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Research Article

Site Suitability Analysis of Shelters for Dam Break Flood Hazard Using Gis

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ABSTRACT

Emergencies occur at unpredictable places at unexpected time. During unexpected emergency situations, where there are no existing shelters, evacuation is done to local facilities which serve as temporary shelters. The temporary shelters should satisfy certain criteria to be deemed suitable. Prioritizing the shelters based on their suitability prior to an emergency save a lot of time during evacuation and it helps the authorities to attend to the various needs of evacuees during their temporary settlement. In the present study an effort is made to classify available shelters in the study area based on their site suitability in the face of a disaster. Here we are considering shelters for temporary evacuation from Dam Break flood. Analytic Hierarchy Process (AHP) is used for assigning weights to each parameter used for shelter selection and site suitability is found through Weighted Linear Combination (WLC) method.

INTRODUCTION

During disasters people are evacuated to shelters, where they could stay safely until the danger passes. In disaster prone area shelters are constructed and maintained to be used whenever needed. But some emergencies happen in unexpected places at unexpected time. In such situations, facilities in the locality like schools, colleges, churches etc. are used as temporary shelters. Although considered of low risk, incidents with dams may cause significant damage both directly and indirectly. Dam break emergency response involves evacuating the affected population to safe shelters in the best possible way. Prioritizing the shelters based on their suitability prior to an emergency save a lot of time during evacuation and it helps the authorities to attend to the various needs of evacuees during their temporary settlement. Shelters are facilities in which rescues can find health assistance, food, and safety. The location of these facilities depends on the location of other facilities (e.g., hospitals, fire stations), the road network and the evolution of the flood (water depths and speeds). Shelter is a critical determinant for survival in the initial stages of a disaster. Beyond survival, shelter is necessary to provide security and personal safety, protection from the climate and enhanced resistance to ill health and disease. Jairaj and Nair (2017) have conducted a dam break study and emergency action plan preparation for the three dams in Pampa river basin. By conducting dam break analysis they prepared an inundation map for pampa river valley. In this project, an attempt is made to classify temporary shelters situated in selected panchayath based on their site suitability.

STUDY AREA

More than sixty panchayath will be inundated if any of the three dams in Pampa river basin break (Jairaj and Nair, 2017). In this work, six panchayath in Pampa River Basin are selected for shelter suitability study. They are Aranmula, Eraviperoor, Kuttoor, Thiruvalla and Thiruvanvandoor panchayath of Pathanamthitta district and Chengannur Municipality of Alappuzha district as shown in Fig 1. Study area spans from 76° 32' E to 76° 42' E longitude and 9° 18' N to 9° 24' N latitude. Of the selected six panchayat, Kuttoor is fully inundated and rest is partially inundated.

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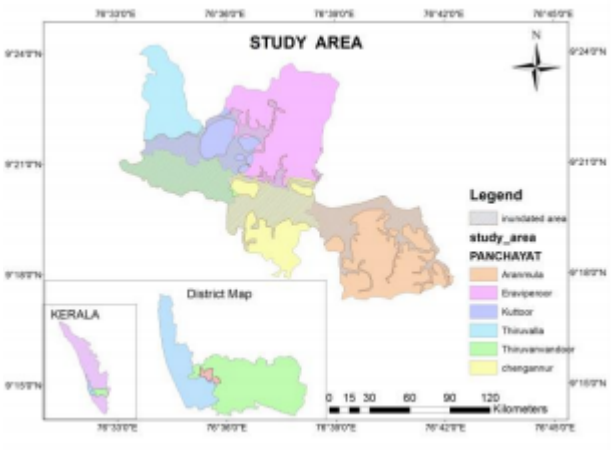
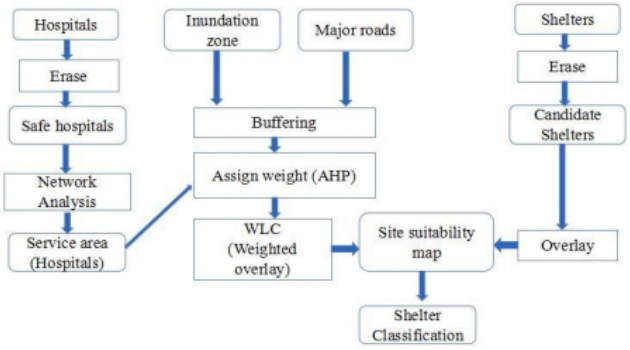


Figure 1: Study Area.

METHODOLOGY

There are a number of parameters which affect the suitability of shelters. In the present study the location suitability of shelters is considered. The study area is not situated in an earthquake faulty region and there are no hazardous industries in the region. So while checking the site suitability of shelters mainly three factors are considered: 1. Accessibility to shelters. 2. Proximity to inundated area. 3. Proximity to medical centers. Fig 2 shows the methodology followed to prepare the priority map of shelters. Service area of hospitals are found using Network Analysis. AHP method is used to assign weights to each parameter. Then Score of each shelter is found by WLC method. For that, Weighted Overlay tool in ArcGIS is used and a site suitability map is prepared. The candidate shelter layer is then overlaid over this and shelters are ranked and classified based on the suitability area they fall in.

Figure 2: Methodology for Shelter suitability classification.



ANALYSIS AND RESULTS

Shelters in the study area include facilities like schools and colleges. To check the suitability of these facilities during a disaster, they are classified based on site suitability. Three parameters are considered for ranking of candidate shelters and they are accessibility, proximity to hospitals and proximity to inundated zone. We are only considering accessibility through road in this study. First step is to assign weights to each parameter using AHP. Pair wise comparison between each parameter is done based on their importance level. Then each value in the matrix is divided by the sum of each column to get normalized relative weight. Weights are then derived from the obtained normalized matrix. To ensure that the weights given are consistent, consistency property of the matrix is checked. Consistency Index (CI) and Consistency Ratio (CR) are calculated as in (1) and (2):

$$CI = (\lambda_{max} - n) / (n-1) \quad (1)$$

$$CR = CI / RI \quad (2)$$

Where n is the order of the matrix, λmax is the principal Eigen value of the matrix and RI is the Random Index. Consistency ratio (CR) should be less than or equal to 0.10. The value of RI for suitability parameters with n value 3 is 0.52. Principle Eigen value calculated is 3.042. Here the CR values obtained are 0.04 which indicates the weights assigned are consistent. From the above paired comparison weight for proximity to inundated area is 18 %, proximity to hospitals is 38% and proximity to major road is 44%. Proximity to hospitals is found by defining service area for hospitals. Service area is created using Network Analysis. Here the impedance for analysis is travel distance, so distances for the generation of service area are specified. Once all the parameters for analysis are specified, service area polygons are generated. A new thematic layer is created by exporting service area polygons. Proximity to inundation zone and major roads are found based on the distance of shelters from them. For measuring that distance, multilayer buffer maps of varying distance are created around inundated zone and major roads.

Suitability Classification of Shelters

The WLC was implemented to estimate site suitability of shelters. 'Weighted Overlay' tool in ArcGIS performs the WLC analysis. Service area layer of hospitals and buffer maps are converted to raster format and added to weighted overlay tool. Weights for each input raster are specified before analysis. As the input criteria layers are of different ranges, to combine them in a single analysis, each cell of each criterion must be reclassified into a common preference scale. The preference values are on a relative scale with the highest value being most favorable. Locations close to major roads, hospitals and evacuation zone are assigned higher scale value. The Layers, the criteria used, their rating, and their weights are summarized in Table I. Weighted overlay tool then multiplies the cell values of input raster by its weight of importance and adds the cell values together to produce the output raster. Higher values in the output raster generally indicate that a location is more suitable. As a result of the weighted overlay operation, site suitability map of the study area is obtained. To get a simplified map, number of classes in the output map is restricted to three. So we get a suitability map showing areas of high, medium and low suitability (Fig 3). The classification is done based on Jenk's Natural Breaks Algorithm. It is a data clustering method designed to arrange the available values into different classes in the most suitable way. This optimization method seeks to reduce the variance within classes and maximize the variance between classes. In order to classify shelters, the 'candidate shelter' layer is overlaid over the suitability map. Candidate shelters are the shelters obtained after erasing shelters in inundated area. The shelters are classified based on the score for the location it falls

within. All the candidate shelters present are classified into three classes: low suitability, medium suitability and high suitability (Fig 4). It is observed that about 64 % of the available shelters belong to highly suitable shelters. Among them 11 % are classified to be in medium suitable location. Only 25 % of the facilities are classified as less suitable.

Figure 3: Suitability map of study area.

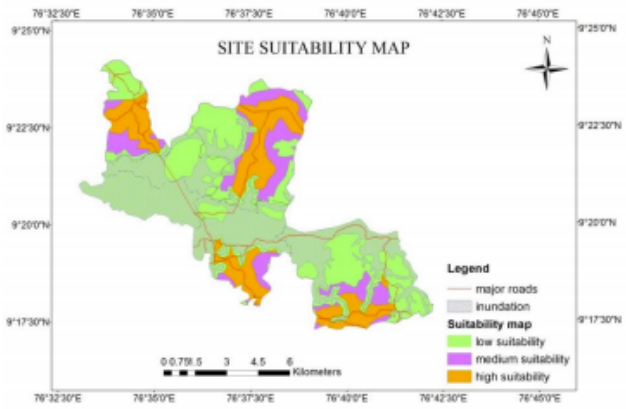
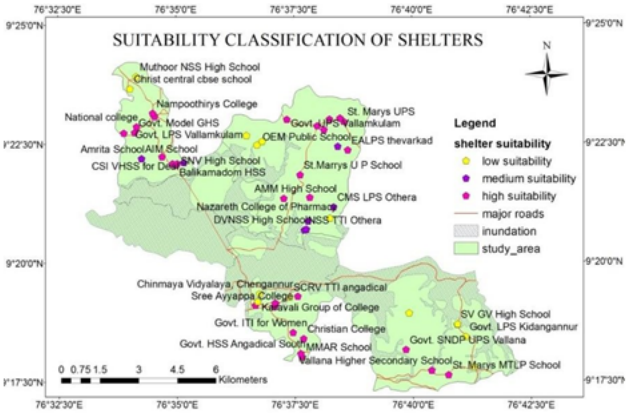


Table I: Factor rating and weights assigned to each parameter.

Sl. No.	Factor	Buffer Distance (m)	Factor rating	Weights
1	Proximity to health care facility	<500	8	38
		500-1000	6	
		1000-2000	4	
		2000-3000	2	
2	Proximity to major roads	<250	8	44
		250-500	6	
		500-1000	4	
		1000-1500	2	
3	Proximity to danger zone	<500	8	18
		500-1000	6	
		1000-2000	4	
		2000-2500	2	

Figure 4: Suitability classification of shelters.



CONCLUSIONS

Shelters in the study area are classified based on their site suitability by considering three parameters: Proximity to major roads, Proximity to hospitals and Proximity to inundation zone. Each proximity layer is divided into multiple intervals and factor ratings are assigned to them. Then these ratings are multiplied with weightage of each parameter (WLC method) to produce the site suitability map. Weights are found by AHP method. This is done using Weighted Sum too in ArcGIS. Then the candidate shelters are overlayed over this map and reclassified based on their site suitability. All the candidate shelters present are classified into three classes: low suitability, medium suitability and high suitability. It is observed that about 64 % of the available shelters are highly suitable and 11 % are classified as moderately suitable. Only 25% of the facility are classified as less suitable.

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