UTILIZATION OF SPACE BASED TECHNOLOGIES FOR DISASTER RISK REDUCTION (Delta Region, Myanmar)

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Abstract: Delta region, southern west of Myanmar, is a low land area and naturally vulnerable to natural hazards associated with severe loss of lives and wealth. During the years from 1948 to 1994, Myanmar has been hit by 10 serve tropical cyclones. 'MALA' Cyclone(25/4/06), TORNADO (28/4/06) and Nargis (3/5/2008). Cyclone Nargis is the worst one and accompanied by storm surges. Cyclone hazard zonation is necessary to emphasize after the devastating cyclonic surge of May 2008 when about 150,000 people lost their lives along with other damages. This study used Geographic Information Systems (GIS) together with Remote Sensing Technology for Disaster Risk Reduction. The Storm Surge Model was applied to generate different cyclone hazard zones which is helpful to mitigate the impact of cyclones and is essential for Disaster Prevention and Preparedness. Hazard zonation Maps have been prepared taking into consideration storm surge depth, the geomorphological Map and the Digital Terrain Model (DTM). Images of inundation for different surge heights corresponding to different return periods were produced by using the spread functions of GIS. Images of inundation depths were also produced using DTM and the Geomorphological Map.

INTRODUCTION

The study area 'Delta Region' which is also called 'Ayeyarwady Division' is situated in the South West part of Republic of Republic of the Union of Myanmar. It is a kind of low-lying coastal area and being an alluvial plain by its geographical nature, the area is naturally vulnerable to seaward hazards and cyclonic storm surges. The area was affected by the cyclone of May 1975, cyclone Mala of April 2006 and cyclone Nargis of May 2008. The death toll and damage is extremely high in the case of Cyclone Nargis in compare with the previous cyclones. Collective assessment data from the authorities and international communities indicates that more than hundred townships were significantly affected by the cyclone Nargis. According to official Figures, 138,373 people were missing or dead, houses and over 4000 schools were destroyed in more than 6000 villages by the Nargis. It is said that the impact was severe due to very high vulnerability of the area such as very low lying and most populous region, many tributaries and less high ground, impede efficient response and less awareness, no developed hazard Maps and risk assessments for that region. Moreover, it was also point out that 90 percent of the deaths were caused by a direct consequence of the storm surge. Bearing in mind with these facts, the 'Delta Region' is selected as the study area and the disaster type for the case study is emphasized on 'cyclone hazard' for supporting future risk reduction in the area integrating of remote sensing and GIS. Remote sensing and GIS is nowadays an essential tool in monitoring changes in the earth's surface, oceans and atmosphere, and is increasingly used as the basic for early warning for hazard modeling, like topography, lithology, and land cover. The use of spatio-temporal data and geographic information technologies have now become part of an integrated approach to disaster risk management. New GIS algorithms and analysis/ modeling techniques are revolutionizing the potential capacity to analyse hazards, vulnerability and risks. One of the key advantages of using GIS-based tools for the risk decision-making process is the possibility to use "what if" analysis by varying parameters and generating alternative scenarios in a spatial context (Longley et al.2005). Earlier publications on this topics can be found in Wadge et al.(1993), Coppock(1995), Emani(1996), and Kaiser et al.(2003).

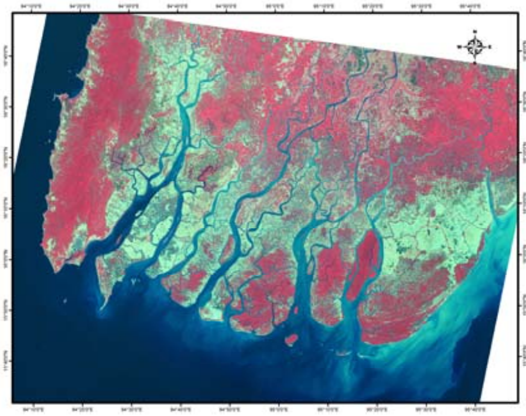


Figure 1: Study Area (Landsat TM 2000, False Color Composite: RGB=432)

CYCLONE FLOOD MODELING

A number of hydrodynamic numerical models have been developed for storm surge generation and propagation. This approach was quite successful in predicting flooding due to a major tsunami in the Chile(Hebenstreit et al., 1985). A very extensive and thorough study by Lewis and Adams (1983) resulted in a complicated numerical solution for the one – dimesional problem only. Kowalik and Bang (1987) derived a solution using a different numerical algorithm, but again, only to the one-dimensional case. Hibberd and Peregrine (1979) studied the runup and back-wash by considering the long wave equations together with the wave front condition represented by a bore. In this paper, Surge Decay Coefficient was used to generate the hazard Map, vulnerability Map and risk Map for study area and the input parameters like surge height and total inundated area are considered based on the surge level of cyclone Nargis 2008 event and post-cyclone field observations depicted in "Cyclone Nargis Storm Surge Flooding in Myanmar's Ayeyarwady River Delta". The study area, Delta region, was shown in figure (1).

Surge Decay Coefficient (SDC)

Before preparing the surge inundation Maps, we have to find out 'how the surge depth decays in land'. This parameter is called Surge Decay Coefficient (SDC). The Surge Decay Coefficient (SDC) is a function of the friction caused by surface forms (morphology, embankments and elevated roads) and land cover (houses, rice fields, homestead gardens with trees, etc.). By that definition, the inundation Maps will be developed assuming that the surge height decreases with SDC starting from the shore line to further inland depending mostly on the distance from the shoreline and elevation of the study area. For the modeling, the flood height of 7.5 m Nargis case with the total limit of inundation from the coastline as 60 km is taken. Constant surge depth in the first strip along the coast is taken as 4 km.

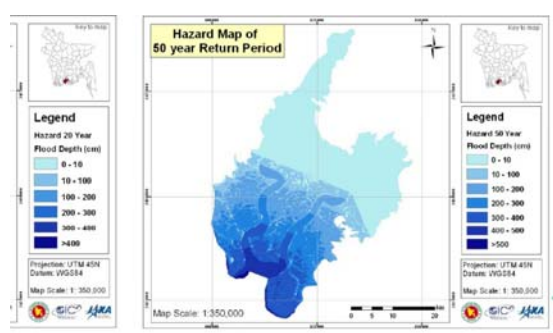


Figure 2(a): Hazard Map of Bangladesh

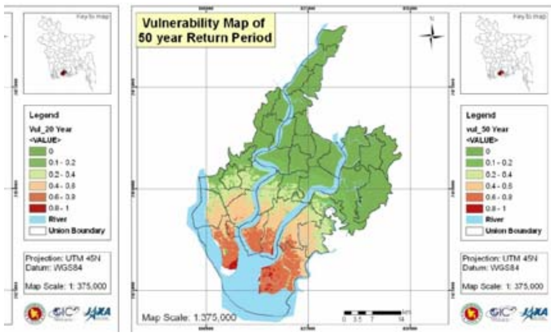


Figure 2(b): Vulnerability Map of Bangladesh

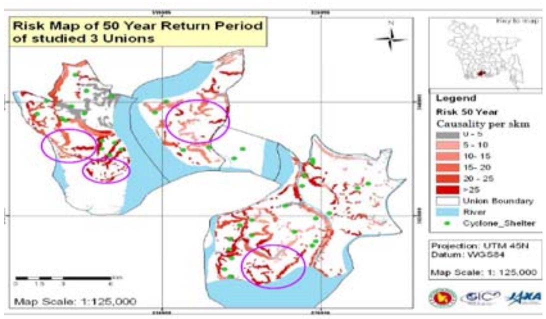


Figure 2(C): Risk Map of Bangladesh

Table 1: Relation between Flood Height and Inundated Area

Flood height	Area under constant surge (distance from coast in m)	**Total inundated area (distance from the coast in km)**
7.5	4000	60

Surge Decay Coefficient (SDC) is calculated by this formula:

$$SDC = \frac{\text{Surge height - Avg elevation of the land at end of the surge}}{\text{Width total inundated area - Width area with constant surge}}$$

The calculated SDC value from the above formula is to be used for surge modeling on 7.5m inundation depths. For visualization, the following figure (3-a) illustrates an example for a surge height of 7.5 m decay inland. The Nargis scenario Map was developed based on the inundation Map with decay from 4 km to 60 km using SDC value and the flow chart of methodology was shown in figure(3-b).

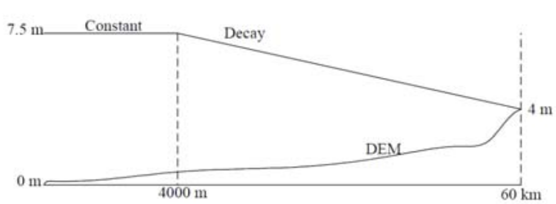


Figure 3(a): Illustration of 7.5 m Surge Height Decay in Land

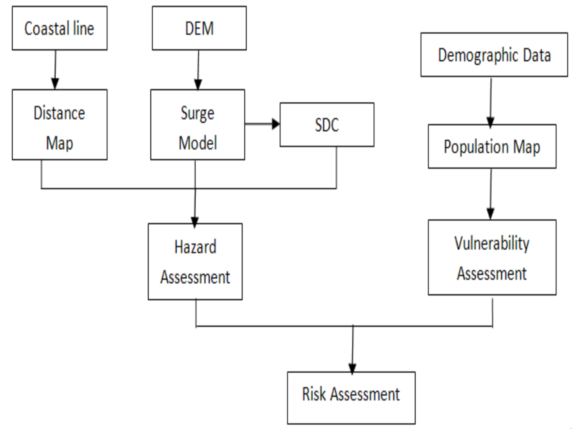


Figure 3(b): Illustration of 7.5 m Surge Height Decay in Land

Hazard Analysis

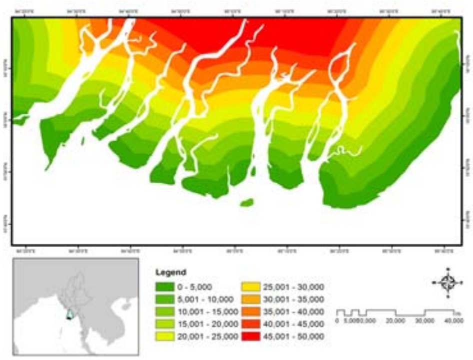
Following steps have been carried out to get Cyclone Surge hazard Map of Delta region, Ayeyarwaddy Division, Myanmar, using Digital Elevation Model(DEM) as a primary input Map.

(a) Distance buffer Map was generated from the coastline (Figure 4-a)

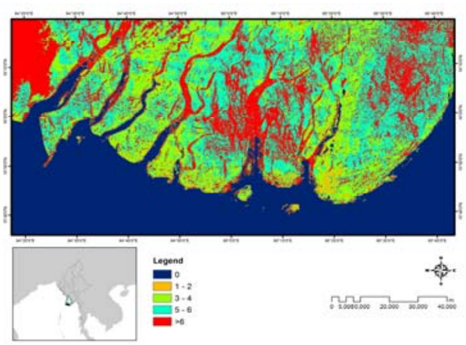
(b) Map calculation was done taking into consideration the distance Map, the Digital Elevation Model (DEM), data about the length of the area from coastline where the surge depth remains constant and the surge decay coefficients for that particular surge height. This was done to create a Map with the same elevations of the original DEM in the area of constant surge depth and progressively added “elevations” with distance from the coastline according to surface frictions (in other words surge decay coefficients for GIS analysis) (Figure 4-b). The equation for calculating modified elevations per decay coefficient with respect to the original DEM data is as follows:

Modified DEM(m)= (inundation distance – constant surge depth distance) (m) X Decay coefficient (SDC) (m) + DEM (m) (Original)

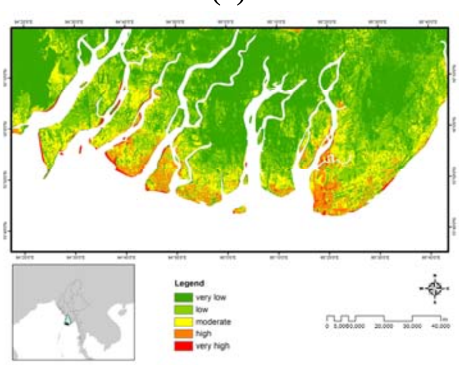
(c) The final hazard Map at the Nargis scenario will get subtracting the elevation Map from Modified DEM (Figure4-c)



(a)



(b)



(c)

Figure 4: (a)Elevation Map (m) (b) Distance Map (m) (c) Hazard Map

Vulnerability Analysis to the Population

The vulnerability of the people to flooding is the degree of loss to the total population, or particular categories, resulting from flooding by a certain depth. It has to be expressed on a scale from 0 to 1. The vulnerability is increased linearly with the flood depth. Therefore, for calculating vulnerability to people at different flood depth, the relationship between flood depth and vulnerability is derived from the following assumptions:

- Near the coast (15 km from the coast), the vulnerability is 0.7. Then calculate the average flood depth at 15 km by using surge inundation Map and distance Map started at the coastline.
- From the histogram of the 15 km flood depth Map, it can be seen that the average flood depth at that distance is 2.5 m.
- At some further distance from the coast (~30 km from the shoreline), the vulnerability is less and assumed as 0.3. The average flood depth at that distance is 1.4 m.
- The vulnerability of 1 is reached at an arbitrary depth of 3.2 m flood level that occurred around 4 km from the coast.

Based on the mentioned parameters, the vulnerability Maps can be obtained by multiplying Vulnerability Coefficient (Vc) with flood depth values of hazard Maps. In that case, Vc are calculated based on the assumption of flood depth and percentage of vulnerability. Calculated values of Vc derived from the relation of vulnerability and flood depth are summarized in Table 2, (Figure 5).

Table 2: Vulnerability Coefficient Values

Distance from coast	Flood depth (m)	Vulnerability	Vc

(km)			
-	0.0	0	0.0000
30	1.4	0.3	0.21429
15	2.5	0.7	0.36364
4	3.2	1	0.42857

According to Vc Map, it can be seen that the Vc of 0.0 m flood depth is obviously ‘0.0000’. The Vc of flood depth between 0.0 m and 1.4 m is 0.21429 and between 1.4 m and 2.5 m is 0.36364. The highest Vc of 0.42857 reached between flood height of 2.5 m and 3.2 m. Above the flood depth of 3.2 m the vulnerability is always 1.

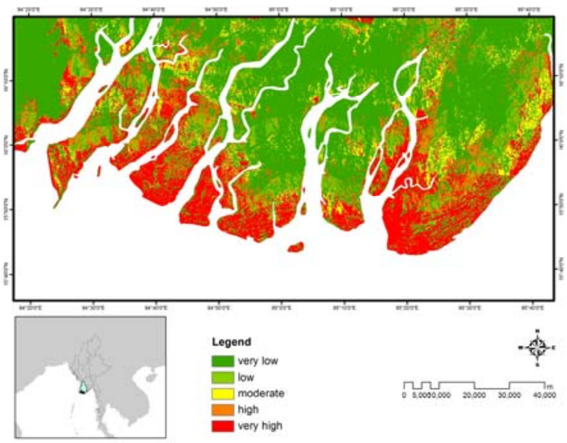


Figure 5: Vulnerability Map

Casualty Analysis

After making the vulnerability Maps, the number of population at risk were estimated for a certain surge height over the effected area. Since the casualty is depend on the vulnerability and number of people living in the area, we first need to calculate population density (figure 6) over the certain area for a certain categories of people such as children, men, women and elderly. For the risk analysis on total population, assume that 16% of population has been moved to safer places by early warning prior to the cyclone event (Figure 7).

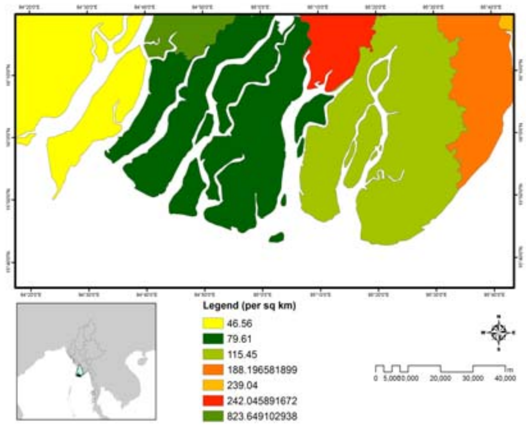


Figure 6: Population Density Map

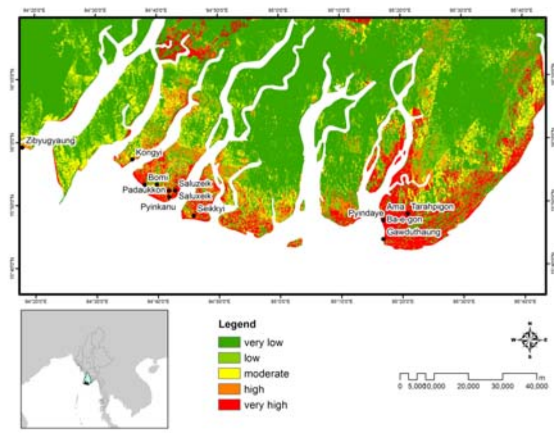


Figure 7: Casualty Map

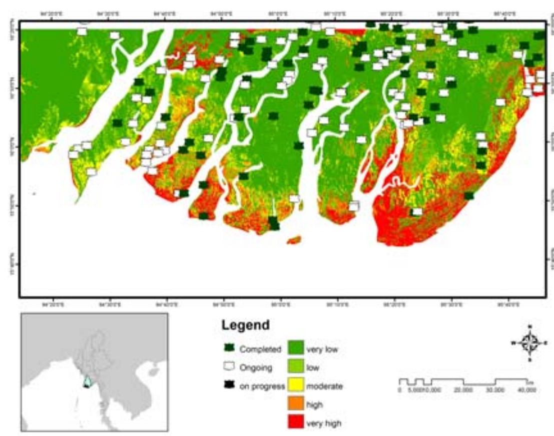


Figure 8: Location of Shelters

Table 2: Risk Area (%) of Study Area

No.	Risk Class	Area (%)
1	Very low	64.24
2	Low	7.80
3	Moderate	10.70
4	High	6.40
5	Very high	10.87

Results and Discussions

The analysis at regional scale shows that the coastal part of southern east of Delta region is the most susceptible area in terms of surge height. The fieldwork in the Delta Region (done by Myanmar Engineering Society, MES) gave the opportunity to gather actual information, by interviewing the local people, about the total water height and the limit to inundation by the surge water during the May 2008 cyclone. Flood level comparison was done using final hazard Map and the fieldwork data. Flood depth at different regions generated from model is almost matched with the field data and the accuracy is over 70%.

It was found that flood depth at Kyaukchaung, Pyinkanu and Bomi village is over 6m, the highest one, and at Zinbyugyaung, Ba-e-gon, Chaunggyi is greater than 5m. Konegyi, Saluseik, Tarapigon, Kywegyaung and Migyaungaing has flood depth range is between 3 and 4 m (Figure 3.c). All these villages belong to the most susceptible area where it is 10 km far away from coast line and the average elevation of these area refers to less than 3 m. Risk assessment of cyclone affected area was done based on both hazard Map, and vulnerability and exposure. According to Risk analysis result, it was found that very high risk area (red color in Map) is 9, 054.42 ha in area and the area, 17,533.24 ha was in high risk condition (orange color in Map). In figure 5, Ahmar, Bawathit and Kadonkani Township has the highest risk level and Saluseik, Pyinkhayaing and Konegyi township follow the second stage of risk level.

Conclusion

This paper portrays the ways and use of RS & GIS technology for reducing vulnerability to reducing disaster risk. Relation between surge height and inundation area is estimated based on the available data (DEM, coastal line, population, land use / landcover) in the case of cyclone Nargis in Myanmar Ayeyarwady Division. Total inundated area was predicted in proportion to the estimated flood level rises. From the resulted output of this exercise, it can visualize the vulnerable areas, risk areas and safe areas for evacuation. Moreover, it can be seen that casualty is directly related to the population density and vulnerability of the area. The results of the storm surge modeling show improvements in applying GIS by adding few parameters and simplifying the method. This model was mainly based on distance from coastal line and digital elevation data to generate Maps like hazard, vulnerability and risk zone and that's why it is very useful in emergency risk assessment case. It is very useful for not only in storms surge flood case but also in other flood risk caused by sea level high. The accuracy of this model is depended on the resolution of digital elevation model (DEM) data. The higher resolution of DEM, the more accuracy we can get. Here the DEM's resolution is 30 m and it is also suitable for regional scale and the accuracy is not more than 75%. This analysis is one example of the application of a Geographic Information Systems (GIS) in Disaster management. While deciding the location of cyclone shelters, the parameters that should be considered such as population distribution in the area, available road network and travel distance to the nearest shelters could be make out based on the products of this case study. Further research and fieldwork is however required on friction values of individual land use and surface forms to fully justify the methods used.

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