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Application of GIS and RS in Flood Evacuation Planning: A Case Study of Flood Affected Wards in Muvattupuzha Municipality

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Abstract- *Flash floods are rapid flooding where the rise in water is within few hours. Flash floods are unpredictable. Many factors have relevance to the occurrence of a flash flood such as terrain gradients, vegetative cover, human habitation, heavy rainfall, shutter opening in dams etc. In the recent years the world has witnessed large number of flash flood, which is a potential threat to both life and property. It causes huge destruction in urban areas. Increase in population and high cost of land in these urban areas tends people to build their residential place in the areas at high risk of flood. Muvattupuzha Municipality of Ernakulam District was chosen as the study area. This urban area is highly vulnerable for flooding. The low-lying area and huge urban population in Muvattupuzha which is very close to the river causes huge destruction. To avoid great losses due to this natural disaster a flood disaster management is necessary. Evacuation planning is one of the fundamental instruments for flood risk mitigation. GIS helps to identify suitable relief centers, hospitals road network availability etc. Evacuation of people from flooded area to safe location is necessary. Evacuation planning is useful at time of disaster for movement of people to a safer location and their return. Road network is available between relief center and flood area. All this information and decision making is done with help of GIS.As a result the loss in life and property can be reduced to a certain limit. Thus a proper evacuation planning during flash flood disaster can be very effective for future applications.*

***Key Words*: Flash flood, Disaster management, Evacuation planning, GIS, Relief centers**

1. INTRODUCTION

Flood impact is one of the most significant disasters in the world. More than half of global flood damages occur in Asia. India has also witnessed several flood disasters cases during the monsoon season. According to the National Weather Services (NWS), a flash flood is defined as a flood that develops in under six hours, though they can form in a matter of minutes. Causes of floods are due to natural factors such as heavy rainfall, dam break, tsunami etc. and human factors such as improper land use, deforestation in headwater regions etc. Floods result in losses of life and damage properties. Population increase results in more urbanization, more impervious area and less infiltration which results in flood. According to research conducted by Eve Gruntfest, associate professor of geography and environmental studies at the University of Colorado, Colorado Springs, three general conclusions are:

1. Rainfall intensity is the primary determinant of flash flood occurrence and severity. Though important, rainfall amount and topography play a less significant role.

2. Regional differences emerge rainfall amount, rainfall duration and antecedent conditions are and East than they are in the West.

3. The impact of urbanization on flash floods cannot be ignored. Any analysis of flash flood risks must take into account the impact humans and their environmental modifications have on the occurrence and severity of flash floods.

Fig -1: Study area – Muvattupuzha Municipality

This study was conducted at Muvattupuzha Municipality of Ernakulam District is shown in Figure 1. This area is highly vulnerable for flooding. The low-lying area and huge urban population in Muvattupuzha city which is very close to the river causes huge destruction during the last years. The three main river which meets at Muvattupuzha increases the flood impact. The Kaliyar, Thodupuzha and Muvattupuzha are the three rivers

Evacuation is a response to the immediate or forecast threat of flooding that is expected to pose a risk to life, health or well-being. To avoid great losses due to this natural disaster a flood disaster management is necessary.

Evacuation planning is one of the fundamental instruments for flood risk mitigation. It involves people moving from their houses or places of business to safe locations, out of the flood risk area where they are able to shelter until it is possible and appropriate for them to return. The evacuation planning needs a proper methodology. The impact and disaster to life and property can be reduced with correct decision making made by the people before the flood level rises. So, a proper evacuation route map is necessary. The roads are completely blocked after the flood water enters the city and the people have no chance to rescue other than air and water ways and hence it becomes more complicated and ineffective way of rescue and this type of rescue is difficult to manage and control. Proper warning system, evacuation flow management helps to reduce this confusion in decision making during evacuation.

A Questionnaire survey was conducted in about 150 houses and 50 commercial buildings. This questionnaire survey conducted in the local community helps in knowing more about the flood conditions, damages to life and property, the evacuation route, the flood relief camps, nearby hospitals, schools, warning systems, rescue methods adopted. The data obtained in questionnaire survey is inputted into QGIS and the analysis and processing are done to conclude the right way of flood evacuation planning. Table 1 shows the summary of the questionnaire survey. QGIS thus helps in disaster management plan. Flood management helps to identifying map areas at risk of flooding. It provides a good foundation for efficient flood-risk management. Flood-risk management plan are used for preventing flood damages also it helps in rescue operations. In the most case, disaster management was associated with mapping to identify the impact. The mapping for flood disaster involves several technologies such as Global Positioning System (GPS), remote sensing, and Geographic Information System (GIS). GIS helps to identify suitable relief centers, hospitals road network availability etc. Evacuation of people from flooded area to high elevation safe location is necessary. Road network is available between relief center and flood area. All this information and decision making is done with help of GIS.

Table -1: Summary of questionnaire survey

Study Area	Muvattupuzha Municipality
Date	16,18,23,30 of January 2020 and 4,5,6,13 of February 2020
Method of survey	Visiting and asking questions (Random selection)
Num. of household in study area	About 1872 households
Num. of respondents	About 200 houses
Personal attribute	Name, Address, No of family members, Ward number, Street name
Household attribute	Year of living, Structure of house, River distance from Household area, Days taken to recover from flood.
Other attributes	Flood warning received or not, Areas not affected by flood, Nearby (schools, hospitals, relief camps), Road network, River network
Evacuation behavior and awareness	Adopted evacuation method
Social conditions in neighborhood	Conditions of commuting, Evacuation conditions, Business conditions of neighborhood stores, Conditions of neighborhood roads and weather conditions.
Preparedness	Experience of flood, possibility of flood of the Muvattupuzha River, Preparedness of flood

2. STUDY AREA AND DATA USED

Muvattupuzha Municipality which is situated at of Ernakulam District was selected as the study area. The latitude of Muvattupuzha is 9.979882, and the longitude is 76.580307 with the GPS coordinates of 9° 58' 47.5752'' N and 76° 34' 49.1052'' E. This area is highly vulnerable for flooding. The low-lying area and huge urban population in Muvattupuzha city which is very close to the river causes huge destruction during the last years. The three main river which meets near Muvattupuzha city increases the flood impact. The Kaliyar, Thodupuzha and Muvattupuzha are the three rivers.

One of the main reasons for flash flood in Muvattupuzha region is the shutter opening in Malankara dam due to heavy rainfall. Muvattupuzha Municipality has a population of about 30397 among which 15010 are male and 15387 are female as per the Census 2011 data. There are about 7414 houses and the population density of city is about 2306 persons per km sq. Over 520 family members were shifted to 14 evacuation centers in Muvattupuzha .There are about 25 wards. The wards are classified as high, moderate and low in risk zones for evacuation planning as shown in Table 2. The population data of 25 wards is shown in Table 3. Many factors such as elevation, river distance, continuously flood affecting areas and the area where road network gets blocked within few hours are the factors which have taken into account. Evacuation is a response to the immediate or forecast threat of flooding that is expected to pose a risk to life, health or well-being. It involves people moving from their houses or places of business to safe locations, out of the flood risk area where they should get a shelter until it is possible and appropriate for them to return. Figure 2 shows the elevation data map

of flood affected houses from the datam line using Elevation Finder application.

Fig -2: Elevation data map of flood affected areas

Table -2: Table categorizing different zones

High risk wards	Medium risk zone	Low risk zones
Municipal Stadium (4)	Model High School (18)	Central Vazhapilly (1)
Nehru Park (8)	Vyvasaya Park (23)	Molekkudi (5)
Randarkara (10)	Janasakthi (2)	M I E T School (6)
Kizhakkekara (11)	Ilahia School (3)	Pandarimala (14)
East High School (12)	Tharbiyath School (7)	Nellimala (16)
Kallinkalkudi (13)	Perumattam (9)	Housing Board Colony (17)
Petta (15)	J B School (24)	
Kacherithazham (19)		
Murikkallu (20)		
Muvattupuzha Club (21)		
Sangamam Club (22)		

Table -3: Table showing population data

Ward	Population	Male	Female	Houses	Average (p/h)
1	1696	833	863	397	4
2	1388	691	697	326	4
3	1052	524	528	263	4
4	1096	537	559	284	4
5	1415	719	696	323	4
6	1176	565	611	253	5
7	1399	693	706	308	5
8	799	438	361	199	4
9	1683	812	871	396	4
10	1444	736	708	344	4
11	1472	750	722	338	4
12	1218	559	659	289	4
13	1061	520	541	249	4
14	1171	567	604	310	4
15	1009	476	533	247	4
16	1150	566	584	276	4
17	1171	559	612	319	4
18	1047	509	538	287	4
19	1222	597	625	282	4
20	822	366	456	198	4
21	1153	581	572	320	4
22	1154	593	561	302	4
23	1248	631	617	312	4
24	1166	594	572	300	4
25	1185	594	591	292	4

3. METHODOLOGY

Most of the wards of study area are well connected by roads. Major road network consists of National Highway, State Highway and District Roads. The road network map of Muvattupuzha Municipality is shown in Figure 3. Based on field observations the available hospital facilities is shown in Figure 4. Based on QGIS analysis data for elevation, resources available like shelters, road network, population density of wards are computed in software and following classification is done for wards. The proposed system is intended to provide the best evacuation route for people and emergency vehicles during disaster situation. According to the complex structure road network and absence of best evacuation route guiding system, there are many difficulties in many developing countries. Road network transportation is important for evacuation processes, to provide the emergency facilities, to bring and transport the people from the disaster affected area to the safe places.

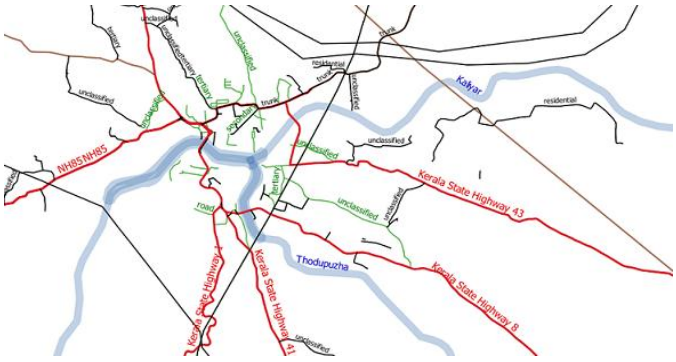

Fig -3: Road network of Muvattupuzha

Transportation of road network is required to search and rescue operation, to deliver the emergency supplies and services, to carry and move the victims from the collapsed shelters in case of disaster etc. Such strategies can save lives, decrease sufferings, and provide substantial savings and benefits to humanity. Effective respond actions and evacuation processes are a vital role during natural disaster. The proposed system will provide the hazard location and close services discovery components and the best evacuation route calculation by using our proposed modified method in QGIS. The data of road network, emergency services locations and damaged locations are prepared and stored in the database. The data used in this system are collected from related emergency service departments of Muvattupuzha Region, Google Map and GPS. Data collection is one of the important phases in designing a GIS system. The methodology of collecting data is shown in Figure 5 Flowchart.

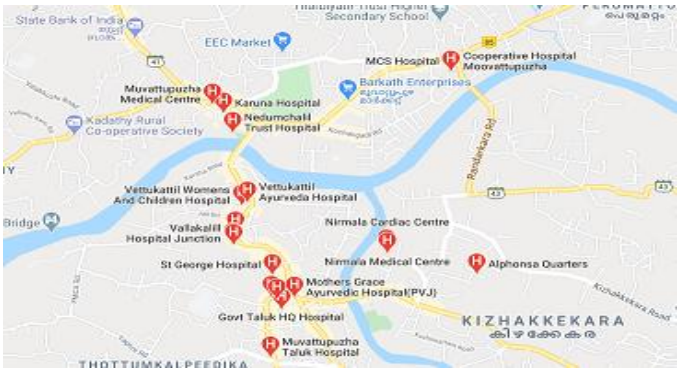

Fig -4: Hospital facility in Muvattupuzha

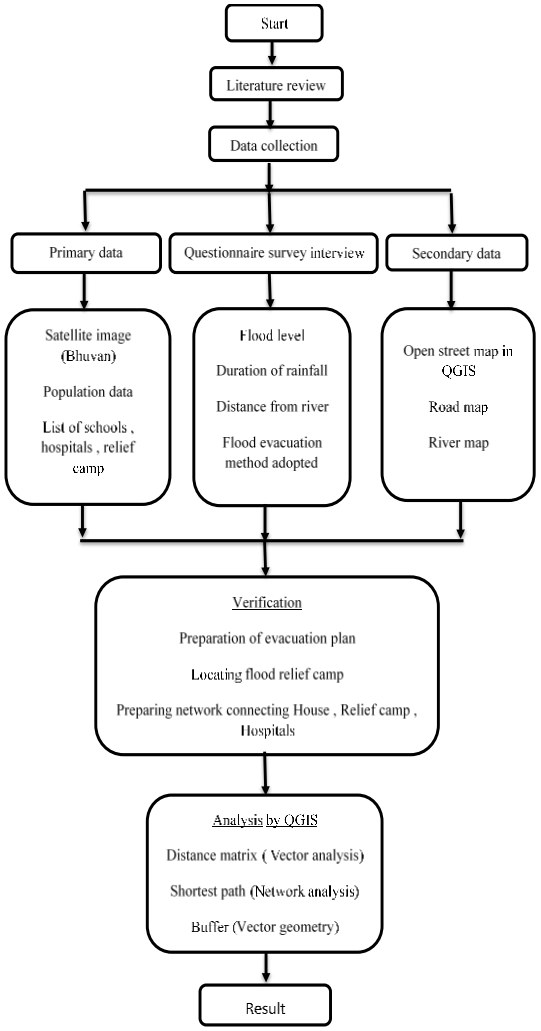

Fig -5: Schematic representation of methodology

3.1 Flood Preparedness

This will determine the level of flood awareness and is likely to influence whether people receive official (or unofficial) warnings and how they act on them. Gather emergency supplies and follow local radio or TV updates. According to the study conducted in about 200 houses,62% of the area gets continuous information about the flood and how to prepare for it by the government officials and 38 % of the remote areas were not given or not informed about flood warning this is shown in Figure 6. This clearly shows that only main areas which is close to the city gets informed while the remote village areas were not informed. The rest 38% were aware only through public communications such as phone calls from relatives, Television, Social medias etc. This causes chances of false news or create panic situation. This can be avoided by providing flood warning to all the people by the officials from the Village, Municipality or Police etc. This helps to know your community's warning signals, evacuation routes, and emergency shelter locations.

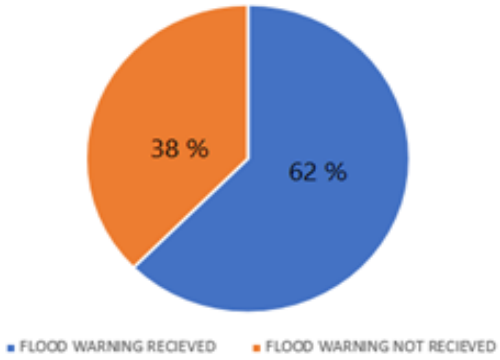

Fig -6: Pie diagram showing the percentage of people getting awareness

3.2 Evacuation

After the Flood preparedness public gets clear idea on the next step of what to do, how to do and when to do. Evacuation planning of the public is shown in Figure 7.According to the questionnaire survey conducted in about 200 houses which gets affected by flood about 50 houses (25%) went to the relief camps ,about 30 houses (15%) went to the neighborhood houses which is at higher elevation,30 houses still stayed at the top floor of the house i.e. about (15%) and about 90 houses (45%) went to the relative's houses. The people who stayed at their own houses faces problems such as the road network gets blocked and people has no access to move out of the houses as the water reaches the top floor. The rescue teams provide them food and other supplies and if needed they moved the house members to the flood relief camps. Whether or not people evacuate in a structured manner, for an evacuation to be effective it must be appropriately planned and implemented

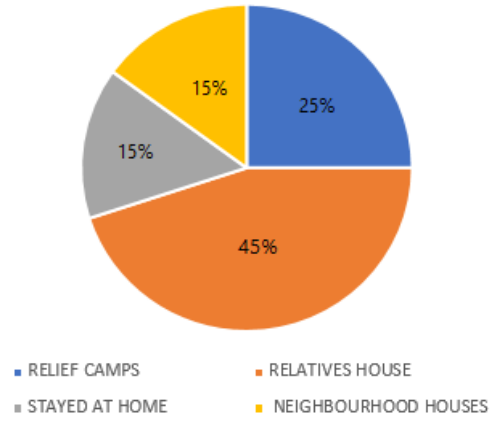

Fig -7: Pie diagram showing the evacuation methods adopted by people

3.3. Emergency Shelter (Relief Camps)

Emergency shelters are mainly the flood relief camp. Table 4 shows the list and location of relief camps. An Evacuation Center is established to provide shelter to people who are directly affected by an emergency situation and for a people that do not have anywhere else to go for. Evacuation Centers are usually established in halls or schools, auditorium to provide basic shelter. As the accommodation is fairly basic, it is recommended that people seek shelter with family or friends or private accommodation if they are able. Relief Camp should also be concerned with the spreading of diseases during monsoon season when people stay close together in the emergency shelters with the help of medicines and other hospital facilities. Relief camp should also provide first aid for those injured or wounded during evacuation to these emergency shelters. Figure 8 shows the network of houses which is connected with the relief camp and hospitals which is best suited by GIS calculation.

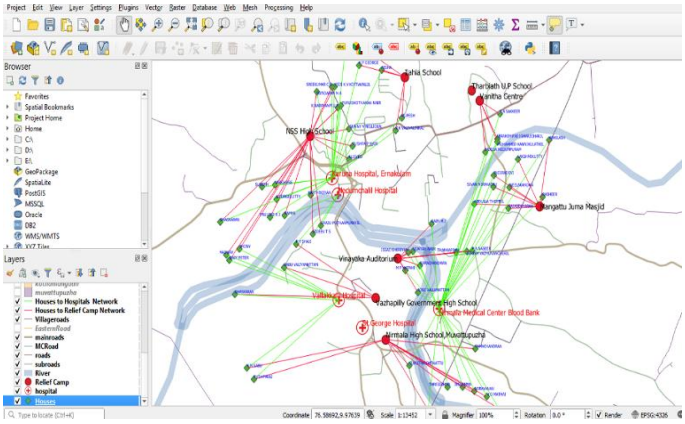

Fig -8: Network of houses connected with the relief camp and hospital facility

Table -4: Table showing list and location of relief camp

Relief camp	Latitude	Longitude
Nirmala High School,Muvattupuzha	9.980022	76.581211
RSS Camp	10.004801	76.547142
Vazhapily Government High School	9.982542	76.580487
NSS High School	9.992357	76.575752
Ilahia School	9.995907	76.582571
Vanitha Centre	9.994465	76.587973
Tharbiath U.P School	9.995083	76.587388
Vinayaka Auditorium	9.984925	76.582064

Mangattu Juma Masjid	9.988075	76.592287
Town U P School,Muvattupuzha	9.989836	76.579192
SNDP High School,Muvattupuzha	9.984609	76.575942
Loretto Ashramam	10.002058	76.581938
JBS Vazhapilly	9.996353	76.571673

3.4 The Return and Recovery

The return and recovery are the last stage. In case of flash flood which occurs yearly in the monsoon season the return and recovery is only possible after about 10 to 15 days. So, the disaster caused by flash flood last for a short period till the water level decreases and all the road network gets possible to access. A flash flood may occur within short period and also last for a short period. In this short period of time the evacuation planning should be effective to decrease the loss of lives and property. The return and recovery are possible only when the condition of weather gets better. The return to the houses is possible only after the order from the government officials till then all the facilities are provided from the relief camp and health centers.

4. CONCLUSION

The field study conducted in the Muvattupuzha Municipality helps to understand that a proper evacuation management is strictly necessary as the area has no proper evacuation planning that is the reason of damage to life and property. So, this study had managed to improve several aspects on the evacuation center selection by the proper road network. After the road networks are blocked it is very difficult for rescue operation. As per the public information the rescue teams take time to reach the Muvattupuzha region. In order to find the best solution a method by using GIS and Remote Sensing software have been created which is important contribution to the process of rescue and selection of the location for evacuation center and for finding the best evacuation route. It helps to verify the precise location of disaster area and the optimal evacuation routes to transport people from the hazard location to the safe places. This system can give the significant help to the emergency rescue teams by supporting the best route to go the disaster location in time. Thus, the evacuation planning is effective in a well-structured manner.

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