Application of Remote Sensing and GIS Technology in Natural Disaster Management and Rehabilitation

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ABSTRACT:

Cyclone Nargis was a strong tropical cyclone that caused the deadliest natural disaster in the recorded history of Myanmar. Satellite maps show that the storm's damage was concentrated over an area of about 30,000 sq km, stretching along the Andaman Sea and Gulf of Martaban coastlines. This area is home to nearly a quarter of Myanmar's 57 million people. Satellite images can be used to identify storm damage from multiple vantage points and can help with the planning of disaster recovery and rebuilding efforts. Images collected before and after Nargis slammed into the Myanmar coastline illustrate just how quickly flood waters rushed and swelled over the network of creeks that meander through the lower Ayeyarwaddy delta. Using pre-impact images and post-impact images, damaged area and risk zone classification can be done integrated with remote sensing and geographic information system (GIS) technique. It is firmly believed that the outcome result will surely contribute to foresee and target medical and other assistance in both ongoing and emergency relief efforts in Myanmar.

KEY WORDS: Cyclone Nargis, Remote Sensing, GIS, DEM, Pre-impact and Post-impact Images.

1. INTRODUCTION

Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use land cover are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales. These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. The intensity of tropical cyclones (hurricanes/ typhoons) has increased substantially over the past 50 years due to climate change.

Many of the coastal areas around the Bay of Bengal are densely populated and prone to flooding, making it easy for natural hazards -- unusually heavy monsoon rains, tsunamis or cyclones -- to become natural disasters. A disaster unfolded in Myanmar in early May 2008, as Cyclone Nargis swept over the Ayeyarwaddy River Delta, pummeling the area with high winds, storm surge, and heavy rains. Meteorologists figure that it achieved highest wind speeds of around 135 mph around landfall- that would be at the low end of category four on the Saffir Simpson scale, considerably above average for hurricane power. According to Wikipedia, Nargis is the deadliest named cyclone in the North Indian Ocean Basin, as well as the second deadliest named cyclone of all time, behind Typhoon Nina of 1975. Including unnamed storms, Nargis is the 8th deadliest cyclone of all time.

Remote Sensing tasks involving very large geographic areas and relatively small ones, analysis results presented in image format and in tabular format, and both qualitative and quantitative ways of evaluating analysis results, which have proven their usefulness in disaster management. Remote sensing and GIS provides a database from which the evidence left behind by disaster that has occurred before can be interpreted, and combine with the other information to arrive at hazard maps, indicating which area is potentially dangerous. Multi temporal data obtained from remote sensing satellites are the most suitable means which cover large areas with considerable reduction in time and efforts than needed for ground surveys. Many types of disasters, such as floods, droughts, cyclones, volcanic eruptions, etc. will have certain precursors that satellite can detect. This paper only refers to produce risk zone map and make a comparison with simulated result and result extracted from satellite images.

2. STUDY AREA

The Ayeyarwady Delta coastal zone is between the Mawdin point in the west and the Gulf of Mottama in the east. In the west, the deltaic land area is adjacent to the eastern foothills of Rakhine Ranges and in the east by the Sittaung River basin. The delta is a flat alluvial plain with a network of distributaries of the Ayeyarwaddy River and total area-coverage of the delta plain is not less than 35,138 km^2.

Majority of the catchment areas of Ayeyarwady and its major tributary Chindwin are located in the northern hilly region of Myanmar. The Ayeyarwady River, the most important river in Myanmar is about 2,170 km in length. The Chindwin River, 960 km long, joins the Ayeyarwady River at the centre of the Lowlands. The two rivers flow across the country longitudinally and the river basin occupies the vast area of the central Myanmar. This river basin trending north-south along the centre of the country is known as Central Lowlands of Myanmar. In the south, the river enters the Andaman Sea and forms a vast delta of 240 km in width and by 210 km in length.

The delta region is densely populated, and plays a dominant role in the cultivation of rice in rich alluvial soil as low as just 3 meters above sea level, although it also includes fishing communities in a vast area full of rivers and streams.

3. METHODOLOGY

All images were registered to topographic maps of UTM before processing, interpreting and analyzing. After images had been registered to UTM projection, images were resized accordingly for geo-rectification. DEM is used and it involves interpolating digital contour map having 10 m interval that may have been produced by direct survey of the land surface.

Broad steps followed during the present study are:

1) Preparation of base maps
2) Interpretation of multi_date satellite data leading to mapping of area affected by flood.
3) Integration of visual analysis with ground truth data.
4) Verification of satellite data interpretation by taking up field traverses
5) Building vector map and 3D surface map from DEM image
6) Simulating extended flood area according to rising of sea level
7) Comparison between simulated result and result extracted from satellite images
8) Finalization of hazard zone map after refining and redefining interpretation work
9) Quantify and qualify measurement of impacts of flood
10) Preparation of report.

4. RESULTS AND DISCUSSION

During the Nagis, much of the outer part of the Delta plane was flooded because of the absence of elevated coast line. Morphology of the submerged shoal sandbars are changed. After the disaster, the trees and buildings are completely gone, replaced by messy piles of rubble. The fields are largely submerged under brown and green floodwater.

Figure 1 shows the classified images analyzed which acquired on 5th May2008, by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on NASA's Terra and Aqua satellites. It uses the cloud-free observations from each to get the clearest possible picture. Flooded areas are blue, settlements are pink, and tree cover appears in shades of green (dense tree cover). Extended flood area is defined overlaying and analyzing pre and post-impact classified images. Simple geospatial tool including union, intersection and erase to detect changes. Red region in figure 1(c) shows the extended flood area in lower delta region after Nargis. The whole lower delta region, nearly 6300 km^2, 17.54% of total area, is submerged in sea water. Simulation was done using arcview script together with DEM image but it did not consider other parameters of flood such as the direction of wind. Results are classified according to estimated sea level classes. If sea level rises 4m, simulated flood extended area is 20.24% of the total area. The simulated result and real situation are almost same (Figure 2). As a result of Nargis Cyclone, serve damage was occurred in red and orange circle area in figure 3(c) where population are between about 100,000 and 208,876. Only rivers are used as main transportation in most part of Nargis affected area. Main road connection among some townships is shown in figure 3(b). Exiting hospital as well as health intervention reached townships are shown in figure 3(d).

Analyzing is extent to one of townships in the Delta Region according to data available and ground control points. Figure 4 presents a preliminary satellite-based damage assessment for the affected Town of Maubin Township, Ayearwady Division, Myanmar and based on SPOT-5 imagery. After Nargis inundated the area with heavy rains and storm surge, standing water covered almost the entire area in this township. Rainfall totals range from 500 to 600 millimeter in this area and wind speed was approximately between 64 and 95 knots/hr (category 3) at that time. As of May 5, flooding in the heart of the township appeared to be less than in the surrounding areas. Pre-impact and post-impact classified result indicate almost 50% of total area of township is still submerged. DEM image shows elevation in anywhere of this township is almost same. But flooded area was extended to only east part of township because large amount of water was forced to this place because of the direction of wind.

Overlaying and analyzing these maps, hazard ranks of flood hazard map were categorized into five groups. Hazard ranks 1 (low), 2(moderate) and 3(severe) are classified (Figure 4(d)). There are thirty five villages in the severe zone and only six villages are in low hazard zone or safety zone (Figure 4(d)). Escape routes and locations for storage of temporary housing were proposed in figure 4(c).

5. CONCLUSIONS

Space-based system is the only system which never be destroyed by natural disaster and can work in any serious natural disaster situation. Disaster Mitigation and Space technology communities work together in developing effective and accurate methods for prevention, preparedness and relief measures. An important aspect in terms of satellite monitoring involves assessment of the damage incurred during the disaster. Satellite technology can also help in identifying escape routes and locations for storage of temporary housing. The research reflects the data acquired, its analysis and results which substantiate the fact that Remote sensing and GIS Technique can be applied to achieve the ultimate goal of assessing high-risk area due to natural disaster. It can also represent the pre-disaster plan which can be used as a resource tool for disaster planning. Disaster risk zone map was prepared by integration of DEM image (Figure 4(c)), grid vector map and land cover map using ArcGIS and Suffer software.

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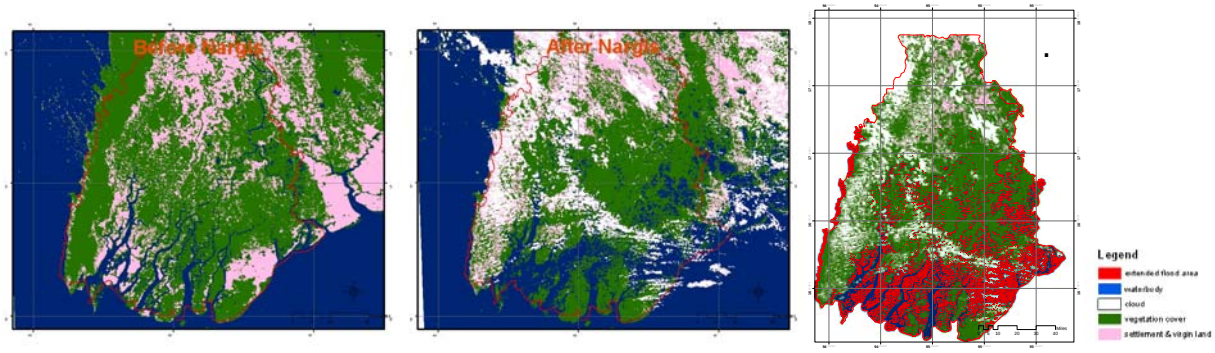
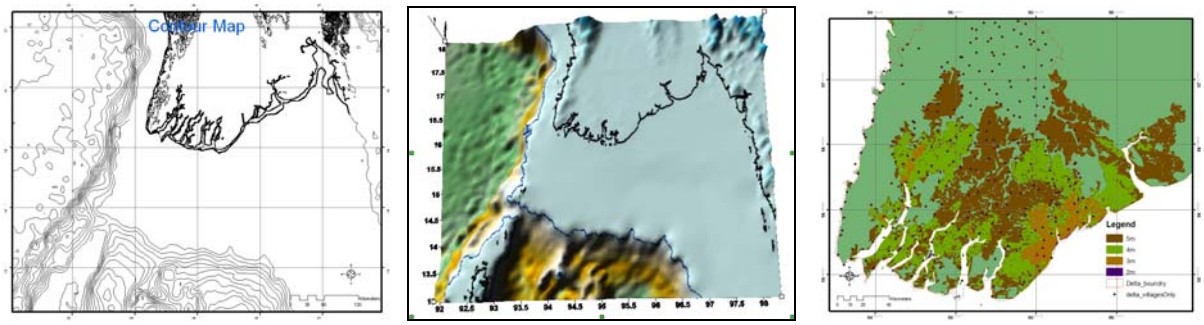


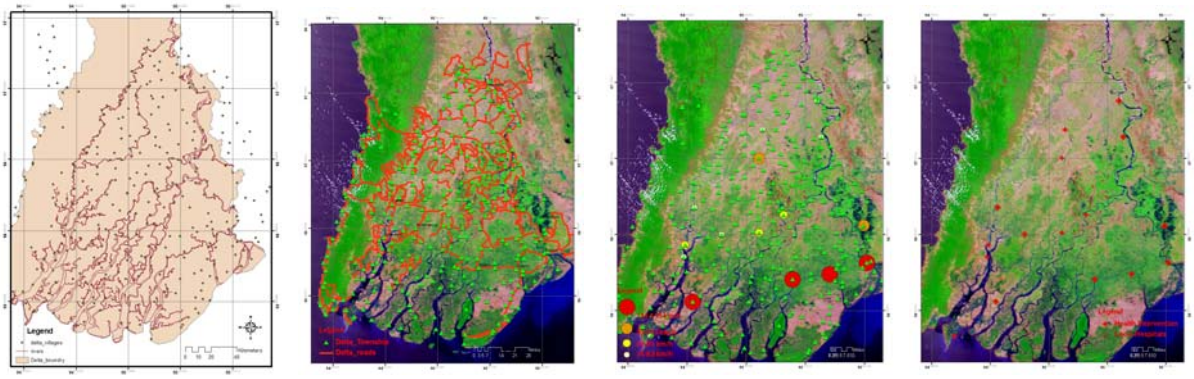
(a) (b) (c)

Figure 1. Classified Images (a) Pre-impact (b) Post-impact (c) Flood extended
Source: NASA/MODIS Rapid Response Team



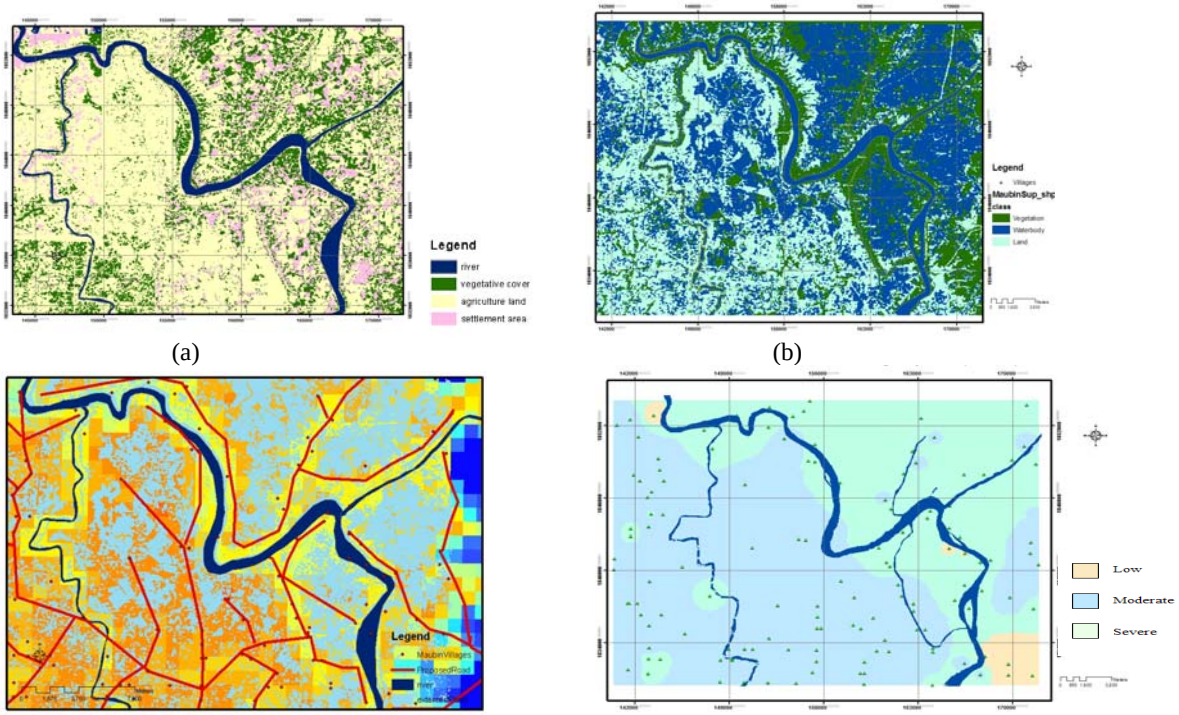
(a) (b) (c)

Figure 2. (a) Contour map of Delta Region (b) DTM of the Ayeyarwady deltaic shelf delimited by the 200 meter isobath (blue line) and the coastline (black line) (c) Stimulated flood extended area



(a) (b) (c) (d)

Figure 3. (a) River Configuration Map (b) Main Road Connection Map (c) Population and Strong Effected Area (d) Health Intervention Reached Townships in Delta Region



(a) (b)

(c) (d)

Figure 4. (a) Maubin Pre-impact Classified Images (b) Maubin Post-impact Classified Images (c) Proposed Road Map of Maubin Township (d) Disaster Risk Zone Map of Maubin Township