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Modelling of Flood Risk and Flood Prevention Measures for Amballur Panchayat at Ernakulam, Kerala

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Abstract - *The heavy rainfall that occurred in Kerala in the years 2018 & 2019 flooded the entire state, causing intense damage of life and property. This project intends to make a flood hazard zone map of Amballur Panchayat using ArcGIS and Digital Elevation Model (DEM). Various parameters such as precipitation, soil characteristics, land use, topography, slope and population are considered for the flood modelling. The flood hazard zone map and other relevant maps are prepared using the following steps: (1) digitization of topographical data and preparation of digital elevation model using ArcGIS, (2) simulation of flood lows of different return periods using a hydraulic model, and (3) preparation of flood hazard zone map by integrating the results. ArcGIS is successfully used to visualize the hazard level of flooding and also to analyze the flood maps to produce flood damage estimation maps and flood hazard zone map. The study highlights the potential for the detection of flood prone areas which will be flooded during heavy downpour and the situations when the river water level rises. Relevant information can be extracted from the flood hazard zone map for disaster management.*

Key Words: ArcGIS, Digital Elevation Model, Digitization, Flood Hazard Zone Map, River Embankment, River Training Works.

1. INTRODUCTION

Floods are among the most destructive acts of nature. Worldwide, flood causes damages to agriculture, houses and public utilities amount to billions of dollars each year in addition to the loss of precious human and cattle lives. In the majority of cases, flooding is caused by a river over-spilling its banks. India is no exception as far as floods are concerned. Severe floods occur almost every year in one part of the country or the other causing tremendous loss of life, large scale damage to property and untold misery to millions of people. Floods mostly occur in the country during the southwest monsoon period spread from June to September, though cyclonic storms are common from October to December.

The management methods to decrease flood hazards are divided into structural and non-structural categories. The structural measures are construction of embankments, levees, spurs etc whereas the non-structural measures are flood forecasting and warning, flood plain mapping, flood hazard mapping and flood plain zoning. Geographic Information Systems (GIS) are successfully used to visualize the extent of flooding and also to analyze the flood maps to produce flood damage estimation maps and flood risk map. Flood hazard mapping forms the foundation of the decision-making process by providing information which is essential to the understanding of the nature, risk and characteristics of flooding to the community or city that could be affected by the flood. Floods are among the most destructive acts of nature. Worldwide, flood causes damages to agriculture, houses and public utilities amount to billions of dollars each year in addition to the loss of precious human and cattle lives. In the majority of cases, flooding is caused by a river over-spilling its banks. India is no exception as far as floods are concerned. Severe floods occur almost every year in one part of the country or the other causing tremendous loss of life, large scale damage to property and untold misery to millions of people. Floods mostly occur in the country during the southwest monsoon period spread from June to September, though cyclonic storms are common from October to December.

2. FLOOD MODELLING OF AMBALLUR PANCHAYAT

We consider Amballur Panchayat as the study region as it is a prominent location near to our college which was severely affected by the floods of 2018 and 2019. Amballur is situated on the banks of the River Konathupuzha in Ernakulam District of Kerala State in India. Amballur Panchayat has a total area of 2259 Hectares. The total population is 25,628 with a population density of 1134 persons per sq.km.

2.1 Rainfall Data Collection

One of the objectives of this project is to analyze the past rainfall events. This is done to evaluate whether there is any direct or indirect effect caused by the rainfall on flood. The rainfall observatory of The Indian Meteorological Department (IMD) nearest to Amballur Panchayat is established at Piravom. Thus, the rainfall data of Piravom observatory for the past 12 years between 2008 and 2019 was obtained from IMD Trivandrum

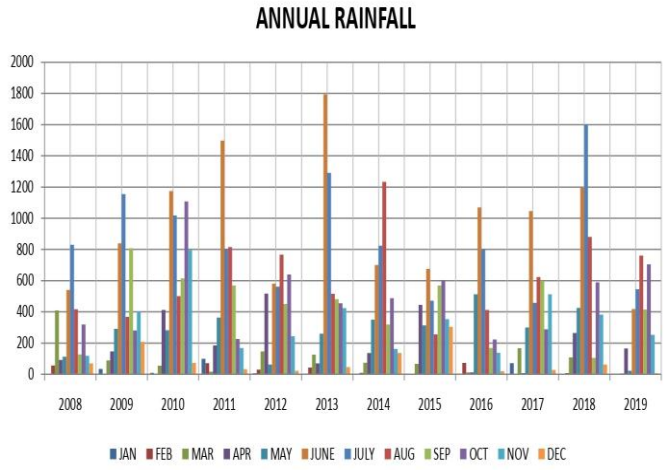

Fig -1: Rainfall hyetograph of Piravom IMD station

The hyetograph indicates that the strongest rainfall occurred during the June, July months of the monsoon season. It is also observed that the rainfall has been increasing every year from 2008 to 2018. Taking into consideration the years from 2008 to 2019, the year 2013 received the heaviest rainfall. This heavy rainfall does not give rise to flood. The second heaviest rainfall was obtained in the year 2018. Though the second heaviest, the rainfall in the year 2018 caused the worst flood in the history of Kerala state, causing far more damage than the 'Great flood of 99' which occurred in July 1924. This implies that the flood was not only caused by the natural phenomenon of heavy rainfall but also by the human errors such as mismanagement of hydraulic structures and increase in the encroachment area. Though natural phenomenon is beyond human control, the human errors could have been avoided thereby reducing the impacts of floods. It is observed from the hyetograph that, the year 2019 received much lesser rainfall than that of 2018. But, 2019 rainfall also caused flooding in Amballur Panchayat. This necessitates the need for basic flood protection works irrespective of the magnitude of rainfall, to prevent flood in the coming years

2.2 ArcGIS

ArcGIS is a geographic information system (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a data base. ArcMap is the main component of ESRI's ArcGIS suite of geospatial processing programs, and is used primarily to view, edit, create and analyze geospatial data. ArcMap allows the user to explore data within a data set, symbolize features accordingly and create maps. ArcCatalog is the data management and task manipulation application, used to browse datasets and files on one's computer, database or other sources. In addition to showing what data is available, it also allows users to preview the data on a map.

2.3 Collection of Spatial Coordinates of Flood Prone Areas

To understand the intensity of the 2018 and 2019 floods in various parts of Amballur Panchayat, a site visit of the flood affected areas was carried out. This site visit was helpful in the collection of the geographic coordinates, i.e., latitude and longitude, of the flood affected areas. These coordinates are used in the preparation of maps using the ArcMap extension of the ArcGIS software. These coordinates were collected using the Google My Maps app. Using these coordinates in Google Earth pro, the real-time satellite map of Amballur Panchayat was extracted and exported to ArcMap.

2.4 Parameters used for Flood Hazard Zone Map Generation

The five parameters used for the generation of flood hazard zone map in this project are altitude, slope, land use land cover, river boundary and distance to water body.
The rank and weightage of parameters used for weighted overlay analysis are:

Table -1: Altitude ranking

Parameter	Value	Rank	% influence on causing flood
Altitude	0-5	5	23.2
	5-15	4	
	15-25	3	
	25-35	2	
	35-56	1	

Table -2: Slope ranking

Parameter	Value	Rank	% influence on causing flood
Slope	0-1.5	5	13.8
	1.5-3	4	
	3-4.5	3	
	4.5-6	2	
	6-10.5	1	

Table -3: Land use land cover ranking

Parameter	Type	Rank	% influence on causing flood
Land use land cover	Water bodies	5	8.4
	Wet lands	4	
	Agriculture	3	
	Fallow land	2	
	Built-up	1	

Table -4: Distance to water body ranking

Parameter	Value	Rank	% influence on causing flood
Distance to water body	0-500	5	54.6
	500-1000	4	
	1000-1500	3	
	1500-2000	2	
	2000-3162	1	

2.5 Maps Generated using ArcGIS

The maps of Amballur Panchayat are prepared for GIS modeling, which is the mathematical construct for representing geographic surfaces as data. Various maps generated using ArcGIS are:

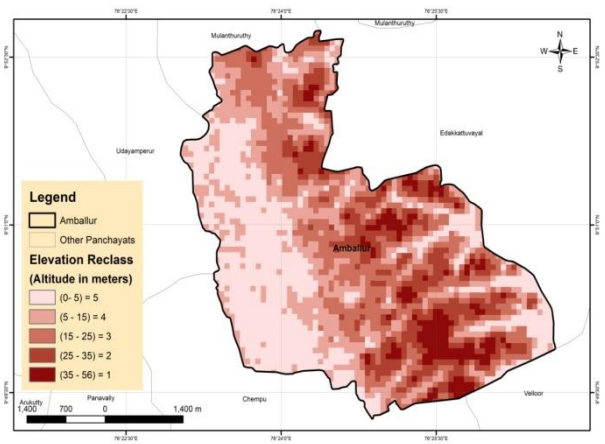

Fig -2: Elevation reclass map of Amballur Panchayat

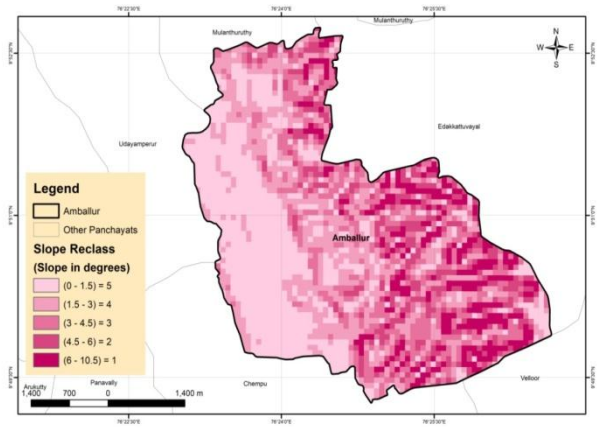

Fig -3: Slope reclass map of Amballur Panchayat

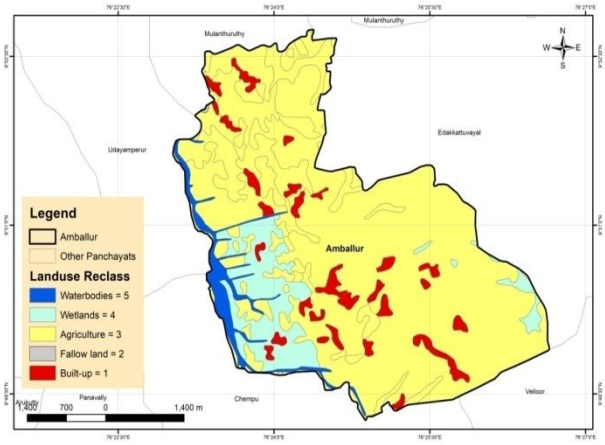

Fig -4: Land use reclass map of Amballur Panchayat

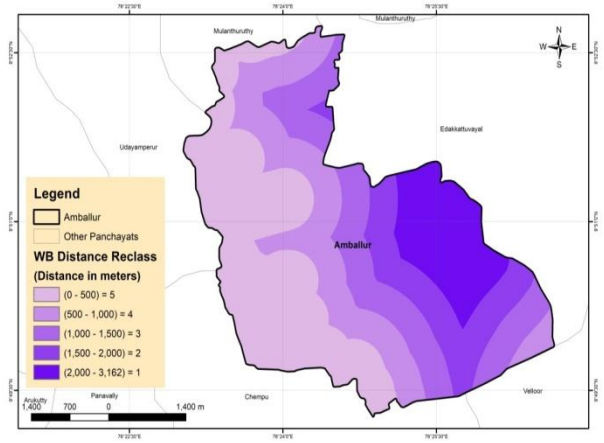

Fig -5: Water body distance reclass map of Amballur Panchayat

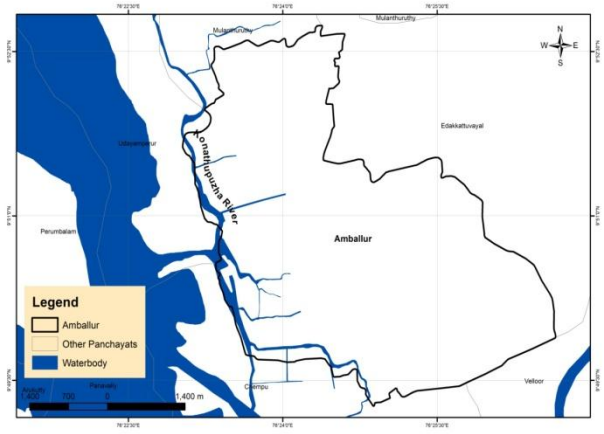

Fig -6: Water body map of Amballur Panchayat

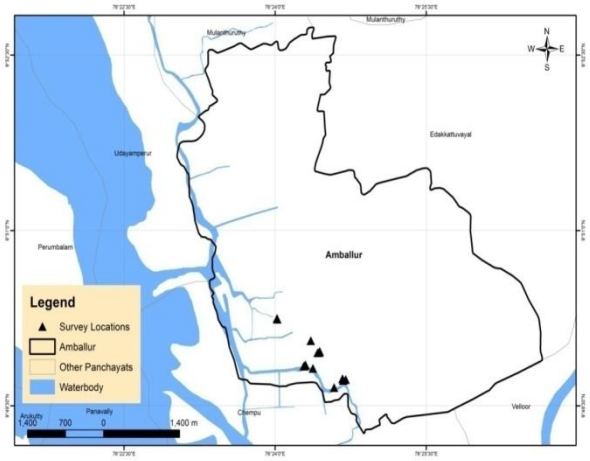

Fig -7: Map showing survey locations of Amballur Panchayat

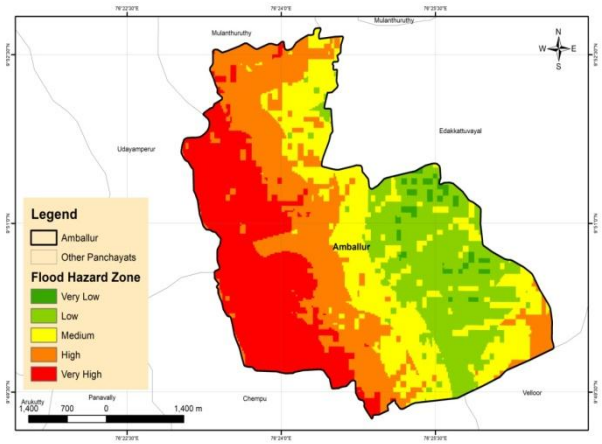

Fig -8: Flood hazard zone map of Amballur Panchayat

2.6 Land Area under Zones of Different Hazard Levels

Table -5: Flood hazard area statistics

Intensity of flood	Area (sq. m)	Area (sq. km)
Very high	6008874.55	6.008874
High	6158403.66	6.158403
Medium	5639828.08	5.639828
Low	4904196.48	4.904196
Very Low	330408.05	0.330408
Total area		23.04171

3. FLOOD CONTROL MEARSURES FOR AMBALLUR PANCHAYAT

The various measures that can be adopted to control flood in Amballur Panchayat are:

3.1 Construction of Embankment along the Banks of the River Konathupuzha

In the flood hazard zone map shown in Fig -9, the river embankment proposed to be constructed is represented by a black triangular shape and the river training works are represented by a thick black line along the river bank.

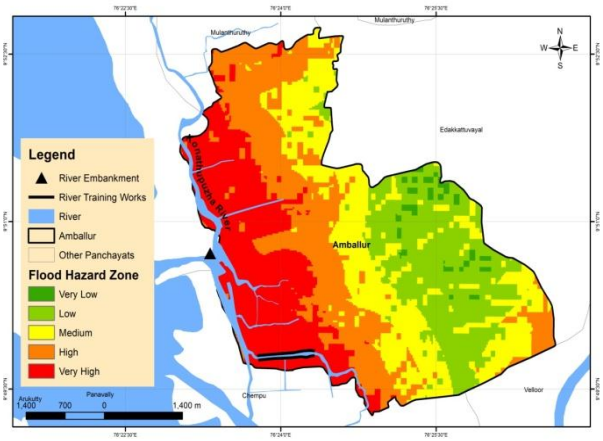

Fig -9: Map showing the locations to construct river embankment and execute river training works

3.2 Soft Engineering Techniques and River Training Works for Flood Protection

Soft engineering techniques recommended for Konathupuzha River are:

1. The removal of encroachments.
2. Rectification of river depth.
3. Routine maintenance programmes and desilting of river.
4. River bed smoothening.
5. The impact of flood can be reduced by providing steel fenders or rails on both the sides.
6. The maintenance of existing ring bunds or embankments can be done.
7. Geotextile polymer lining of river bed.

4. CONCLUSIONS

Kerala has witnessed the most devastating flood and related losses in its history in the years 2018 and 2019 due to unusual high rainfall during the monsoon season. It was the worst flood in Kerala in nearly a century. Over 483 people

died, and 140 are missing. According to Kerala Government, one sixth of the total population of Kerala have been directly affected by the floods and related incidents. The Indian Government had declared it a level 3 calamity, or "Calamity of a severe nature". Thirty five out of the fifty four dams within the state were opened, for the first time in history. Amballur Panchayat was one of the most affected regions in Ernakulam district. This project intends to make a flood risk map of Amballur using ArcGIS Digital Elevation Model (DEM) and by considering various parameters such as precipitation, soil characteristics, landuse, slope, altitude, river boundary and distance to water body. Flood control techniques to control future floods, such as the construction of river embankment and soft engineering techniques are being suggested. A questionnaire survey using Google form was carried out based on the factors identified from Amballur Panchayat. The survey possessed with certain details such as name of the owner, address, ward number, building number, distance from water body, maximum flood level reaching, draining time, nature of soil, current land condition, building dampness, land area and plinth area of the building. Then rainfall events of past 12 years, between 2008 and 2019 were analysed and a rainfall hyetograph of Piravom station has been generated. From the graph, it is observed that the unusual heavy rainfall occurred in the months of June, July increased the water level of major dams of Kerala to rise near to maximum capacity and the rainfall has been increasing every year.

Then the study focuses on the design of flood control measures and to propose it in the area using ArcGIS with suitable measures. The most commonly used way of flood protection is to provide embankments. Soft engineering techniques and river training works of flood protection are the most economical control methods that can be implemented in Konathupuzha River.

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