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Vulnerability of Flood Hazard in Selected Ayeyarwady Delta Region, Myanmar

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Abstract: Flood disaster is a function of both natural hazard and vulnerable environs. It is needed to identify the flood hazard area for proper management and mitigation damage. River flood occurs because of heavy rainfall and geomorphology. In this study, Flood vulnerable areas for different return period flood are assessed by using Hydrologic Engineering Center's River Analysis System (HEC-RAS) model, GIS and Remote Sensing technique. Flood vulnerability analysis is carried out by overlaying the land use map and flood hazard map generated by the hydraulic model. GIS can be used to create interactive map overlays, which clearly illustrate which areas of a community are in danger of flooding. The main objective is to assess the flood vulnerable areas. Special attention of the concerned area on this disaster should be done to minimize loss from damage.

Keywords: flood hazard area; GIS and Remote Sensing; HEC-RAS; River flood; vulnerable.

1. INTRODUCTION

Myanmar's high vulnerability to natural disasters results from its unique geographic location. Ayeyarwady delta region is the worst flood affected region as it is located in low lying area. Due to this, it is necessary to do hazard assessment in order to know how much area would be the damage if a hazard occurs. An important prerequisite for developing management strategies for the mitigation of extreme flood events is to identify areas of potentially high risk to such events, thus accurate information on the extent of floods is essential for flood monitoring, and relief. Hydraulic modeling, especially HEC-RAS model is used to carry out the flood simulation to produce flood level at various locations along the river.

2. DESCRIPTION OF STUDY AREA

The study area is located between North latitude of 17°00' and 17°40' and East longitude of 95° 20' and 95° 50'. The drainage area of the study basin is about 2606.1km^2. The length of the river in the study area is 121.061km. The study area falls under the Ayeyarwady Regional Division.

3. DIGITAL ELEVATION MODEL

DEM is the digital elevation of the topographic surface. DEM must be a continuous surface that includes the bottom of the river channel and the floodplain to be modeled. DEM is also used to calculate the flooded depth by incorporating it into HEC-RAS flood modeling software. Because all cross-section data will be extracted from the DEM, only high-resolution DEM that accurately represent the ground surface should be considered for hydraulic modeling. Measurement units used are those relative to the DEM coordinate system.

4. LANDUSE CLASSIFICATION

To obtain the land use data of the study area, IRS satellite image of 2010 was classified in ENVI software. The following four types of land use classes were reclassified; agricultural land, forest, residential and water or herbaceous wetland (Figure1).

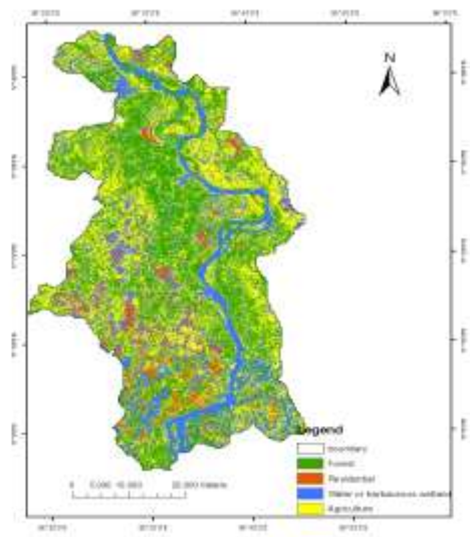

Figure1. Landuse map

5. METHODOLOGY

HEC-RAS model is chosen for flood inundation mapping and thereby to produce flood hazard maps correspond to 10, 20, 50 and 100 years return period flooding events [5]. The discharge data set for the inundation model was produced from the rainfall-runoff modeling. Flood hazard assessment is carried out using GIS and HEC-RAS [6]. Vulnerable areas are identified for 10, 20, 50 and 100 years return period flood. The general method adopted for flood hazard analysis are (1) Pre-processing of geometry data to generate HEC-RAS import file (2) Running of HEC-RAS to calculate water surface profiles (3) Post-processing of HEC-RAS results and floodplain mapping (4) flood hazard analysis and mapping and (5) Assess flood vulnerable areas.

5.1 Hydraulic Modeling

HEC-RAS is the hydraulic model which is used to calculate the water-surface profiles and energy grade lines in 1-D, steady-state, gradually-varied flow analysis. Knowing water surface elevation under various flow conditions, it is possible to evaluate flooding depth [1]. The data needed are geometry data and steady flow data. Geometry data are required for any of the analyses performed within HEC-RAS [1]. The basic geometric data consists of establishing the connectivity of the river system, cross-section data, reach length, energy loss coefficient.

5.2 Geospatial Hydraulic Modeling

HEC-GeoRAS is a set of ArcGIS tools specifically designed to process geospatial data. The extension allows users with limited GIS experience to create an HEC-RAS import file containing geometric data from existing digital elevation model (DEM). Results exported from HEC-RAS may be processed. The current version of HEC-GeoRAS creates import files containing reach, station identifiers, cross-sectional cutlines, and cross-sectional bank stations; downstream reach length for the left overbank, main channel, and right overbank and cross sectional roughness coefficients. Water surface profile data exported from HEC-RAS may be processed into GIS data sets [1]. Process flow diagram is shown in Figure 2.

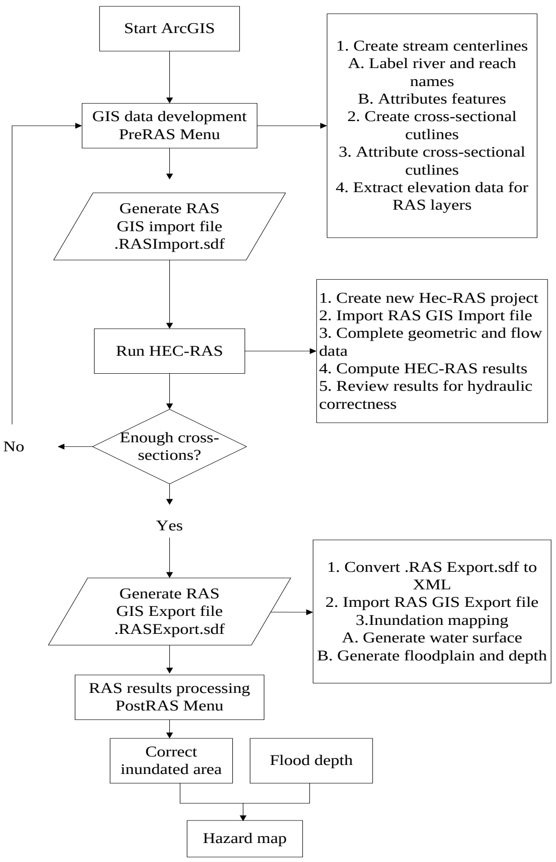

Figure 2. Process flow diagram of flood hazard mapping

5.2.1 Cross Section Data

Cross-sections are one of the key inputs to HEC-RAS. Cross-section cutlines are used to extract the elevation data from the terrain to create a ground profile across channel flow. The intersection of cutlines with other RAS layers such as centerline and flow path lines are used to compute HEC-RAS attributes such as bank stations (locations that separate main channel from the floodplain), downstream reach lengths (distance between cross-sections). Therefore, creating adequate number of cross-sections to produce a good representation of channel bed and floodplain is critical. Guidelines must be followed in creating cross-section cutlines: (1) they are digitized perpendicular to the direction of flow; (2) must span over the entire flood extent to be modeled; and (3) always digitized from left to right (looking downstream).

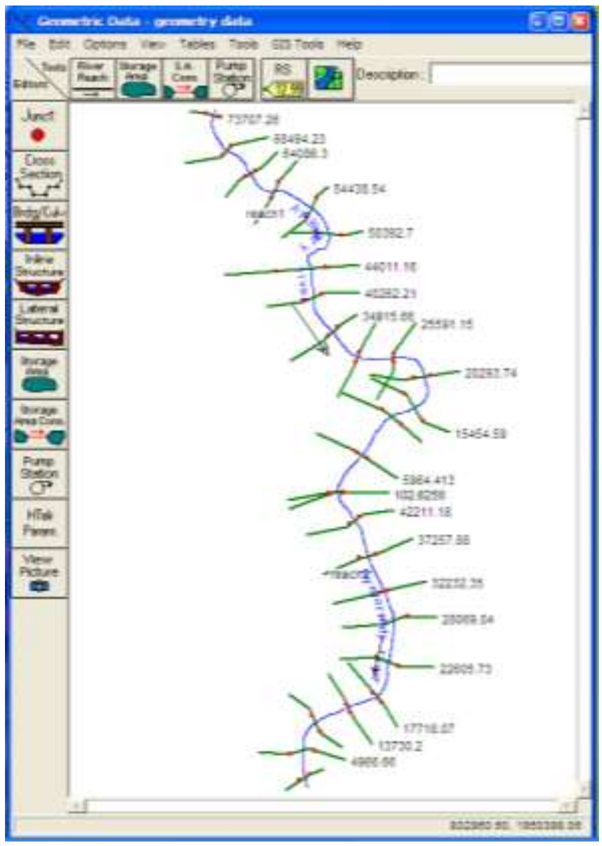

Figure 3. Schematic view of geometry of study river

5.2.2 Flow and Boundary Condition

The amount of flow through the system has to be entered along with certain boundary conditions before running the program to compute the desired results. Determining which boundary conditions are required depends on the conditions of the system and the type of model being run. In this study, steady flow analysis using a subcritical flow regime is used. Steady flow analysis consists of flow regime, boundary condition, and peak discharge information. Peak discharges are simulated by the hydrologic model [2][3].

6. RESULTS OF FLOOD HAZARD ANALYSIS

Flood hazard map shows area which could be flooded according to three probabilities (low, medium, high) complemented with flood extent and water depth or level [7].

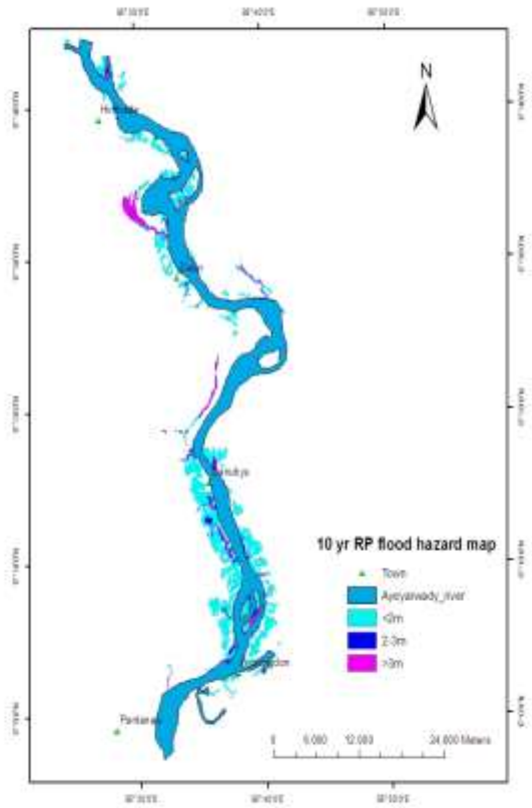

Figure 4. Flood hazard map for 10 year return period flood

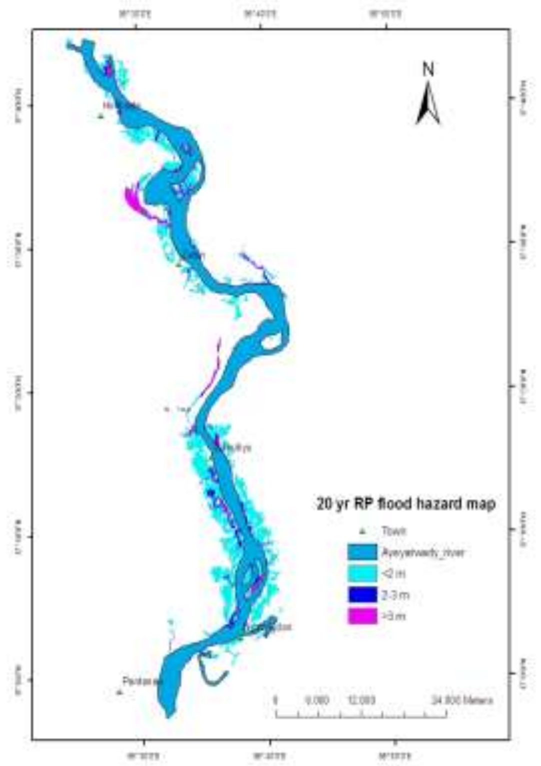

Figure 5. Flood hazard map for 20 year return period flood

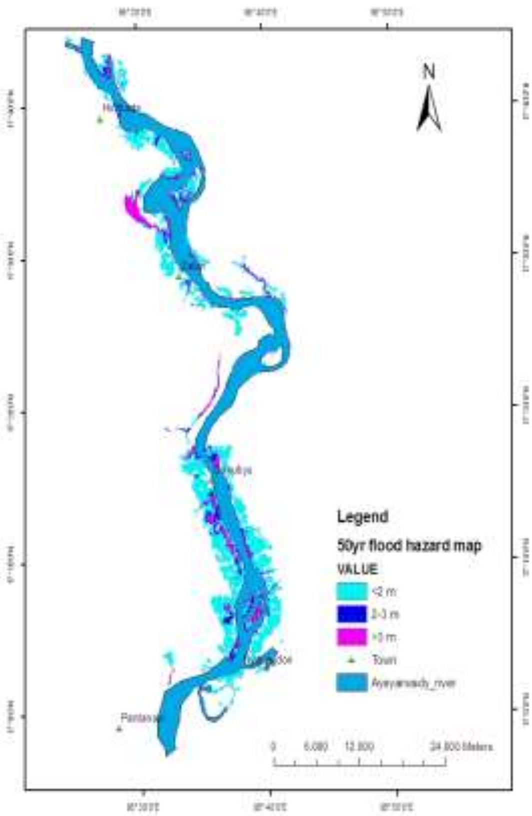

Figure 6. Flood hazard map for 50 year return period flood

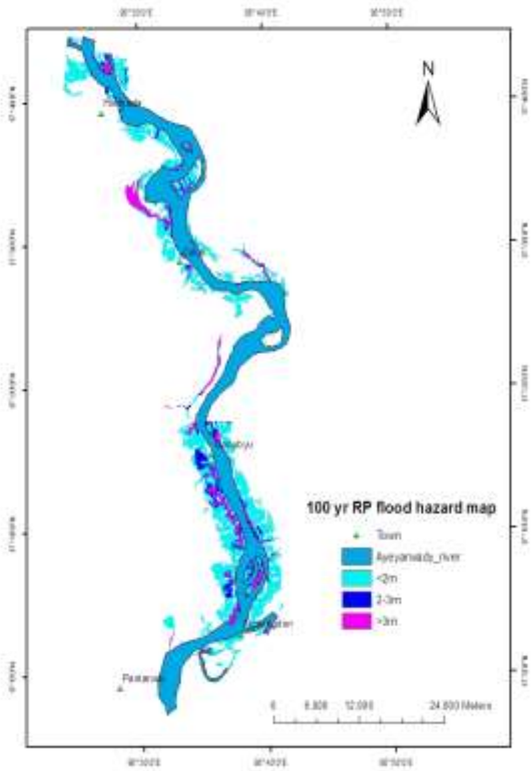

Figure 7. Flood hazard map for 100 year return period flood

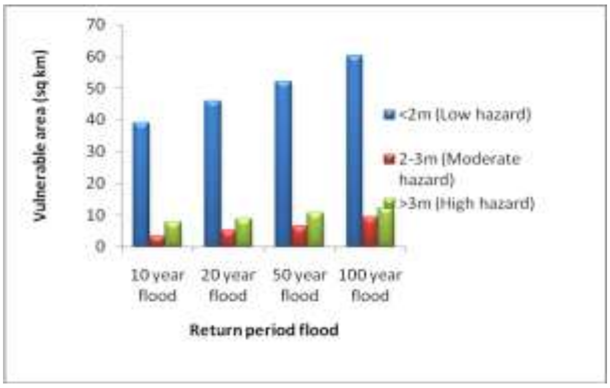

Figure 8. Flood vulnerable area on agriculture

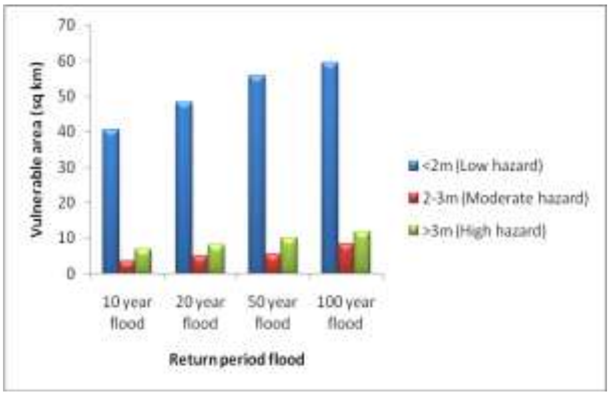

Figure 9. Flood vulnerable area on forest

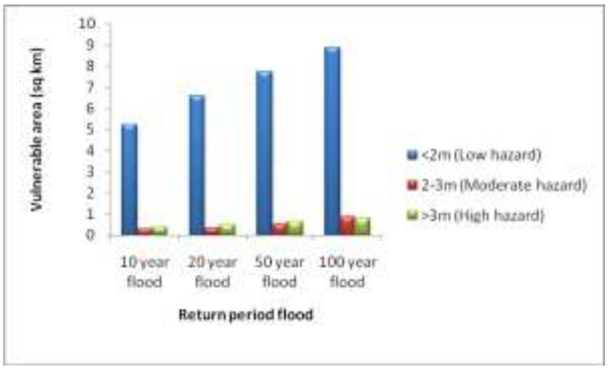

Figure 10. Flood vulnerable area on residential area

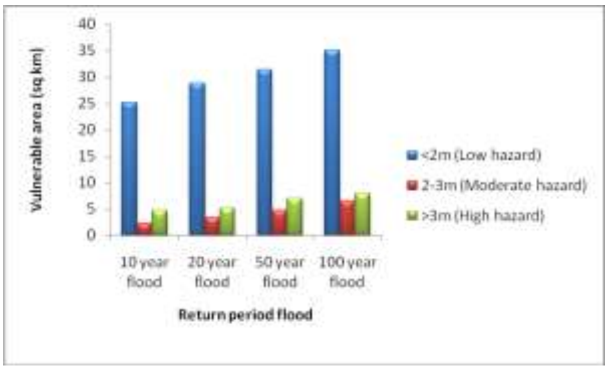

Figure 11. Flood vulnerable area on herbaceous wetland

Table 1. Vulnerable areas for 10 years and 20 years flooding

Landuse type	Flood depth	Total vulnerable area			
		10yr flood		20yr flood	
		km^2	%	km^2	%
Agriculture	<2m	38.9	27.9	45.9	27.6
	2-3m	3.3	2.4	5.07	3.1
	>3m	7.7	5.5	8.9	5.4
Forest	<2m	40.5	29.0	48.3	29.0
	2-3m	3.62	2.6	5	3.0
	>3m	7.05	5.1	8.14	4.9
Residential area	<2m	5.2	3.7	6.6	3.9
	2-3m	0.3	0.2	0.36	0.22
	>3m	0.4	0.3	0.49	0.3
Herbaceous wetland	<2m	25.2	18.0	28.8	17.4
	2-3m	2.4	1.7	3.4	2.0
	>3m	4.7	3.4	5.2	3.1
Total		139	100	166	100

Table 2. Vulnerable areas for 50 years and 100 years flooding

Landuse type	Flood depth	Total vulnerable area			
		50yr flood		100yr flood	
		km^2	%	km^2	%
Agriculture	<2m	51.9	26.9	60.2	27.2
	2-3m	6.3	3.3	9.3	4.2
	>3m	10.8	5.6	12.2	5.5
Forest	<2m	55.9	29.0	59.3	26.8
	2-3m	5.4	2.8	8.3	3.7
	>3m	10.2	5.3	11.8	5.3
Residential area	<2m	7.7	4.0	8.9	4.0
	2-3m	0.5	0.3	0.9	0.4
	>3m	0.6	0.3	0.8	0.4
Herbaceous wetland	<2m	31.4	16.3	35.0	15.8
	2-3m	4.7	2.4	6.6	2.9
	>3m	7.0	3.7	7.9	3.6
Total		192	100	221	100

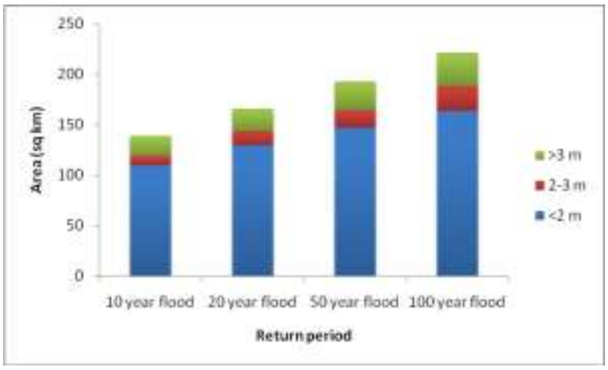

Figure 12. Evaluation of total flood area according to flood hazard

7. CONCLUSION

According to the classification of flood hazard, flood depth less than 2 m has low hazard, flood depth between 2m and 3m has moderate hazard and flood depth greater than 3m has high hazard. About 14 % of the total flood areas in all flood events tend to have high hazard. The total areas under moderate hazard are 6.8 % on 10 year flood, 8.3 % on 20 year flood, 8.8 % on 50 year flood and 11.4 % on 100 year flood. Similarly, 78.9 %, 77.9 %, 76.2 % and 73.8 % of the total flood areas for 10 year, 20 year, 50 year and 100 year are under low hazard. Agriculture and forest are the most vulnerable to different return period flooding. Flood occurs in residential area every year with low hazard (flood depth of less than 2 meters).

8. ACKNOWLEDGMENTS

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