IDENTIFICATION OF ROUTE AND SAFETY ZONE FOR TSUNAMI EVACUATION MAPPING

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Abstract

This study was performed to produce an organized evacuation route that would be of help to the affected community from tsunami. The aim is to spot possible tsunami danger zones, evacuation location and the efficient and safe route towards the safety areas. Langkawi Island, one of the tourist attraction in Malaysia was one of the most affected regions due to tsunami waves in year 2004. Until today this area had experienced several tsunami warning due to earthquake occurrences in the west of Indonesia. Through the use of GIS and GPS technology, the study managed to identify the areas that are exposed to tsunami threats and the areas suitable for tsunami evacuation. The work includes the study of the terrain, existing route, details of building structures and its location and occupancy. The evacuation route map produced will increase the level of public awareness to always prepare and vigilant in facing tsunami treat. The map produced through this study is the first ever developed for Malaysia and will be used as the guidance for the development of more tsunami evacuation plans for other areas.

Introduction

Tsunami Evacuation Map refer to a drawing or representation that outlines danger zones and designates limits beyond which people must must be evacuated to avoid harm from tsunami waves (IOC, 2006). The tsunami is a big tide wave formed caused by the earthquake, seaquake, and volcano eruption or meteorite hit into the sea (Lida, 1985). Tsunami wave is capable to move as far as a thousand miles across the ocean and when it reaches the coast line, its speed will decline temporarily and the wave height will increase. Tsunami can afford to destroy the entire city adjacent to the sea and causes loss to a lot of lives. Open coast, gulf and downstream are which located near the sea is the most potential area for tsunami threats. Most death cases are originated by unawareness of tsunami threat. Therefore, it is imperative that each potential area with tsunami threat needs to be informed with the tsunami danger zone, evacuation zone and route towards the evacuation zones. With the support of GIS software, mapping processes for the study area have been easier because of the ability of the software to link data to digital map that enables the design, storage, maintenance, processing, analysis and display of various graphics and information.

Research area and Demographic data

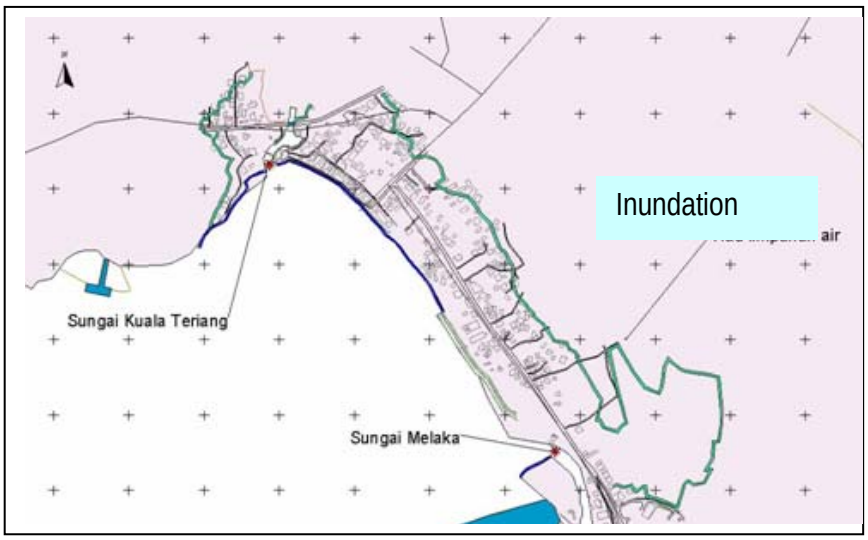
Study area

The study areas (Figure 1 and 2) for this research are located at three villages namely Kampung Kuala Melaka, Kampung Kuala Teriang and Kampung Batu Ara. These villages are the most affected area in the Langkawi Island, Malaysia. The topographical characteristic of this area is almost flat for the entire area except for Kampung Batu Ara which is situated at higher elevation. The highest levels of Kampung Kuala Melaka, Kampung Kuala Teriang and Kampung Batu Ara are 3.371 m, 4.839 m and 4.938 m respectively.

Demographic Data

The total population of these three villages is as many as 1,823 people and the number of residential is 375 units. Most people in this villages work in various sectors such as in hotel industry, fishing, government agencies, farming and business (Ghazali et al., 2005)

Figure 1: Location of Langkawi Island and the epicenter of Tsunami 2004



Methodology

To develop a systematic evacuation map, detail planning and necessary spatial data needs to be organized in a proper manner. Site investigation were done to identify areas that are exposed to tsunami threat. Existing roads were identified to be used as evacuation routes. All demographic data and related information were gathered systematically to facilitate zonings. Initial planning was strategize to facilitate evacuation map production process in the GIS software.

Data Classification

The field survey map is the main medium and plays big roles in any GIS database. This plan is classified into separate spatial data. There are three main component graphic data which are area (polygon), line (arc) and point (node). Classification of spatial data according to its component can be referred to table 1.

Graphic data	Spatial data classification
Area (poligon)	Building, Risk area, Height area, Evacuation area, Deviation zone
Line (arch)	Main road, mini tar and rivers
Point (node)	Tsunami signboard location

Table 1: Classification of spatial data according to graphic data

Identification of Tsunami danger Zone

Identification of tsunami danger zone is made based on survey work through distance inundation maxima revenue land which was done by the Malaysia Department of Irrigation and Drainage (JPS, 2005). The distance is 580 meter from the coastal line. Based on earthquake of nine Richter scale, tsunami danger zones are marked in range of 600 meter from the coast. This study areas are divided into several zones according to the population density, evacuation area, suitable existing road which can be used as evacuation route and period of time for functional. Demography data and household information were uploaded into the GIS. From the encoding process, tables and images can be linked accordingly. All other geographic features and their attribute were encoded to generate a systematic evacuation map. Summary or flow chart for evacuation map production is shown in figure 3.

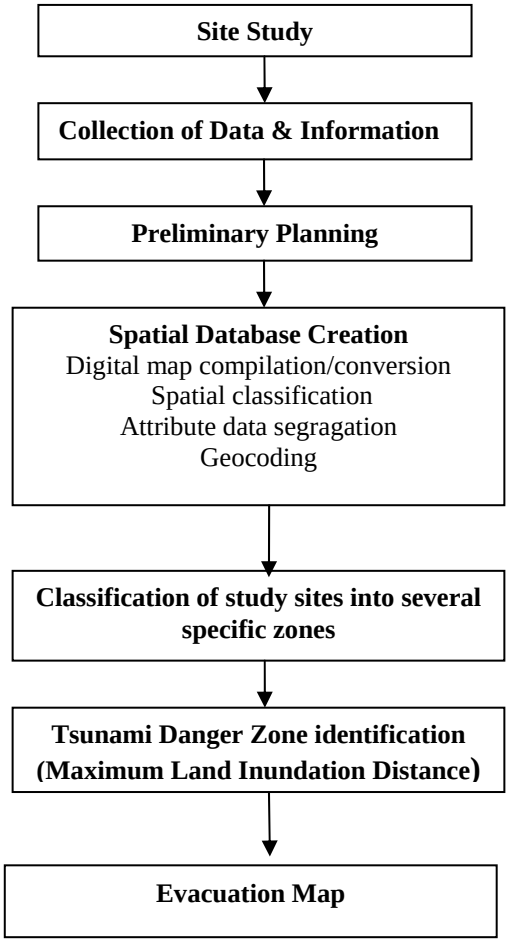


Figure 3: Flow chart of evacuation map production

Site Investigation

With respect to the practice done worldwide on assessing the tsunami risk, following procedures briefly explains on the work done on the ground to investigate the current situation especially on the topographical features and the general activities of the affected site. This will lead to the proposal of an evacuation planning and mapping that shows the affected areas and route leading to safe places. Base on the tsunami risk assessment method implemented in the affected countries such as Japan and United States, the following actions were undertaken.

i. Compilation of maps and feature attributes
The spatial data in the form of topographic map of the area plotted from field survey work were obtained from Drainage and Irrigation Department. Further data collection and verification were done and added to the map.

ii. Classification of areas into several zones
The area of study was divided into several zones, using the boundaries of the existing villages.

iii. Identification of hilly areas, slopes and route leading to safer places
This study was based on the field survey data and also a workshop with the local community. Several strategic locations were identified. Some of the safer locations need to have safety structures (tower/building) built for safe refuge.

iv. Identification of tsunami hazard zone and evacuation centre
A site visit were done together with the community leader to verify boundary of the previous affected areas and a ground thruthing were done to clarify the identified location for evacuation center. The evacuation centre must fulfill certain criteria base on vertical and horizontal evacuation distance.

v. Identification of existing road network for evacuation routes
This work involves study on existing road network, location of physical structures, and identifying strategic positions to place the evacuation signage. The location should be placed along roadways and pathways to indicate the direction inland or to higher ground. In some places, there may be more than one direction available to reach safer areas. These routes should be marked with several signs showing additional options for evacuation.

vi. Identification of substantial buildings (minimum 3-storeys high)
Based on the map and site visit, all possible structures were visited to check the possibility to be the evacuation places. That's including the nearest hotel, schools and bridges (Ahmadun et al., 2007).

Results and Discussion

The main products of this research are evacuation maps (Figure 4 and 5) that show the tsunami danger zone, evacuation zone, road leading to the evacuation zones and community's center that can be placed with warning siren for tsunami. This study area has been divided into 4 large zones which are Zone A, Zone B, Zone C and Zone D. Each of these zones was divided into 12 separate zones (Figure 4). This zoning will facilitate the process of monitoring by the authorities and representative of each zone will give report from time to time.

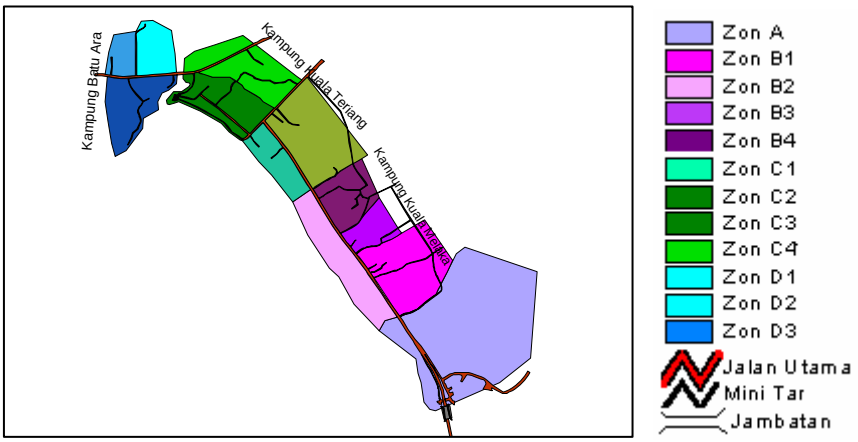


Figure 4: Zone Division

There are 33 routes and 4 evacuation areas that are suitable to be developed as a preparation to face any tsunami event. Evacuation area is selected based on the capacity to accommodate people and its location should be sufficiently far from tsunami danger zone. A tower is proposed each in zone A and zone B because residential areas in these zones are situated far from the present community center. Each house has its own evacuation access which can help to accelerate the evacuation process and reduce accidents that can cause loss of life. Main roads to be used as evacuation roads should have an average of 8 meter width and for mini tar

is about 3 meter width. Tsunami warning siren location must be correctly located in the middle of residential area.

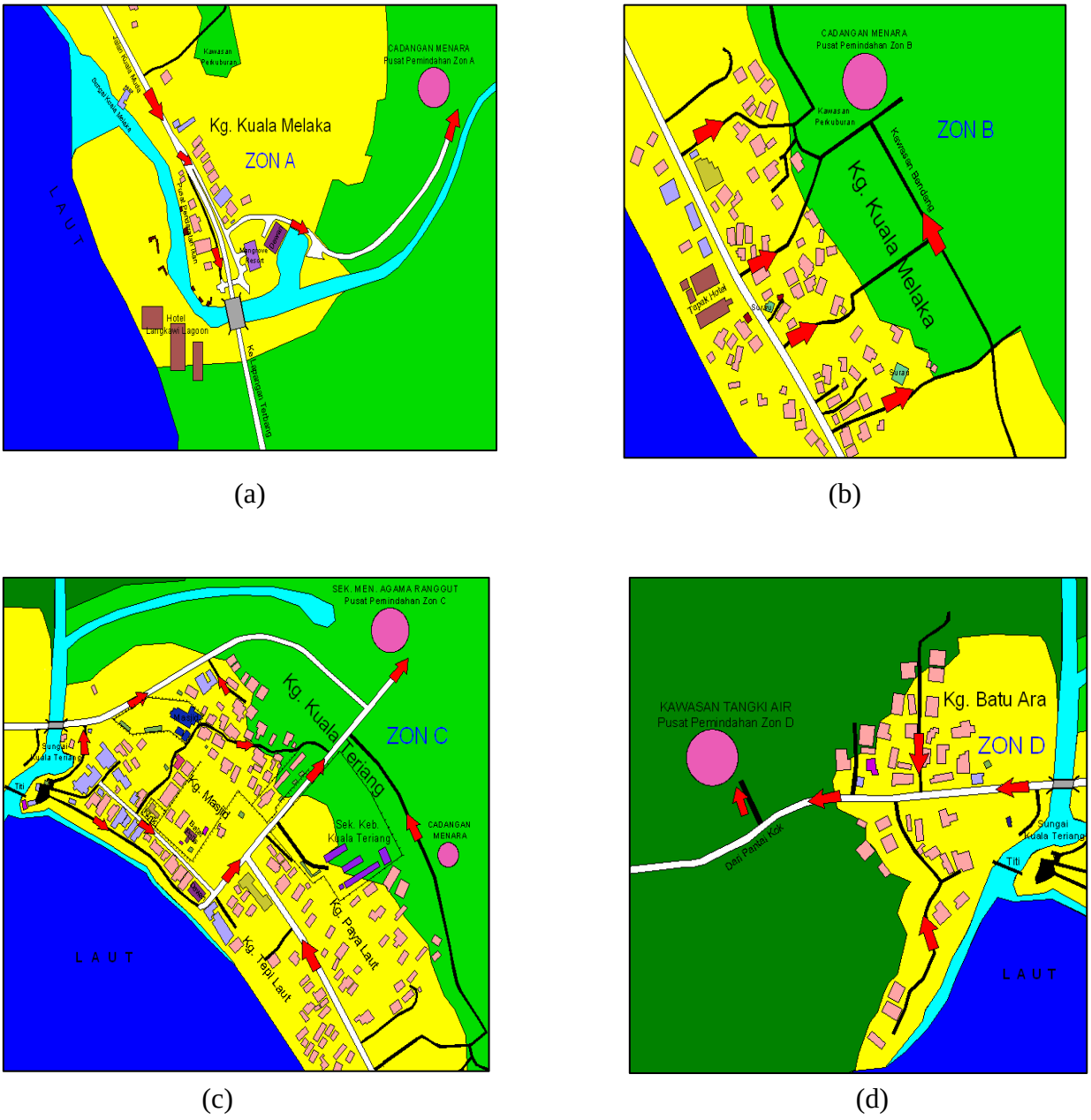


Figure 5: Evacuation map for each zone; (a) Zone A, (b) Zone B, (c) Zone C, (d) Zone D

Another technique that can be practiced to assist the evacuation process is the use of tsunami signboard (Darienzo, 2003). Through this study, five types of tsunami signboards have been designed that can be placed in strategic areas (Figure 6). For example, tsunami danger zone signboard must be placed in public center and costal area. Blue color is used for the background, while for text and sketching tsunami wave, white color is used.

Figure 6: Tsunami Signboard Design

This study has also identified several steps in preparation of tsunami encounter. It is suggested that the existing rivers and coastal waters to be upgraded such as depth improvement and planting of buffer trees such as mangroves. Seawalls are also necessary to be created as breakwater and ladder should be constructed as evacuation route. Apart from that, early education and exposure about tsunami can also help to increase tsunami awareness and evacuation strategies. Pamphlets regarding tsunami and evacuation map needs to be distributed to the villagers as reference and additional information.

Conclusion

This study has created systematic evacuation map for the affected areas. Through this map, people can easily identify evacuation route, evacuation area and tsunami danger zone area and thus, can reduce the extent of damage and loss to lives that may happen in a tsunami event. Evacuation map needs to be distributed earlier and education about tsunami need to be applied to villagers involved, so as better preparation can be made. However, the evacuation map produced would be ineffective if there is no regular training on evacuation being given to the people on how to stay calm and responding correctly to the predefined evacuation plans.

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Author Biography:

The authors are the lecturers of the University Putra Malaysia whom are actively involved in teaching, research and consultancy jobs in emergency response planning. They have been energetically involve in giving the tsunami education to the community in the affected areas as part of their obligation to the public.