

## GIS Aided Evacuation Planning: A Path to Relief in Disaster

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### Abstract:

Evacuation planning for a disaster is one of the most complex tasks of response actions. Evacuation is carried out in two situations. Precautionary evacuation is carried out before the triggering of disaster and the community as a whole is transferred to safe areas. Post disaster evacuation is more tedious than precautionary evacuation because there may be chances of damages to infrastructure e.g. bridge collapse, blockage of road with debris or due to many other factors. Therefore, an already developed evacuation plan can help in evacuation during disaster or disaster like situations.

This paper would describe an evacuation plan which is developed using easily available assorted tools and technologies. To find out vacant areas for evacuees/relief camp, GIS helps to search out the available safe areas at the outskirts of disaster stricken location. There are two ways to find out the safe area in a city. First one is by using the already built in GIS file of land use of stricken area and second one is by using the satellite imagery. For a planned or partially planned city, first method is more effective than the latter one because land utilization (mapped by transport department, municipalities etc.) is already known.

This paper focuses on a very practical issue of evacuation during the great mass gathering at Allahabad for the Kumbh Mela. Reports of stampede resulting in deaths are not rare. Thus, as they say, prevention is better than cure, it is always better to have a mitigation and management plan for this issue, which is nothing less than a disaster, when it is known for its eventual recurrence. The paper highlights the methods of obtaining optimal shortest path from the site to the safe areas.

Optimum distribution of victims is carried out by considering and optimizing various factors like distance of safe area from the stricken point, the capacity of safe area and the population at the incident point etc. Users of the proposed method can also find out the available closest facility e.g. hospital, community centers etc. from the disaster strike point by giving their own constraint.

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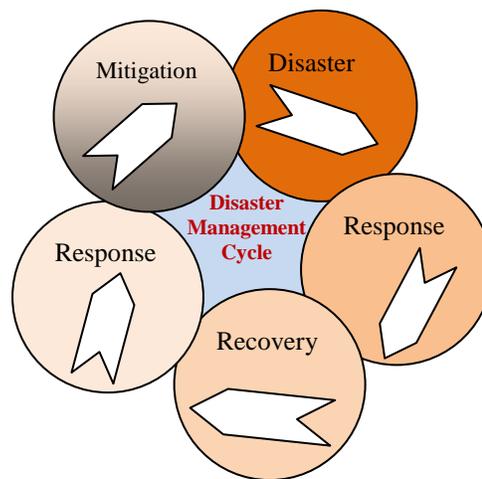
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## Introduction

Almost every day newspapers, radio, television reports disasters in several parts of the world. What exactly is a disaster? Organizations define the meaning of disaster according to their trade. World Health Organization (WHO) defines disaster as “any occurrence that causes damages, ecological disruptions, loss of human life, deterioration of health and health services, on a scale sufficient to warrant an extraordinary response from outside the affected community or area”. According to United Nations International Strategy for Disaster Reduction (UN-ISDR), disaster is defined as “a serious disruption in the functioning of the community or a society causing wide spread material, economical, social and environmental losses which exceed the ability of affected society to cope using its own resources.” To stand against these calamities either natural or manmade, a peculiar pre-planned disaster management is mandatory (Alexander, 2002).

Keeping this in mind, disaster management can be carried out by performing various activities including preparedness, response, recovery, and mitigation (Mansourian, 2005). ‘Preparedness’ comprehends all those activities which are performed by various Government organizations, Non-Government Organizations (NGO’s) and other national and international organizations to giving quick response to disaster, if it occurs. Response refers to the immediate activities to address the immediate and short term effects of disaster which focus primarily on the actions necessary to save lives, protect properties and to meet basic human needs. Rescue and relief operations, fire fighting, medical aids, shelters, evacuation, law enforcement and security are parts of response activities. Recovery indicates all those activities, like (reconstruction of buildings, exemption in taxes and long term medical care and counseling), which brings back the society to its normal condition. Prevention and mitigation leads to all those activities which reduce the effect of disaster. Building codes and zoning, vulnerability analysis and public education are the example of mitigation activities.



**Figure 1: Disaster management cycle**

In today’s world, urbanization and modernization has been encroaching into the supremacy of nature, resulting in increment of the number of disasters in comparison of past history. Humans have created new tools and technologies and hence it becomes mandatory to develop solutions or services by using these tools and technologies that could be used in the disaster incidents and will help to impair the impact of disaster (Naghadi *et al*, 2008). In this context, an evacuation plan, a part of preparedness activity, can help in circumstances that require relocation of people and their families; and this includes mounting terrorist attacks and threats, insurrection and other civil mutiny or sudden crisis such as natural disasters.

These natural or man-made disasters require immediate and rapid mobilization of people and response of different organizations due to unexpected occurrence, nature and magnitude of incident, goods and services needed by the evacuees (Apte, 2009). The main purpose of relief operation is to prepare a transportation system for supply of first aid material, food, cloths, medical help, equipment, shelters and rescue personnel from the point of supply to the various geographically scattered

nodes in disaster region including evacuation and transfer of people affected by disaster to the healthcare centres and shelters safely and rapidly (Barbarosoglu and Arda, 2004).

In this context, logistics during the disaster and emergency operations is known as humanitarian logistic. Transporting the critical supplies, rescue personnel from relief centre to affected areas, evacuation of victims to shelters and medical facilities play an important role in humanitarian logistic (Chandes and Paché, 2009).

Evacuation can be mandatory, recommended or voluntary, besides it may differ by scale, objects of relocation and by level of control by authorities. An emergency evacuation plan assigns evacuees to fixed route and direction even before the disaster and defines evacuation policies for the occupants from areas under risks of disaster (Compos *et al.*, 2012).

## Evacuation Planning

Any calamity either natural or man-made is not considered as a disaster until or unless it causes lot of losses, structure failure, environment degradation, deaths and injuries. Disasters, those occur in the inhabiting areas trap people in the houses, debris, fire or any other kind of obstacle. A disaster management authority should have pre-developed plan to handle the situation if it occurs and should be kept in contact continuously or periodically to the life-line departments like Police, Fire-fighters, NGO's, voluntarily working organizations, National Cadet Corps (NCC), National Service Scheme (NSS), National Disaster Response Force (NDRF) and many others if needed. Evacuation during the disaster is a very complex and continuous process. Duration of evacuation varies from hours to days and sometimes it takes weeks and months to evacuate the people at safe areas, depending on the type and magnitude of incident. Decision makers need to communicate with the supporting departments and to inform victims for evacuation. The major problem with evacuation is limited number of exit points which causes very heavy rush on the roads which leads to further problem for the effective implementation of evacuation plan. Thus it is sensible to choose many routes for relocation of people in mass by ignoring the cost of distance from incident point to safe areas (Stepanov and Smith, 2009).

## Procedure of Evacuation Plan

Basic thumb rule of any evacuation plan is "run and run as fast you can" and the fact is true for all kinds of incidents. But for developing an evacuation plan everyone has to follow certain rules and regulations. First find out the location of disaster, its intensity and magnitude. After that, find out all the vacant places near the point of incident and then among them, select safe areas having easily accessible transportation network for humanitarian logistic supply and other help. Choose the best optimal route which takes minimum time from disaster node to safe areas, shelters or healthcare centers. At last, correctly distribute people at incident point and send them to safe areas, otherwise, there will be further chaos at safe area due to limited capacity of safe area. So, it is better to overcome the occurrence of this problem before happening (Padmanabhan, 2001).

## Development of Evacuation Plan

Evacuation plan is developed by following some set of rules, like find the safe area at nearby location, safe route to reach there and then correct division of multitude of people proceeding to safe areas.

- I. **To find out safe areas:** There are two ways to find out the safe area in a city. First one is by using the already built in GIS file of land use. Second one is by using the satellite imagery. For a planned city, former method is more efficient than the latter one because land utilization (mapped by organizations like transportation, municipalities) is already known. There are so many available instruments like Theodolite, Total station and Global Positioning System (GPS) which are being used in surveying and creating the map and toposheet of a surveyed land. Here, the below figure is a digitized map of a city with point, polygon and line features. Dark red patches are those areas which can be used as safe areas during emergency evacuation. Basically, these patches are of schools, colleges, community centres, government

buildings and hospitals etc. These are mapped this way using Arcmap. ArcGIS also has the provision to calculate the size of those areas which will help in ramification of people in mass at disaster point.

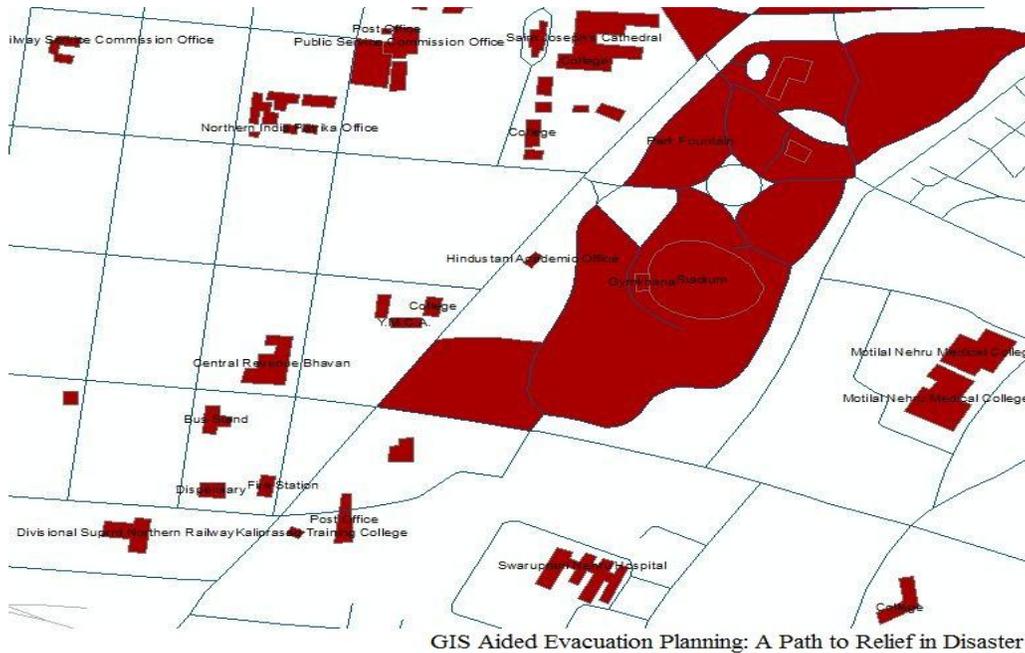


Figure 2: Emergency Areas

II. **Determination of Path:** Most important part of evacuation plan is to find out the shortest path for humanitarian supply, closest facility and to deploy the search and rescue team. The routing solvers within network analyst tools, namely the route, closest facility and origin to destination cost matrix are based on the well known Dijkstra’s algorithm for finding the shortest path. Closest facility uses multi-origin multiple-destination algorithm based on Dijkstra’s algorithm and same concept is used in origin destination cost matrix with some constraint like destination is within the specific cut-off or to solve for fixed number of closest facility.

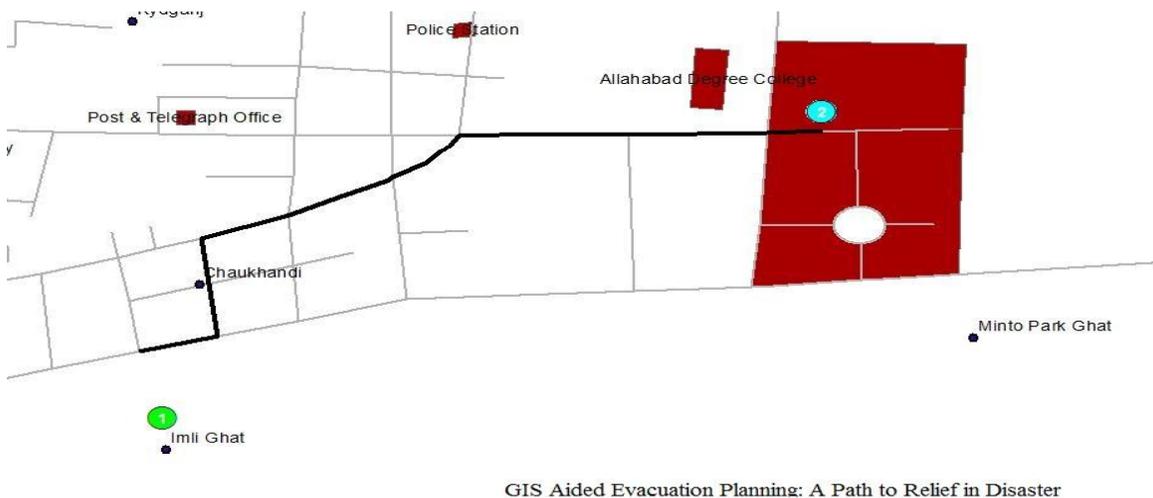


Figure 3: Shortest route from point 1 to point 2

Figure 3 describes how ArcGIS can be useful to find out the closest distance from origin to destination. For instance if a fire or stampede takes place at point one (Imli Ghat) then point 2 (Allahabad degree college) can be closest safe area for relocation of people and to set the relief camp.

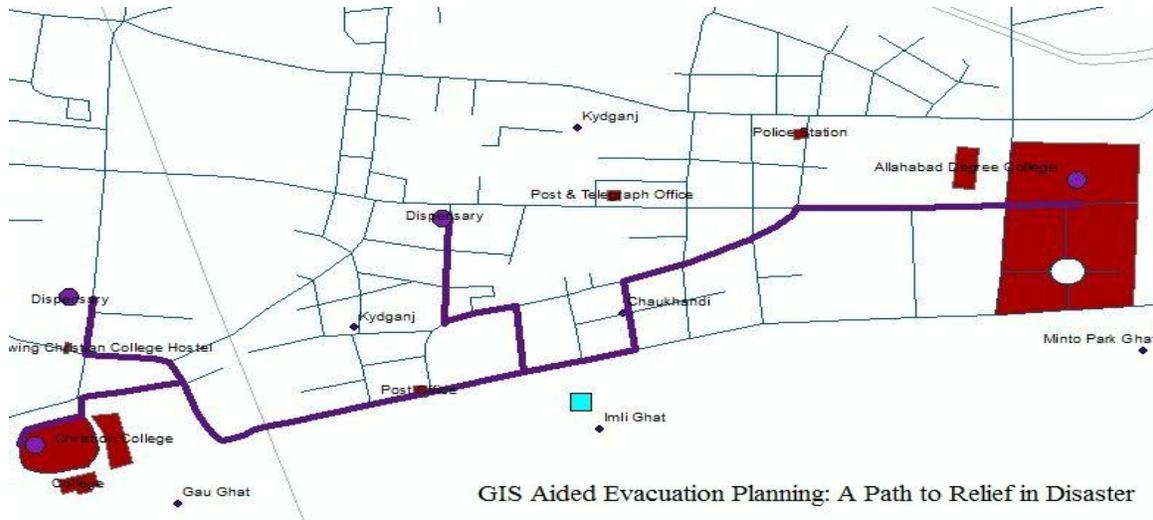


Figure 4: Closest Facility Analysis

Figure 4 describes the closest facility from the point of incident to targeted safe area. For instance, a kind of disaster takes place at Imli Ghat then by using the closest facility analysis, Allahabad Degree College, Christian College and two dispensaries has been find out which can be used in various relief and response activities. The distance of these facility points from the point of incident is given in below Figure 5.

Directions (Closest Facility)		
[ - ]	<b>Route: Graphic Pick 14 - Graphic Pick 11</b>	0.6 km <a href="#">Map</a>
	1: Start at Graphic Pick 14	<a href="#">Map</a>
	2: Go west on Unknown Line Type (Yamuna Bank Road) toward Yamuna Bank Road	< 0.1 km <a href="#">Map</a>
	3: Turn right at Yamuna Bank Road to stay on Unknown Line Type	0.1 km <a href="#">Map</a>
	4: Turn left to stay on Unknown Line Type	0.1 km <a href="#">Map</a>
	5: Make sharp right to stay on Unknown Line Type	0.2 km <a href="#">Map</a>
	6: Finish at Graphic Pick 11	<a href="#">Map</a>
	Driving distance: 0.6 km	
[ + ]	<b>Route: Graphic Pick 14 - Graphic Pick 10</b>	1 km <a href="#">Map</a>
[ + ]	<b>Route: Graphic Pick 14 - Graphic Pick 12</b>	1 km <a href="#">Map</a>
[ + ]	<b>Route: Graphic Pick 14 - Graphic Pick 13</b>	1.1 km <a href="#">Map</a>

GIS Aided Evacuation Planning: A Path to Relief in Disaster

Figure 5: Directions to Closest Facilities

The distance from incident point to facilities is given in ascending order of distance. It means, it is quite intelligent to decide the closest facility.

- III. **Ramification of People:** Disaster management authority, police, paramilitary force, army, NDRF and other government and non government organization which works voluntarily during calamity emergencies do these works better than any

other, provided that they have a good coordination and synchronization according to the situation. Prior to evacuation gather all the information about the capacity of crowd, census data of inhabitants and exit points of incident area so that easy ramification of people could take place. Disaster managers command all the organizations working in search and rescue operation and make co-ordination among them. Soldiers and volunteers take the instructions from disaster managers and help evacuees by indicating towards the safe areas and by helping them to evacuate. There is no certain rule or algorithm which is applicable in efficient and effective distribution of people because the moment when disaster triggers it creates havoc at that place. So ramification of people should be done by accurate analysis and inspection of situation.

## Conclusion

Evacuation plan is very useful to those areas which are highly vulnerable to disasters. The importance of evacuation plan emphasize on evacuation of mass, giving them the instructions to proceed towards the safe areas and to search and rescue field. This plan is very useful to evacuate people even before the occurrence of disaster and help disaster management personnel to manage emergencies more effectively.

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