# Preparation of Inundation Map of Pathanamthitta Municipality

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**Abstract -** *Flooding is one of the most frequent and devastating natural disasters and can often result in severe damage to agricultural products, commercial infrastructure, personal property and loss of human lives. Flood inundation mapping (FIM) is required to understand the effect of flooding in a particular area. By taking Pathanamthitta municipality, Kerala as study area we have designed a methodology for calculating the flood inundated area using Arc GIS software. Flood depth was surveyed directly with help of local people and ward members. The elevation data is extracted using SRTM DEM and thus the flood level above sea level is obtained. From this method, we find the areas with high flood level to zero flood level and it is denoted using different colour. Among the 32 wards in Pathanamthitta municipality, 11 wards are affected by the flood. The resultant map shows highest range of flood level lies between 3 to 4 m, that is around 6.43% of the total area is highly affected by the flood whereas 52.3% of the total area is zero flooded.*

***Key Words*: GIS (Geographical Information System), Kerala Flood, Flood mapping, Flood Management.**

## 1. INTRODUCTION

Flooding, as a major natural disaster, affects many parts of the world. Floods can be explained as excess flows exceeding the transporting capacity of river channel, lakes, ponds, reservoirs, drainage system, dam and any other water bodies, whereby water inundates outside water bodies areas. Due to this natural disaster, million of infrastructure and property damages and hundreds of human lives are lost. On 16 August 2018, severe floods affected the south Indian state Kerala, due to unusually 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. About a million people were evacuated. All 14 districts of the state were placed on red alert, one-sixth of the total population of Kerala had been directly affected by the floods and related incidents. These hazards and losses can be prevented and reduced by providing reliable information to the public about the flood risk through flood inundation maps. A flood inundation map library is a set of maps that shows where flooding may occur over a range of water levels in the community's local stream or river. Flood inundation maps (FIM) are very essential for municipal planning, emergency action plans, flood insurance rates, and ecological studies. 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. The FIM of Pathanamthitta municipality helps communities to protect lives and property by providing tools and information to help them understand their local flood risks and make cost- effective mitigation decisions. Users can also access historical flood information and potential loss estimates based on the severity of the flood.

## 2. MATERIALS AND METHODS

### 2.1 Study area

Pathanamthitta municipality is the study area selected, which lies in Pathanamthitta district, Kerala state. Total geographical area of Pathanamthitta municipality is 24 $km^2$. Population density of the city is 1597 persons per $km^2$. There are 32 wards in the municipality as shown in Fig. 1. Among them Pathanamthitta Ward No 11 is the most populous ward with population of 1654 and Pathanamthitta Ward No 09 is the least populous ward with population of 845. Nearest railway station is Chengannur which is 26 km far from here. Kozhenchery is the sub district head quarter and the distance from the city is 13 km. District head quarter of the city is Pathanamthitta. Thiruvananthapuram is the state head quarter of the city and is 113 km far from here. Yearly average rainfall of the city is 2790 mm. Maximum temperature here reaches up to 30°C and minimum temperature goes down to 23°C. Portion of Achenkovil river is pass through Pathanamthitta municipality. The one side of river is Valamchuzy, Azhoor, Kodumthara. Pathanamthitta municipality was flood affected on 15 August 2018.

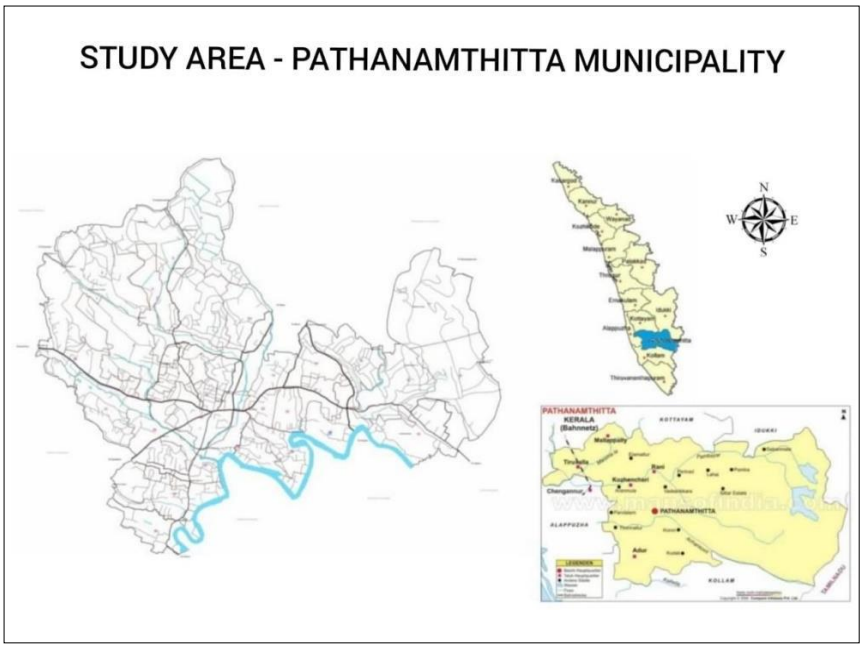


**Fig -1**: Study area

### 2.2 Methodology

**ARC GIS.** Arc GIS is a geographic information system (GIS) for working with maps and geographic information maintained by Esri. It is used for creating and using maps, compiling geographic data, analysing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database. The system provides an infrastructure for making maps and geographic information available throughout an organization, across a community, and openly on the Web. ArcGIS is a platform for organizations to create, manage, share, and analyse spatial data. It consists of server components, mobile and desktop applications, and developer tools. This platform can be deployed on-premises or in the cloud with ArcGIS Enterprise, or used via ArcGIS Online. The flood height of certain points on the study area is taken directly by field survey. The collection has 2 stages primary and secondary stage. In primary stage, the data are collected with the help of local people and ward members. In secondary stage, the data were verified by deputy town planning officer Pathanamthitta. The GPS location of the taken points are also noted. More than one point is taken in areas where there is fluctuation in the flood level due to geographic characteristics. The data collections from the field survey are:

**Location Details:** GPS Lattitude, Longitude

**Flood Details:** Flood level, Ward name.

Total of 293 points was collected from the field. The location details are collected using mobile phones. The final data are converted into an excel sheet and export it as a shape file to input the data to ArcGIS.

### 2.3 Flood Mapping

The flood boundaries were mapped using Flood depth points collected and SRTM DEM.SRTM DEM was downloaded from "https://search.earthdata.nasa.gov". Registration is required in this website; this website is an initiative by NASA for sharing and archiving earth data from multiple mission worldwide.

**Georeferncing and Digitizing.** The surveyed data was saved as excel format. This table contains the Latitude(Y) and Longitude (X) collected using mobile GPS. This table is added to the "ARC Catalog" GIS software. The coordinate system is set as Geographic coordinate system "WGS1984" because the GPS collects coordinates in "WGS1984".This point has the survey results in its attribute table, which is useful in using for further analysis. There is a great deal of geographic data available in formats that cannot be immediately integrated with other GIS data. In order to use these types of data in GIS it is necessary to align it with existing geographically referenced data, this process is also called geo referencing. Geo referencing is also a necessary step in the digitizing process. Digitizing in GIS is the process of “tracing”, in a geographically correct way, information from images/maps. The process of geo referencing relies on the coordination of points on the scanned image (data to be geo referenced) with points on a geographically referenced data (data to which the image will be geo referenced). By “linking” points on the image with those same locations in the geographically

referenced data you will create a polynomial transformation that converts the location of the entire image to the correct geographic location.

**Extraction of elevation data.** In order to extract the elevation data, SRTM DEM was projected using the "Project Raster" tool in ArcGIS and Survey Point feature class projected using "Project (Data management)" tool. Small imperfections and sinks are removed using the "Fill" tool in the "Hydrology" toolset. This will remove the error pixels in DEM. The Flood depth collected is from ground level and for Finding out the inundated area, Flood level above sea level is needed. In that case, SRTM DEM was used; the elevation values in SRTM DEM are above sea level. The Ground elevation is added with surveyed flood depth to get the flood height above sea level.

**Flood surface Raster.** The field survey data is made into an excel sheet. This Table contains the Latitude (Y) and Longitude (X) collected using mobile GPS. This table is added to the "ArcCatalog" GIS software. Using create feature class from "X-Y table" tool, the point feature class with entire survey details were created. In "X-Y table" tool dialogue box the X Field is selected as Longitude column and Y field is selected as Latitude value. The coordinate system is set as Geographic coordinate system "WGS1984" because the GPS collects coordinates in "WGS1984". This Point has the survey results in its attribute table, which is useful in using for further analysis. Project Geo-database was created and DEM and Survey point feature class was imported to it. For analysis and manipulation, the data must be in a projected coordinate system. According to the standards, the UTM Projection was chosen and for the study area the UTM zone is "UTM 43 North zone".. The Elevation values from DEM is extracted and added to survey Point feature class using the "Extract by points" tool in ArcGIS. This tool captures the elevation values from pixels, where the points are located. A new field was added to the attribute table, prior to the running of the tool. So the DEM elevation and Flood depth values were added using the "Field calculator" in attribute, to get the Flood level above sea level. These Flood level points are interpolated to get the flood surface raster. Interpolation method used was "Kriging".

**Kriging Interpolation**

Kriging is a geostatistical interpolation technique that considers both the distance and the degree of variation between known data points when estimating values in unknown areas. A kriged estimate is a weighted linear combination of the known sample values around the point to be estimated. . Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. Kriging is a multistep process; it includes exploratory statistical analysis of the data, creating the surface, and exploring a variance surface. Kriging is most appropriate when you know there is a spatially correlated distance or directional bias in the data. Variation in the surface can be explained using the spatial correlation of the sample points.

Formula:

$$Z(So) = \sum {}_{i}Z(S_i)$$

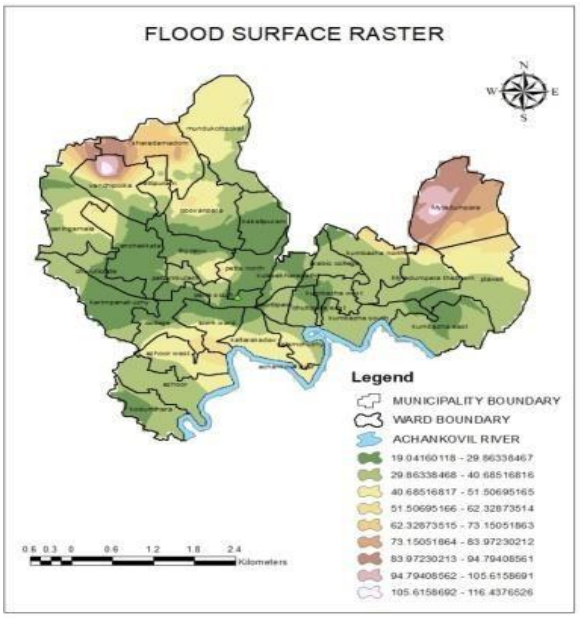


**Fig -2**: Flood surface raster

Where: $Z(S_i)$= measured value at the $I^{th}$ location.

$\lambda_i$ = an unknown weight for the measured value at the $I^{th}$ location.

$S_0$ = the prediction location N = No: of measured values.

So the Flood surface was predicted using the surveyed GPS locations.

Delineating the Flood boundary

Flood boundary was delineated using Raster calculation. DEM and Flood surface raster were used in the "Raster Math" tool. In "Raster Calculator", the following equation was done.

"Flood inundated area = Flood surface raster – DEM"

In resultant raster, all Positive values are flood inundated area and negative values should be removed for extracting flood inundated area raster , this is the result when subtracting the flood level with DEM, flood inundated area were found. This is due to the technique we used, subtraction method will always show flood in low lying regions below flood level, but there could be barriers, dams or natural hills which prevent direct entry of flood water.

**Reclassify,** For the purpose of converting the raster to polygon feature, it was reclassified into 4 using the "Reclassify tool" which is from spatial analytic tool from that reclass and select Reclassify.

For example: Pixel values in cost distance raster range from 0 to 6300, which was reclassified to one class and value was given as "1". Inundated area polygon was created using "Raster to Polygon tool", thus reclassified raster was converted into polygon feature class. Then calculate the area using "calculate area" tool from spatial statics tool.

### 3. RESULT AND DISCUSSION

The method used was very effective in mapping the flood inundated area. By ground truthing, it was observed that the area was inundated during the flood event. The map in fig 3, shows the variation in flood height on different wards of the Pathanamthitta municipality. The highest range of flood level (3 to 4 meter) is depicted in red colour. The non-flooded area is in green colour. The intermediate flood levels ranging from 0 to 1 meter is shown in blue colour and 1 to 3 meter is shown in yellow colour. The percentage of area where flood affected is, in red zone 6.43 %, yellow zone 14.68 %, blue zone 26.85

% and 52.3 % of total area is zero flooded in green zone. Almost 25 % of total area is highly flooded. Achenkovil river is

one of the large water body in Kerala that passes through Pathanamthitta district. The flood affected wards are on the bank of this river.

**Table 1:** Zone wise flooded area

| Zone | Height (m) | Flooded area ($km^2$ ) | Area in percentage |
|---|---|---|---|
| Red | 3-4 | 1.5097 | 6.43 |
| Yellow | 1-3 | 3.45 | 14.68 |
| Blue | 0-1 | 6.31 | 26.85 |
| Green | 0 | 12.29 | 52.3 |

### 3.1 Ward Wise Flooded Area

There are 32 wards in Pathanamthitta municipality. 11 wards were affected by flood ie, Town Ward, College Ward, Kallarakadavu, Valamchuzhy, Azhoor West, Azhoor, Kodumthara, Kumbazha South, Kumbazha North, Chuttipara East, Myladumpara Thazham. Almost all portion of town ward are under flood. Highest flood level was reported at Valamchuzhy, Azhoor west, kallarakadavu, College Ward, Azhoor and Town ward (Red zone). Wards like Poovanpara, Mundukootakal , Vanchipoika are situated away from the river, so there is no flooding except on paddy fields and low lying areas.

### 3.2 Flood Map

In fig 4, Green colour shows the non flooded area and dark blue colour shows the flooded area. Water from streams and canals of the river entered directly to the water shed areas, it was observed that low lying land like paddy fields and agricultural lands were severely affected by flood. Also observed that Pathanamthitta town area is under flood, newly build settlements in town area were more affected during the flood. City was constructed in the low lying area. Flood map of the study area gives the details of passive areas affected by flood in Pathanamthitta municipality region.

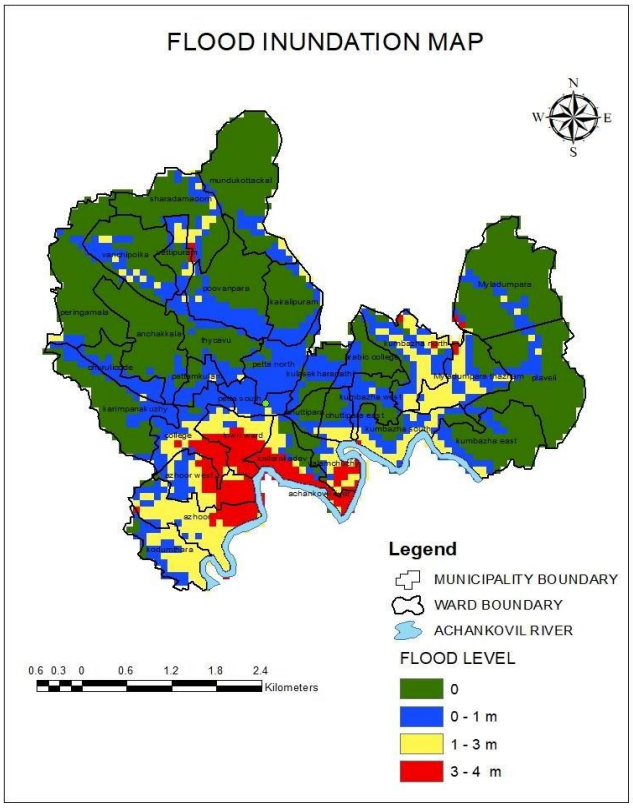


**Fig – 3**: Flood Inundation map

## 4. CONCLUSION

This research paved the way to find the flood inundated area and the preparation of the map. This map will facilitate future uses in disaster awareness and land use planning for the effective use of flood plain. The flood which occurred on August 2018 in Kerala was a major one and it affected many places including Pathanamthitta district. Pathanamthitta was relatively less prone to flood till 2017 but the events thereafter changed this concept.

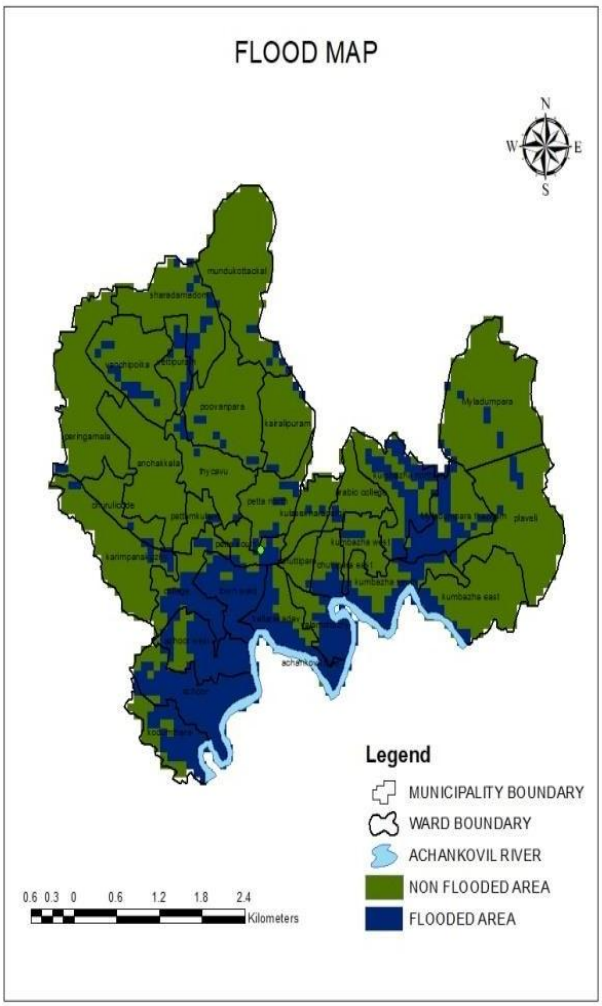


**Fig – 4**: Flood Map

Thus the need for a flood map initiated. The paddy fields of low lying areas were filled for development purpose which led to the occurrence of flood in that areas. These flood maps shows the flooded areas and non-flooded areas which can be used as a reference and management tool for further development planning. It was observed that several landfilling occurred in low lying paddy fields and agricultural lands for the construction of houses, religious buildings and commercial establishments.

Further constructions or development on low lying and flood prone areas can be avoided. The unscientific way of landfill will increase the destructions in future flood events. Due to the usage of comparatively low-resolution DEM, there will be small variations in the results.

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