CHAPTER 5

GEO-INFORMATION BASED TSUNAMI RISK 3D VISUALIZATION

5.1 Introduction

Coastal areas have always been the most preferred location for settlements. It is because the attractiveness of coastal areas and many economic opportunities providing by coastal areas. Because of these factors and also the long gap between tsunami destructive events, coastal people tend to develop new housing, marine facilities, and resort development. These make people and facilities are threatened by the destructiveness of tsunami. The 26 December 2004 tsunami devastated the coastal environment around the Indian Ocean and the lives of many millions living in coastal areas. Gujarat state has the longest coastline in India about 1600 km, and has massive capital and infrastructure investments in its coastal regions. The coast of Gujarat is prone to many disasters in past. Some of the most devastating disasters that have struck the state in the last few decades include: the Morbi floods of 1978; the Kandla (port) cyclone of 1998; the killer earthquake in Kutch, January 26th 2001; and the flash floods in south Gujarat in 2005 and in Surat in 2006. Also in the past the coast of Gujarat was affected by tsunami (Jaiswal et al., 2009; Singh et al., 2012).

With rapid developmental activities along the coastline of Gujarat, there is a need for preparing tsunami risk 3D visualizations database using geo-information technology. Geo-information techniques have proven their usefulness for the purposes of early warning and emergency response (Bandrova et al., 2012). Displaying spatial data in 3D allows decision makers to easily gain a clear understanding of the physical environment at time disaster, after disaster and before disaster. Visualization is the
graphical presentation of information, with the goal of improving the viewer understands of the information contents. Comprehension of 3D visualized models is easier and effective than 2D models. 3D visualization models are important tools to simulate disaster from different angle that help users to comprehend the situation more detailed and help decision makers for appropriate rescue operations. 3D visualizations are tools for rescue operations during disasters, e.g., cyclone, tsunami, earthquake, flooding and fire, etc.

3D visualization has a big potential for being an effective tool for visual risk communication at each phase of the decision-making process in disaster management (Kolbe et al. 2005; Marincioni, 2007; Zlatanova 2008). 3D visualisations have the potential to be an even more effective communication tool (Kolbe et al. 2005; Zlatanova et al. 2002). Previous studies have shown that the presentation of hazard, vulnerability, coping capacity and risk in the form of digital maps has a higher impact than traditional analogue information representations (Martin and Higgs, 1997). Graphical representation significantly reduces the amount of cognition effort, and improves the efficiency of the decision making process (Christie, 1994), therefore disaster managers increasingly use digital maps. Better disaster management strategies can be designed by visualization. The advances in Geographical Information System (GIS), Remote Sensing (RS) and Computer Aided Design (CAD); supported visualization have a potential to improve the efficiency of disaster management operations by being used as a risk communication tool. 3D models particularly the city and building models are created by CAD software and scanned into computer from real world objects. The 3D visualization and animation can be performed by GIS, RS and CAD, and are powerful tool for conveying information to decision making process in natural disaster risk assessment and management.
5.2 GIS/CAD Modeling Work Steps

In these study a simple methodology developed by generating 3D model of Okha coast, Gujarat (Figure 5.1). The 3D tsunami risk model of Okha coast and tsunami risk zone maps of Gujarat’s coast will be supportive to the tsunami emergency response system and useful in planning the protection measures due to tsunami. The method and execution of the work is shown in a comprehensive flow diagram (Chapter 1; Figure 1.9). The method involves two basic phases. There are: 1) Numerical simulation of tsunami wave, and 2) Geo-information based tsunami risk 3D visualization. The numerical simulation of tsunami wave discussed in previous chapter. The generation of tsunami risk 3D visualization model carried out in two stages.

Figure 5.1: Region selected for generation of 3D Visualization Model
5.2.1 Raster Layer Operations

The first step of raster layer operation is geo-referencing of satellite images. Satellite images collected from Google Earth orthophotos were used for geo-referencing. Nine pairs of images (RGB, jpeg format) from Google Earth cover the study area. There was an average of 12 GCPs (Ground Control Points) collected for each image registration. The World Geodetic System 84 (WGS84) geographic projection was selected for image-to-image registration with Digital Globe image. After creating the geo-referenced images, all images are mosaiced to generate a whole geo-referenced image. The mosaiced result image is given in figure 5.2. The next step of raster layer operation is the digital elevation model (DEM) generation. A DEM is defined as a file or a database containing points over contiguous areas (Manual of photogrammetry, 2004). The needed field height data for DEM generation can be obtained from point, line or polygonal vector height maps or stereo satellite/vector images. The SRTM data were used to create DEM. The geo-referenced image and DEM results constitute the basis of vector layer operations. This study uses SRTM data to generate the tsunami risk zone map.

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uses SRTM data for generate tsunami risk zone map. The geo-referenced image and DEM results constitute the basis of vector layer operations figure 5.4.

Figure 5.2: Geo-referenced image of the Okha coast, Gujarat

Figure 5.3 Coastal area of Okha potentially affected at different sea level rise scenarios
5.2.2 Vector Layer Operation

The purpose of 3D GIS/CAD modeling was the thematic visualization of the disaster vulnerability of the Okha on generated 3D model. The geo-referenced image of the Okha coast was used for 2D building footprint creation in AutoCAD Map 3D. AutoCAD Map 3D provides access to GIS and mapping data to support planning, design, and data management. The building footprints layer was extruded according to height value governed by the number of floors to create 3D building shapes.
Figure 5.5: 2D building footprint of the Okha coast, Gujarat
This shows maximum extent of inundation with every 1m rise in sea level. In figure 5.6 coastal structure overlaid on digital elevation model and that shows structures potentially affected at different sea level rise scenarios.

*Figure 5.6: Structures potentially affected at different sea level rise scenarios*

The creation and visualization of the 3D model is an endless operation. The generated 3D tsunami risk model of Okha can be seen in figure 5.7a, figure 5.7b and figure 5.7c from different viewing angles. A red, blue and green colours scheme was used by their respective susceptibility to tsunami risk as shown in figure 5.8. The classification of tsunami risk zone (susceptible zone) is based on elevation.
It is believed that the digital topographical data has great importance to detect tsunami prone area. The Shuttle Radar Topography Mission (SRTM) is used to provide digital elevation information. Based on the processed SRTM data in GIS/CAD, all low-lying coastal area potentially at risk of tsunami flooding have been identified and are shown in figure 5.8. The classification of tsunami risk zone is based on elevation vulnerability followed by Sinaga et al. (2011).
Figure 5.8: Classification of tsunami risk zone
5.3 Results and Conclusion

As a part of a tsunami emergency response system, the 3D coastal maps should be produced for countries in the vicinity of the MSZ, namely Pakistan, India, Iran and Oman. The lessons learnt from the December 2004 tsunami could be used for future planning. Ports, jetties, estuarine areas, river deltas and population in and around the coast of Pakistan, India, Iran and Oman could be protected with proper methods of mitigation and disaster management. In the future, scientists/researchers need to focus on 3D visualization and animation of tsunami risk. The study was performed to show the advantages of 3D GIS/CAD models and satellite images in tsunami risk assessment of the Okha coast, Gujarat. The main aim of the 3D Okha model is to visualize each building’s tsunami risk level which improves decision-maker's understanding of the disaster level. Merging of SRTM elevation data with satellite images is suitable for tsunami risk zone classification.

Combining the advanced computer-aided modeling, GIS-based modeling, marine parameter measurements by ocean bottom seismometers and satellite, installations of tide gauges and tsunami detection systems and also using conventional
and traditional knowledge, it is possible to develop a suitable tsunami disaster management plan.