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DISASTER RECOVERY THROUGH PREDICTION OF SAFE ROUTE USING DIGITAL ELEVATION MODEL LEVELS

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ABSTRACT

When a disaster occurs, the normal commutation routes are disrupted. People get stuck at these disaster points and would be in trouble, hence people in those areas find it difficult to communicate and evacuation route to safe area is unknown. The aim of the paper is to predict safe routes to reach the refuge point from the disaster point. The prototype was developed using Arc geographic information system runtime SDK for Java Application and APIs in Eclipse. The system was developed with digital elevation model layer, and route layer for India basemap focused to Tamil Nadu. The safe route is found based on the elevation values of the area from the disaster point to a safe point. The developed system could be used by the relief providers to reach the disaster point and rescue victims.

Keywords: Digital elevation model, Disaster, Elevation levels, Environmental Systems Research Institute, Geographic information system, Threshold value.

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INTRODUCTION

Natural disaster is an action occurs due to the natural calamities happens across the globe. Natural disasters may lead to life loss and property damage depending on its intensity levels. Any natural disaster is often beyond repair or takes a lot of time to revert back. Natural disasters, worldwide have become more intense in the recent years. The frequency of earthquakes, Heat waves, and mega storms has gone up in the last few decades. Areas that get hit by floods, cyclones, and hurricanes have encountered more life loss. In some areas, as disaster mitigation activities people engineered shelters to protect themselves against these disasters. However, a certain percent of loss of property is still a problem, and predicting these natural events are difficult. Scientists and geologists work to predict major disasters and avert as much damage as possible. With all the technology available, it has become easier to predict major weather-related natural disasters. However, there are still natural disasters that come rather unexpectedly. Areas that are not used to disasters, affected by flash floods or sudden hailstorms will be affected in an extreme way. There are several organizations set up with the primary goal for providing aid to the victims. These organizations work on global and local scale rescue work. Those who have chosen to make disaster relief their life-work, when disasters hit can be provided with technology to assist rescue activities. Our project can aid as rescue support to victims and organizations to face the disaster.

EXISTING METHODOLOGIES

The research toward climatic hazard management has been addressed by geographic information scientist over a period of time. In this section, various such methods were discussed. In Forkuo's study [10], a composite flood hazard index (FHI) was used by considering the properties such as near distance, population, number of towns in each district, wetland and high ground area. This has been formulated as given below:

$$FHI = (\text{near distance} + \text{population} + N\_Towns + Wetland\_Area + R\_shelter) \quad (1)$$

In Sanyal and Lu's study [11], the identification of higher hazard zone was used as a parameter. In due course of time, geographic information system (GIS) techniques were combined with the technology of remote sensing to provide more accuracy in the prediction. In the papers [12,13], many approaches for creating flood hazard maps are discussed. In all these papers, initial level of the solution is given to manage various problems which can be caused by flood using GIS and remote sensing.

PROPOSED SYSTEM

There are apps and prediction systems available to track the disaster points and inform the user. There are several disaster prediction systems and alert systems that are used to shift the people before disaster. There are apps providing details about the disaster intensity, date, time. However, the situation changes after the disaster. The geographic pattern after the disaster is different from the geographic pattern before the disaster. The geographic data after the disaster are different from before disaster. Hence, it becomes difficult to know the intensity of damage occurred in the area. The proposed system uses services provided by Environmental Systems Research Institute (ESRI), California. ArcGIS a tool provided by ESRI was used in developing the project. ArcGIS provides functionalities to work on maps. It enables us to add maps from ArcGIS online services to the current workspace and enables us to manipulate data in it. The project solely depends on digital elevation model (DEM) is layer of map that can be added to the basemap. It gives the elevation values of the land area from the sea level. To get the elevation values, spatial analysis is done and displayed as point features. We have marked certain points on the map and spatial analysis tool extracts the DEM levels for the points marked on the map. At the final stage route analysis extension is used to find the route between the given points. Route analysis finds the quickest or shortest route depending on the impedance such as time attribute with historic or current traffic data. For our system indirectly, the impedance attribute is DEM levels. To perform route analysis, we need a basemap view called as street view. This would provide the path details for the route analyst. To perform the functionalities provided by the above-mentioned extensions, we need to store our maps and data in the form of a map package. Our system analyses the before disaster scenario and predicts the safe areas. This system is developed on the world street map as its basemap, retrieved from ESRI online services following WGS_1984 geographic coordinate system. For our simulation, we have focused the map on Tamil Nadu, India, as shown in Fig. 1.

Now a DEM layer was added on the map and focused to the same area as the basemap on the tool. The major cities were picked, and their elevation levels were calculated using ArcGIS extraction tool. These points which were picked were considered as the rescue and evacuation points as these belong to the major cities of Tamil Nadu, India. Spatial analysis is feature.

Find disaster point

The disaster point is found out and plotted on the map. The disaster point is a coordinate pair, i.e., latitude and longitude. The coordinate pair on the area could be found by scrolling on map.

Disaster radius

Based on the disaster points and data stored in database, the affected radius/area is found. A script is run to mark a radius around the point on the map. The radius is around 3 km around the plotted point.

Finding route

Finding the route from the disaster point to the safe area based on the disaster radius. Average of the DEM levels is calculated. Based on the DEM levels, the route is drawn on the map. In case DEM level is not possible to find the general route is provided. The project workflow is as follows. The input was taken from the user as latitude and longitude pair to mark the disaster point on the map. A radius around the input point was generated and represented on the map. A threshold value was calculated as the average DEM level of the area drawn as the radius (Fig. 3) for the disaster location the evacuation or rescue point is marked outside the disaster radius and it should of higher or lower DEM value than the threshold value based on the disaster type. This is followed by drawing a route across the input and rescue point in Fig. 4.

Algorithm flow

First, in the process, it is important to know the disaster type and its property. Let us assume a scenario where flood has occurred. The property for flood would be water. Moreover, it is easy to accumulate water in low areas, which is the area of lower DEM level than the threshold value. Hence, this area is affected by the disaster. Hence, we

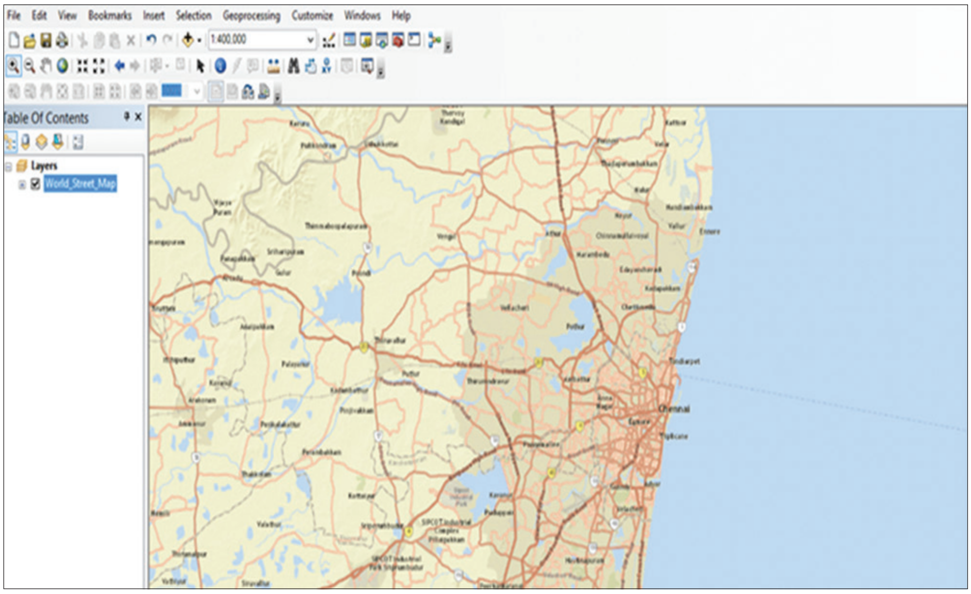

Fig. 1: Map added to the ArcGIS

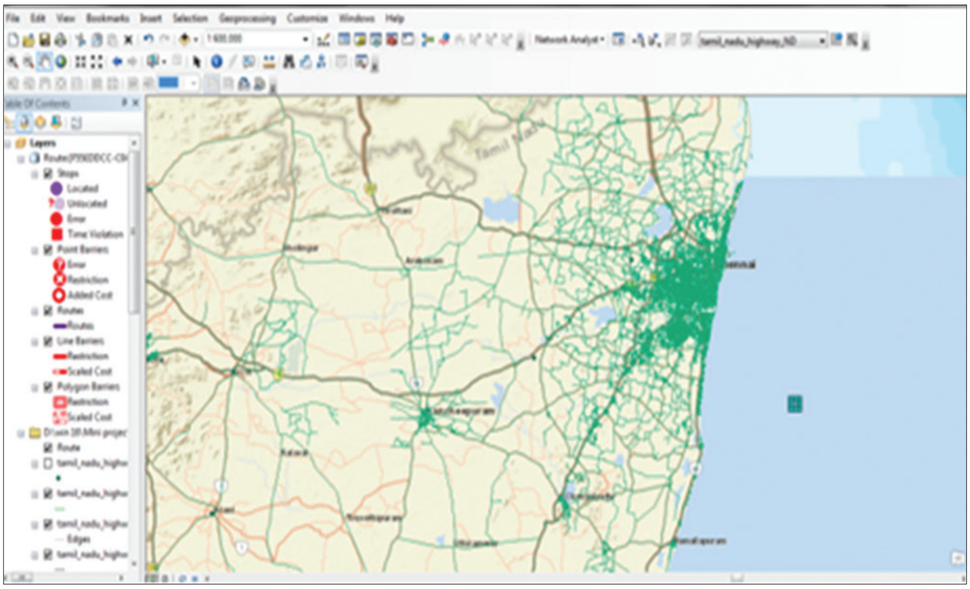

Fig. 2: Tamil Nadu map with dem layer

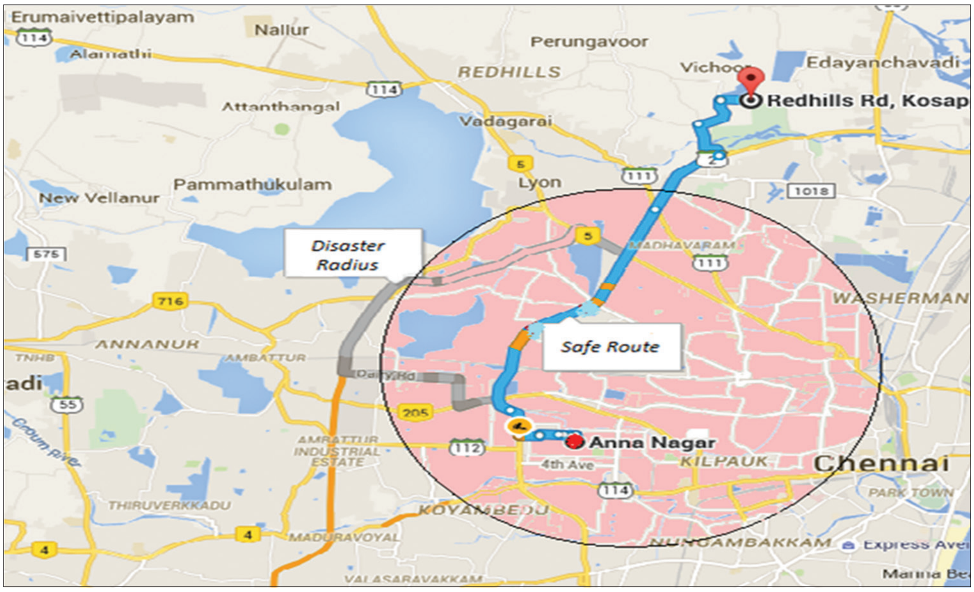

Fig. 3: Radius (3 km) plotting around the disaster point

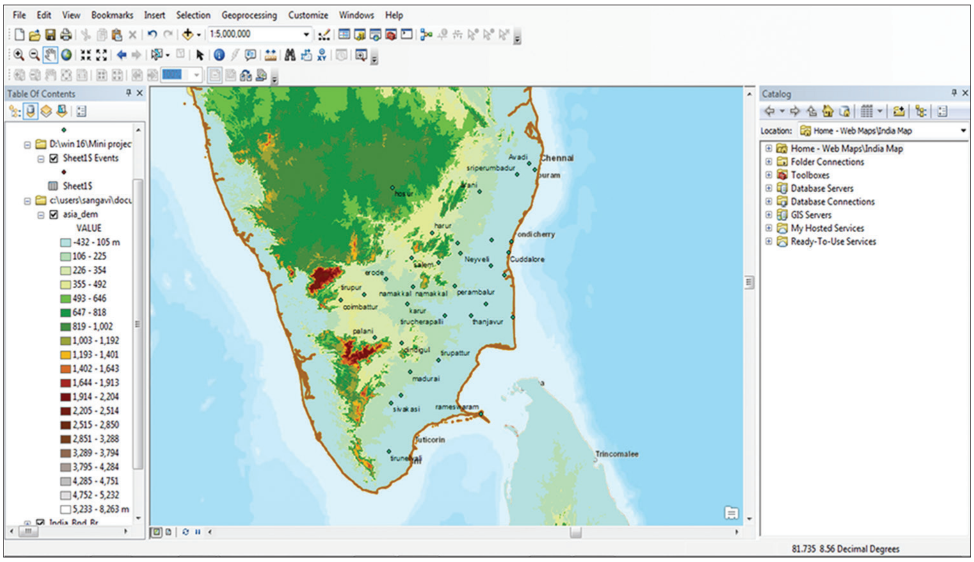

Fig. 4: Major cities of Tamil Nadu plotted on map

Table 1: Classification of composite hazard ranks into qualitative hazard intensity classes [10]

Index value range	Number of districts	Hazard category
6.180-8.000	2	Low
8.001-10.480	5	Moderate
10.481-13.230	2	High
13.231-16.58	4	Very high

need to find an area which has a higher DEM value than the threshold value. A route is drawn from the disaster location to the rescue location.

Steps

1. Disaster_Location=Input (latitude, longitude).
2. Disaster_dem=DEMRaster (latitude, longitude).
3. Threshold_value=Avg (DEMRaster).
   - If (Disaster_Type=Flood) then.
     - Disaster_Property="WATER."
   - If (Disaster_dem<Threshold_value) then.
     - Draw (radius [3 km, (latitude, longitude)]).
     - ID=Search (Rescue_dem>Threshold_value).
     - Rescue_Location=DEMRaster (ID).
     - Draw route (Disaster_Location,Rescue_Location).

If the disaster type is Earthquake, then the property associated is cracked on ground, this affects the high elevated area meaning the buildings with high DEM values than the threshold value. Hence, the rescue location has to be at a higher DEM level. After finding the rescue point, a route is drawn across. Similarly, the algorithm can be extended to all the disaster types and all the states and countries across the world.

DATA COLLECTION

DEM is a raster of elevation values. Raster values represent the map as regular arrangement of pixel cells. Each cell has a value corresponding to the elevation point. We have collected few major cities of Tamil Nadu, India along with its latitude and longitude and plotted it on the map [1].

Table 2: Raster values as output from latitude and longitude values as input using ArcGIS

1	Point	Avadi	13.09963	80.112133	20
2	Point	Ramapuram	13.01147	80.215124	13
3	Point	Puducherry	11.91386	79.814472	7
4	Point	Chidhabaram	11.398194	79.695359	11
5	Point	Cuddalore	11.744699	79.768024	9
6	Point	Neyveli	11.543236	79.476013	42
7	Point	Sankapuram	11.889527	78.91468	153
8	Point	Attur	11.596294	78.598918	218
9	Point	Perambalur	11.240984	78.866573	130
10	Point	Kumbakonam	10.961695	79.388113	57
11	Point	Thanjavur	10.786999	79.137827	288
12	Point	Dindigul	10.367312	77.980291	284
13	Point	Salem	11.664325	78.146014	194
14	Point	Namakkal	11.219439	78.167724	83
15	Point	Tirucherapalli	10.790483	78.704673	7
16	Point	Nagapatnam	10.765608	79.842389	57
17	Point	Thanjavur	10.786999	79.137827	175
18	Point	Erode	11.341036	77.717164	130
19	Point	Perambalur	11.240984	78.866573	75
20	Point	Dharmapur	22.551768	87.163481	141
21	Point	Madurai	9.925201	78.119775	297
22	Point	Tirupur	11.108524	77.341066	431
23	Point	Coimbattur	11.016844	76.955832	324
24	Point	Palani	10.448919	77.520939	54
25	Point	Tirunelvali	8.713913	77.756652	108
26	Point	Sivakasi	9.453285	77.802417	108
27	Point	Karaikudi	9.453285	77.802417	97
28	Point	Virudhunagar	9.568012	77.962444	7
29	Point	Rameswaram	9.287625	79.312929	54

Hence, when DEM levels are extracted using the Spatial Analyst, the plotted points are taken and a table with the raster values of the points from the sea level is extracted as shown in Table 2. Details of the direction from instop (start) to outstop (destination) are collected from ArcGIS which are passed as inputs to our source code where we have a find routes as inbuilt function [2]. This gives a geodatabase as output which has the safest route details such as Route name, arrive curb approach, and departure curve approach [3]. Fig. 5 provides a scatter plot depicting the raster values across the cities.

RESULTS

The project was tested with the disaster locations randomly by selecting the major places of Tamil Nadu, India. For the disaster location, a radius of 3 km around the disaster point is drawn. The route and directions between the disaster location and the rescue point were established. The rescue point on basemap was plotted based on the DEM levels and threshold value obtained by the spatial analysis using ArcGIS.

CONCLUSIONS

When a disaster occurs people will be unable to shift to the refuge point as the routes are unknown. Hence, our work provided a way to predict the routes to reach the rescue point from the disaster point. These routes could be even used by the relief providers to reach the disaster point.

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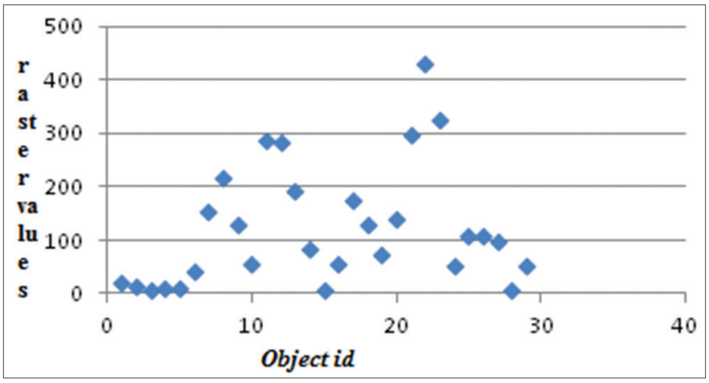


Fig. 5: Scattered plot for the raster values of the disaster location

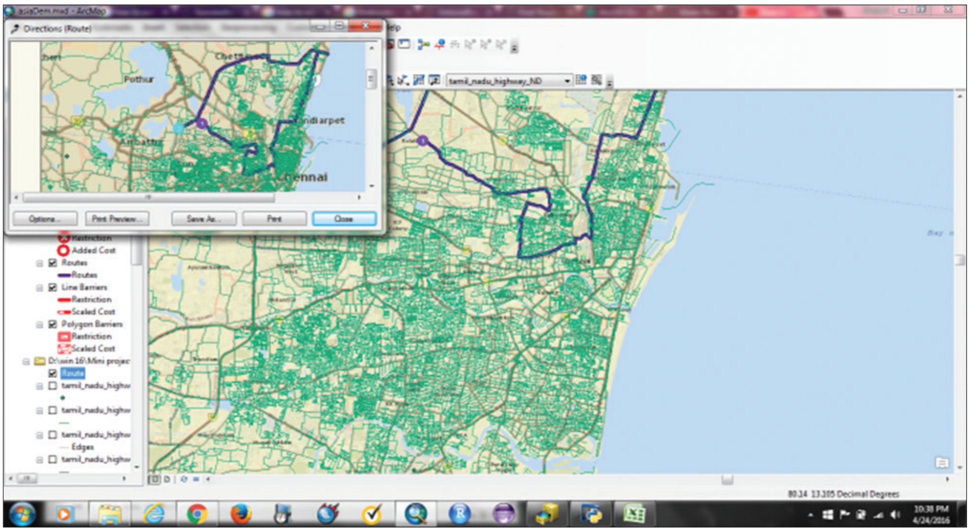
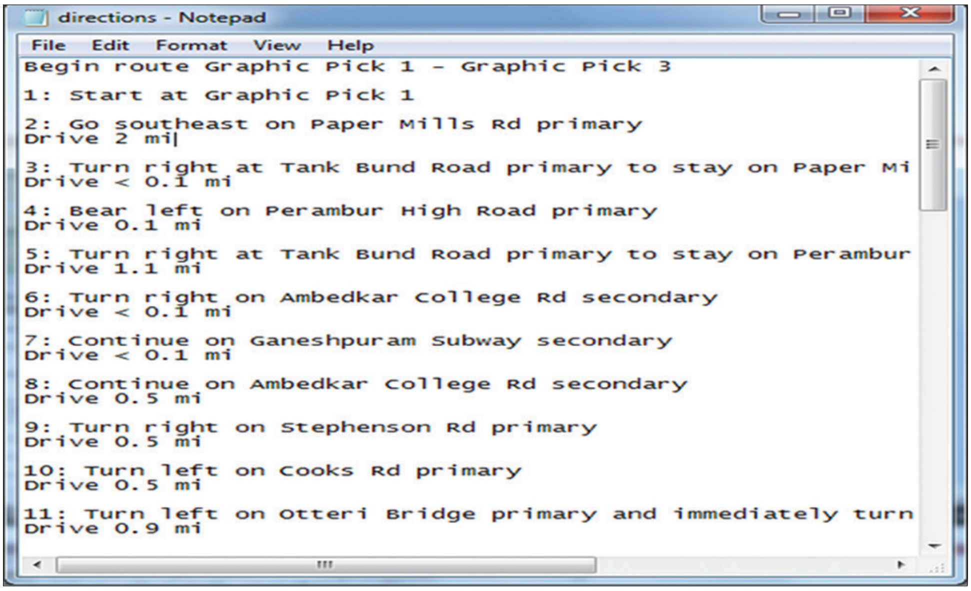


Fig. 6: Route established through spatial analysis



directions - Notepad

File Edit Format View Help

Begin route Graphic Pick 1 - Graphic Pick 3

1: Start at Graphic Pick 1

2: Go southeast on Paper Mills Rd primary
Drive 2 mi

3: Turn right at Tank Bund Road primary to stay on Paper Mi
Drive < 0.1 mi

4: Bear left on Perambur High Road primary
Drive 0.1 mi

5: Turn right at Tank Bund Road primary to stay on Perambur
Drive 1.1 mi

6: Turn right on Ambedkar College Rd secondary
Drive < 0.1 mi

7: Continue on Ganeshpuram Subway secondary
Drive < 0.1 mi

8: Continue on Ambedkar College Rd secondary
Drive 0.5 mi

9: Turn right on Stephenson Rd primary
Drive 0.5 mi

10: Turn left on Cooks Rd primary
Drive 0.5 mi

11: Turn left on Otteri Bridge primary and immediately turn
Drive 0.9 mi

Fig. 7: Directions given form disaster point to refuge point

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