existing embedded systems to do a specific job. It is different from PC which can do many things during the activities and can be programmed.. Embedded system can be used and placed at various places and conditions. Prices and costs to design a series of embedded systems can be quite cheap. The provision of real-time information is also the most important factor in addressing the issues of mitigation. Embedded systems are also energy efficient because it only works on one particular job. Besides, embedded systems do not use the user interface (GUI) to do the job. It is very different from the PC display images and color which causes high power consumption. Specification of embedded system is excellent to help addressing the problems of tsunami disaster mitigation.

3. Research methodology

The method of data collection used is the primary and secondary method, which the data were obtained from the interviews and other related agencies. The method of analysis used is quantitative analysis methods such as spatial analysis (scoring) and descriptive analysis.

4. Results and discussion

4.1 Analysis of resilience and regional preparedness in facing tsunami disaster

Disasters caused by nature will have a significant impact on life on earth's surface. Every human being needs to have a concern with natural disasters in order to reduce the level of its influence on human life. Natural disasters are usually able to damage and destroy story buildings, homes, and even humans' life. Tsunami is an example of natural disaster damaging objects and creatures on the earth's surface. Total volume of tsunami waves is large enough and the high speeds can damage and sweep away buildings, homes and any other living creatures.

Primary and secondary data were obtained from the field and related agencies were processed according to the needs. The data were processed to analyze the coastal community resilience of Bandar Lampung in facing tsunami disaster and tsunami disaster mitigation. Partial secondary data are shown below, while the primary data are not shown for the confidentiality.

Table 1. Society conditions and facilities of each sub-district in Bandar Lampung in 2015 [11]

No.	Districts	Total population	Social Welfare Issues	Health facility			Land Use
				Hospital	PHC	IHC	
1	Teluk Betung Barat	29 799	3,543	0	1	26	• *Embung* (retention
2	Teluk Betung Timur	41 645	4038	0	2	29	

No.	Districts	Total population	Social Welfare Issues	Health facility			Land Use
				Hospital	PHC	IHC	
3	Teluk Betung Selatan	39 353	3,569	3	1	40	basin)
4	Bumi Waras	56 742	6,866	0	1	40	• Industrial area
5	Panjang	74 506	5,229	0	1	51	• Protected area
6	Teluk Betung Utara	50 593	3,236	3	2	42	• General Services
7	Tanjung Karang Timur	37 108	2255	0	1	31	• Port area
8	Kedamaian	52 592	2709	0	1	30	• General Services Region
9	Tanjung Karang Pusat	51 126	3,640	2	2	34	• Mining region
10	Enggal	28 084	1,350	3	1	23	• Trade and Services
11	Tanjung Karang Barat	54 710	3,490	0	2	34	• Fishery
12	Kemiling	65 637	3,199	1	3	42	• Government Offices
13	Langkapura	33 944	1,473	1	1	25	• Settlement
14	Kedaton	49 055	3,085	0	1	31	• Agriculture
15	Rajabasa	48 027	2,645	2	1	35	• RTH
16	Tanjung Senang	45 775	1,636	0	1	25	• Empty land
17	Labuhan Ratu	44 843	1,584	1	1	27	
18	Sukarame	56 921	2,033	0	3	35	
19	Sukabumi	57 334	3067	0	3	44	
20	Way Halim	61 493	2660	3	1	36	
	Bandar Lampung	**979 287**	**59 601**	**19**	**30**	**680**	

The criteria in determining the danger level of tsunami in coastal areas of Bandar Lampung are: 1) the distance to the coastal areas of tsunami sources; 2) the availability of facilities and infrastructure of protection structure; and 3) the value of coastal areas covering the economic, social, cultural, infrastructure, defense and security. Based on these criteria each variable was scored to determine the level of tsunami hazard in coastal areas of Bandar Lampung. The results of primary and secondary data were analyzed using Geospatial Information Systems (GIS), which produces tsunami hazard map of Bandar Lampung coastal regions to coastal communities (Figure 3). Tsunami hazard levels in the coastal area of Bandar Lampung are grouped into five groups, namely:

Table 2. Danger level of tsunami coastal in Bandar Lampung

No	Danger Level	Area with vulnerabilities			
		Panjang	Teluk Betung Timur	Teluk Betung Selatan	Bumi Waras
1	Very low	Srengsem, Panjang Selatan, Pidada, Pidada Utara, Way Lunik	Way Tataan, Sukamaju, Keteguhan, Kota Karang Raya, Kota Karang	Pesawahan	Bumi Waras, Sukaraja
2	Low	Srengsem, Panjang Selatan, Pidada, Pidada Utara, Way Lunik	Way Tataan, Sukamaju, Keteguhan	Pesawahan	Bumi Waras, Sukaraja, Kangkung
3	Moderate	Srengsem, Panjang Selatan, Pidada, Pidada Utara, Way Lunik	Way Tataan, Sukamaju, Keteguhan, Kota Karang Raya, Kota Karang	Pesawahan	Bumi Waras, Sukaraja, Kangkung
4	High	Srengsem, Panjang Selatan, Pidada, Pidada Utara, Way Lunik, Karang Maritim	Way Tataan, Sukamaju, Keteguhan, Kota Karang Raya, Kota Karang	Pesawahan	Bumi Waras, Sukaraja, Kangkung
5	Very high	Srengsem, Panjang Selatan, Pidada, Pidada Utara, Way Lunik, Karang Maritim	Way Tataan, Sukamaju, Keteguhan, Kota Karang Raya, Kota Karang	Pesawahan	Bumi Waras, Sukaraja, Kangkung

The regions that have potential tsunami hazard in the coastal region of Bandar Lampung are mapped to see the magnitude of potential danger of tsunami and to consider the risks and vulnerabilities to the society. Thus, from the analysis, there are four districts that have higher potential danger of tsunami than the sub-sub-districts in the city of Bandar Lampung. The indicators are slope, topography, land use, inhabitants' jobs, available infrastructure such as houses and public facilities.The higher the level of infrastructure, economic level, education communities in the region, the lower the level of the potential hazards of the tsunami. If the infrastructure level is low, the community has low education., The higher the intensity of land use the higher the potential level of tsunami hazard. Subdistricts that have potential level of tsunami are Panjang, Teluk Betung Timur, Teluk Betung Selatan, and Bumi Waras.

Table 3. Size potential of tsunami according to each group

No.	Danger level	Area (Ha)
1	Very low	36.31
2	Low	60.37
3	Moderate	101.82
4	High	23.28
5	Very high	96.89
Total Size		**318.67**

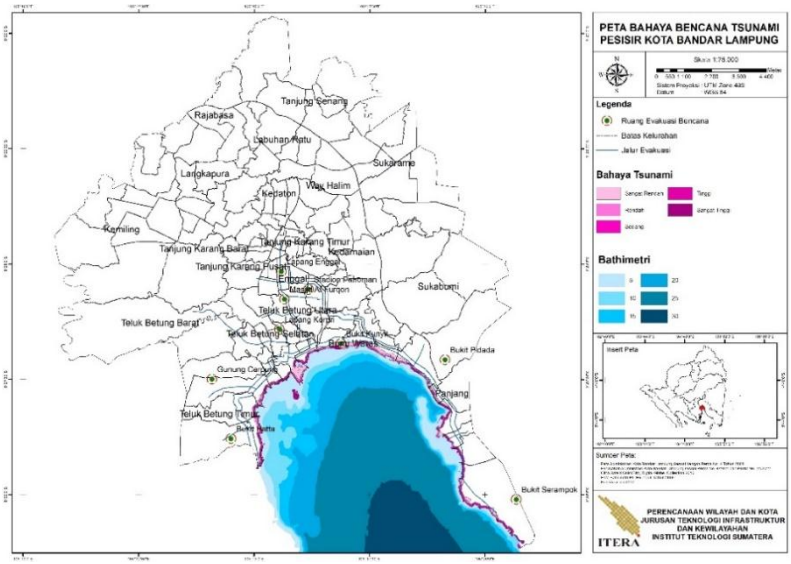

Figure 3. Map of coastal tsunami hazard of Bandar Lampung in 2017

Tsunami caused by the volcanic eruption occurred in Lampung Province in 1883; the eruption of Krakatoa in Lampung Province resulted in the Tsunami. Wave swept the beach of Lampung and Banten, where approximately 5,000 boats were destroyed and many small islands were drowned. The tsunami waves was about 40 Meter, as high as the 12-storey building, destroyed nearly 300 villages and killed more than 36,000 people. It was the biggest tsunami disaster in Lampung Province. Spatial analysis is based on the height of the tsunami.

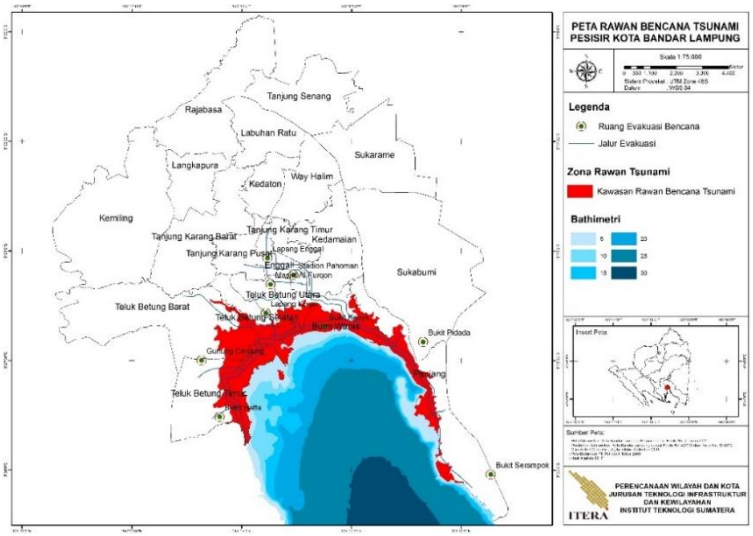

Figure 4. Map of tsunami disaster prone coastal of Bandar Lampung in 2017

Based on the tsunami hazard map of Bandar Lampung coastal areas, is the areas extremely have considerable potential because of high economic, physical, social and environmental vulnerability. There are still many developed regions or inhabitants' houses lie in the tsunami danger zone. The total population is estimated about 292.638 with a population density of about 110 person/hectare. In addition, the education level of coastal communities is low. 60% of the total population does not got to school. Infrastructure protection structure which does not meet the standard is not feasible anymore. the government policy in facing the tsunami disaster and the institution capabilities in tsunami preparedness are still low.

In social vulnerability, the education level is still low and the majority of inhabitant are fishermen. Then, in the physical vulnerability, the infrastructure is old and not well-maintained so that it becomes slum area. It indicates that the level of preparedness in facing tsunami is still low. The criteria of resistance elements are measured from governance, society and economy, coastal resource management, land use and structural, risk knowledge, warning and evacuation, emergency response and disaster recovery. These criteria of resistance elements are still low and it needs to review so that the level of community resilience in Bandar Lampung coastal areas to the tsunami is high.

From the observation and analysis, it was then applied to the concept of mitigation of the tsunami disaster in coastal area of Bandar Lampung horizontally by combining some points that can be used as a tsunami evacuation space, namely Kunyit hill, Hatta hill, Pidada hill, Serampok hill, Cerpung mountain, Al-Furqon mosque, Korpri ground, Enggal ground, and Pahoman stadium. It can be combined with the Spatial Plan of Bandar Lampung. The level of vulnerability to information and communication technologies is being developed at this time. The vulnerability of social, physical, economic, and environment can be reduced, as well as the revitalization/rejuvenation of the residential neighborhood of fishermen in coastal areas of Bandar Lampung. Then, the mitigation of hall construction needs to be done to accommodate the victims of disasters. Model and mitigation concepts used are by combining the technology and the tsunami disaster mitigation as an integrated system of pre-disaster, during disaster and post-disaster to make Bandar Lampung have resilience to tsunamis.

4.2 The tsunami disaster mitigation

Based on the history of the tsunami disaster in Lampung Province by Krakatau volcano eruption, the sea waves caused by this eruption swept the beaches of Lampung and Banten, damaged the environment, left many people dead, damage and material loss. To avoid or mitigate the tsunami disaster that can happen anytime and anywhere, it is necessary to have an attempt to reduce this so-called disaster mitigation.

Tsunami disaster mitigation measures that reducing vulnerability and increasing the capacity of a local tsunami will result in low level of risk. Some activities that can reduce the risk of tsunami are:

1. Relocation of residents living in areas prone to tsunami;
2. Disaster preparedness training for residents in the area;
3. Prepare homes or public facilities that disaster response;
4. Building anti-earthquake and anti-tsunami structure;
5. Creation and dissemination of local knowledge on disaster;

Moreover, in terms of information and communication technology can also be applied in the process of tsunami disaster mitigation. The development and planning of natural disasters mitigation, such as tsunamis, can take advantage of the IOT (Internet of Things) development, which is Embedded system. The use of seismic sensors such as ADXL335 Adruino pre-earthquakes tool vibrations placed on land and in the sea is to read the vibrations that occur on earth in the sea area. Basically, the tsunami is caused by the vibration and faults in the earth's crust under the sea, causing the flow of tsunami waves. Seismic sensors under the sea will read the vibration of the earth's crust under the sea. The sensors will be connected to a flare marker buoys as a means of information to nearest disaster mitigation center (example: lifeguard, or the Agency for Meteorological and Geophysics) using wireless sensors. The information against the danger of tsunami will spread from the center of disaster mitigation through short message transmission systems mobile devices located in the region of Lampung Bay (Coastal Zone of Bandar Lampung) and the use of sirens warning as a sign of the danger of tsunami.

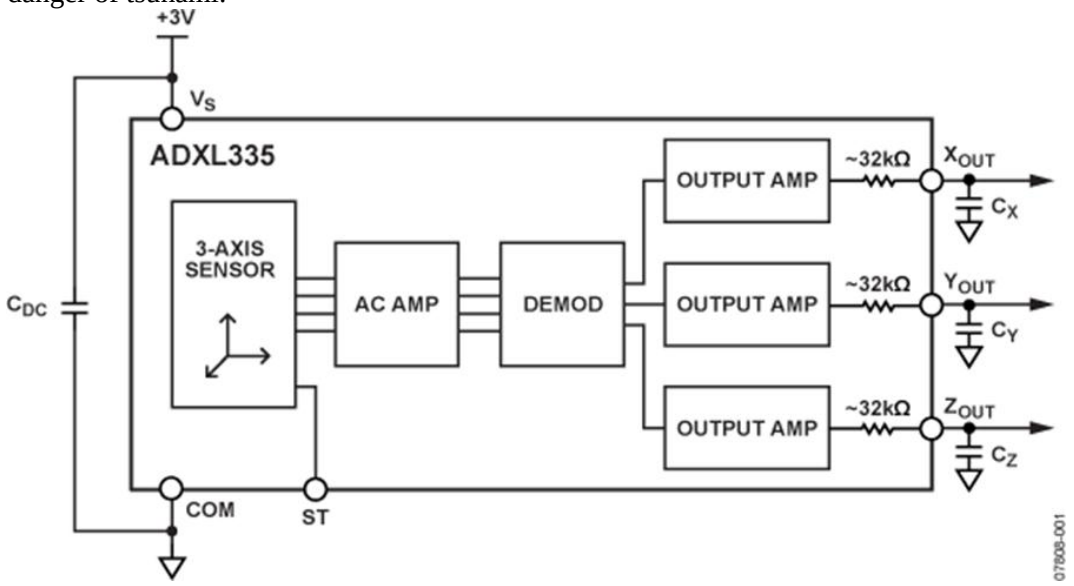

Figure 5. Accelerometer circuit of ADMXL335 [12]

The circuit uses the Arduino Uno board connected to the ADXL335 accelerometer module (connected in CON2) with its ADC input, namely A0 to the X axis, Y axis and Z axis A1 to A2. Two push-buttons via a 5V supply are connected to an Arduino Uno interrupt pins 2 and 3 and pulled to the ground through a resistor R2 and R1. This button is used for increasing and decreasing the threshold of vibration detection. LCD 16 × 2 (LCD1) is connected to a 4-wire mode with contrast control and backlight Arduino pin enabled.

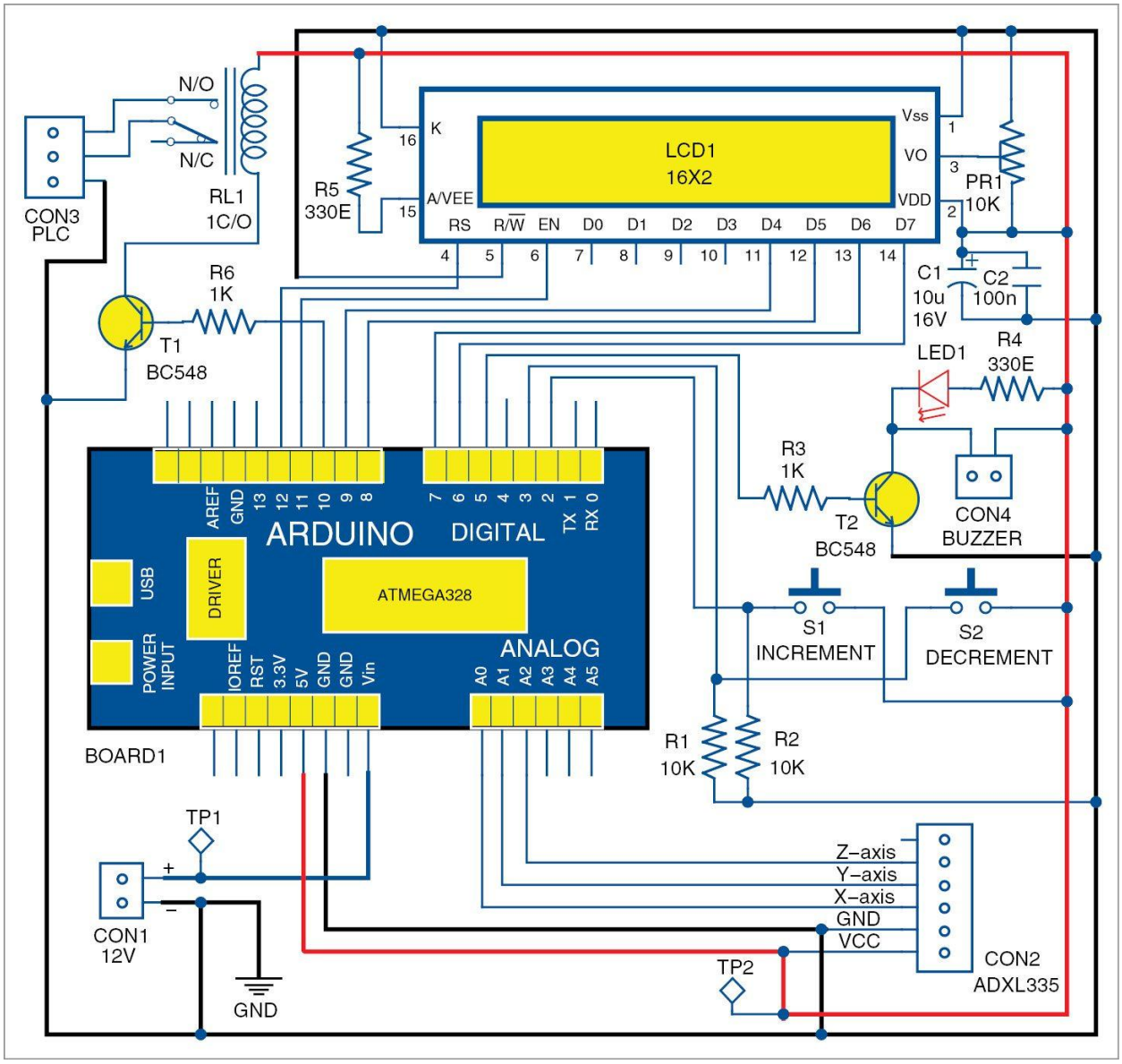

Figure 6. Earthquake Arduino indicators [13]

The wireless sensors are installed on the circuit that can deliver messages in real time with a considerable distance. The tool is typically used for volcanoes to find out when the evacuation of the vibration level of the earth. Since its function is to read the vibration, there is a possibility for the establishment of a new development to cope the tsunami by the earthquake.

5. Conclusion

The above discussion can be summed up as follows:

- Bandar Lampung is one of the vulnerable zones of the tsunami disaster because the southern coast of Bandar Lampung is a bay prone to tsunamis and has potential against earthquakes, floods, and environmental degradation in densely populated settlements along the coast. The potential of the tsunami disaster in Bandar Lampung was not only from the earthquake, but also from the volcano eruption of Anak Krakatau in the waters of the Sunda Strait, which increased the potential of high tsunami disaster.

- There are four sub-districts, namely Panjang, Teluk Betung Timur, Teluk Betung Selatan, Bumi Waras, have a higher potential tsunami hazard than other sub-districts in Bandar Lampung by considering slopes, topographic, land use, occupation dominance, and infrastructure available such as houses and public facilities.
- The height of the tsunami caused by the eruption of Mount Krakatau is a reference of spatial analysis to map tsunami-prone areas in the coast of Bandar Lampung of 1,536.02 hectares with a height of 40 meters tsunami wave covering some sub-districts,Teluk Betung Timur, Teluk Betung Barat, Teluk Betung Selatan, Teluk Betung Utara, Bumi Waras, and Panjang.
- The concept of tsunami disaster mitigation in the coastal area of Bandar Lampung City is proposed horizontally by making some points as a place for evacuation space of tsunami disaster. Spatial Plan of Bandar Lampung can be combined with the current use of information and communication technology by utilizing development of IoT (Internet of Things), that is Embedded system. The tool is designed with the addition of wireless sensor on the circuit that can deliver the actual message with a considerable distance to the vibrations generated by the earth.

6. Suggestion

To fix the lack of this research, some suggestions for further studies are given as follows.

1. Minimize the coverage area of research, to produce more representative and comprehensive results in analyzing the resistance of a region and planning the area and region to mitigate the disaster in more detail.
2. Deepen the analysis for each aspect to measure the level of resistance of a tsunami region and propagate variables/indicators to get better results and test the validity of the data.
3. The need to reduce the level of tsunami hazard risk is done by 1) the structure and infrastructure of the coastal protection building and 2) non-structural (spatial policy).
4. The government of Bandar Lampung is supposed to simplify the bureaucratic system and to revitalize the coastal areas of Bandar Lampung with attention to the inhabitants so that the coastal areas of Bandar Lampung are ready for resistance tsunami disaster in terms of the government, society, economy, and so on, especially in the area of prone.
5. In the process of disaster mitigation in the era of globalization, advanced technology should be applied to minimize casualties from the disaster. The government should pay more attention on disaster-prone areas and allocate funds in terms of preparation, planning and implementation of disaster mitigation.

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