MULTI-CRITERIA DECISION ANALYSIS FOR FLOOD VULNERABILITY MAPPING IN WESTERN ZONE OF AHMEDABAD CITY

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Abstract – Ahmedabad city is most populated and largest city of Gujarat state. The city is on flat terrain and sabarmati river runs through its center. The floods in the city mostly happen in monsoon season. The man-made activities relevant to blockage of natural drainage, unsystematic construction of roads, building and storm water drainage network are the main reasons to the hazardous situation during urban flooding. Mainly the western zone of city is at high risk. It covers areas like Navrangpura, Naranpura, Paldi, Vasna, Wadaj, Sabarmati etc. which are highly urbanized and also covers some main part of city, first step is to identify the area of zone which is at higher risk of flood disaster. Hence this study focused on recognize flood risk zone in western zone of city by multi-criteria decision analysis by geographical information system by remotely sensed data.

Index Terms – Urban flooding, Multi-criteria decision analysis, Flood disaster, Remote sensing, Vulnerability

I. INTRODUCTION

Now days, urban population is increasing rapidly with this growing urbanization and climate change, urban flooding and water logging problems are frequently occurring hazards. Urban flooding has caused extensive economic, social, environmental and human loses.

There can be many reasons of urban flooding like unplanned urbanization, haphazard construction of roads, buildings, blockage of natural drainage, poor waste management, insufficient drainage system, high rainfall intensity. The main reason of major floods are caused due to heavy rainfall, high tidal condition with inadequate drainage and runoff.

For appropriate management of urban flood hazards, flood modeling and forecasting is very essential. It required huge data management and surveying "Remote Sensing and Geographical Information System" technologies helps to collecting, monitoring and managing the data at a distance. Which is mostly done by observing earth surface from aircraft or satellite. It can be used in flood planning, land suitability analysis, flood zone making, flood risk mapping, run-off simulation, digital elevation modeling etc.

II. METHODOLOGY

After collecting required data for present study from various sources like government institutions, published reports, satellite data, internet services and research generals. Image digitization differentiate in different variables like point,line,polygon such as ward boundaries, road, river, population density etc. Now the reclassification of remotely sensed images takes place it includes scanning and geo referencing of toposheets and Landsat data. The remotely sensed satellite images are used to interpreting land use/ land cover and various maps like Slope, elevation run-off, drainage density and population density are generated by ArcGIS (open source) software. This multi-criteria analysis is use to generate flood vulnerability map, after finding the intensity and reason of urban flooding preferred solution should be given.

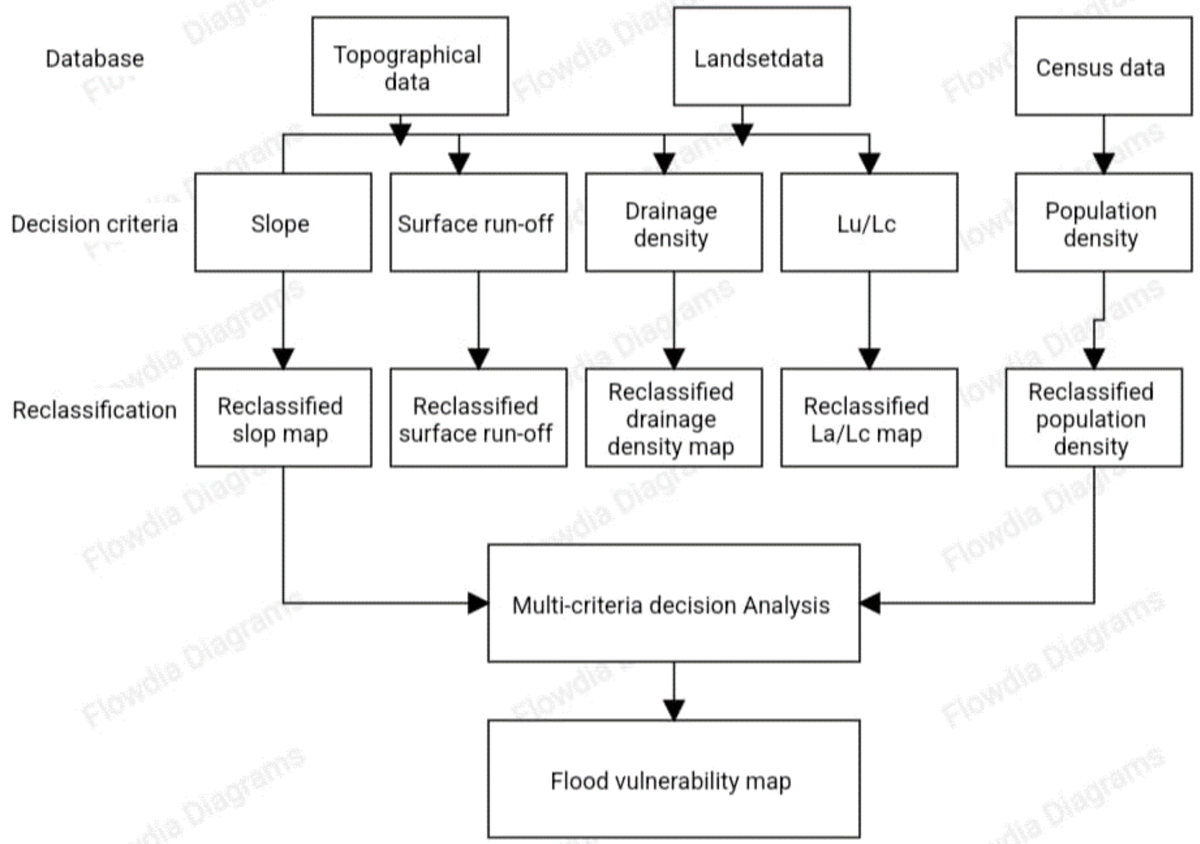


Figure : 1 Methodology

III. MULTI-CRITERIA DECISION ANALYSIS AND RECLASSIFICATION OF DATA SETS

On the basis of availability of data and detail primary survey in the studied region four major criteria are considered for flood vulnerability mapping. There are four major criteria to find out the urban flood vulnerable zone i.e. surface run-off, slope, population density and drainage density.

1.Surface Runoff

Runoff is defined as the portion of the precipitation that makes its way towards rivers or oceans as surface flow. After the occurrence of infiltration and other loses from the rainfall, the excess rainfall flows out through the small natural channels on the land surface to the land surface as subsurface flow, and reappears on the surface at certain other points. Such flows are called interflows. Another part of the infiltrated water percolates downwards to ground to ground water, moves laterally to emerge in depression and rivers and joins the surface flow. This type of flow is called subsurface flow or ground water flow. Runoff can be estimated by rational method.

Rational Equation : $Q = ciA$

Where,
Q = Peak discharge (m^3/s)
c = Rational method to runoff coefficient
i = Rainfall intensity, inch/hour
A = Drainage area, acre/km^2

In metric units, equation is expressed as.
$Q = 1/3.6ciA$
Where, Q = Peak runoff rate (m^3/s)
c = Rational intensity, inch/hour
A = Area of Drainage basin (km^2)

Coefficients of runoff for catchments characteristics shown in Table below.

Ground Cover	Runoff coefficent
Lawns	0.05-0.35
Forest	0.05-0.25
Cultivated land	0.08-0.41
Parks	0.1-0.25
Residential areas	0.3-0.75
Business area	0.5-0.95
Industrial areas	0.5-0.9
Asphalt streets	0.7-0.95
Roofs	0.75-0.95
Unimproved areas	0.1-0.3

Table : 1 Runoff coefficient

In study area there are nine catchment areas like Navrangpura South, Naranpura, Gandhigram South, New wadaj, Sabarmati, Paldi, Stadium, Vasna, Gandhigram North the table below shows total surface area of western zone of Ahmedabad city.

Name of catchment	Area of catchment(Ha)	Watershed Runoff(cum/sec)
Navrangpura South	1382.68	116.16
Gandhigram South	487.98	41.9
Naranpura	240.55	18.22
New wadaj	494.12	41.25
sabarmati	181.00	15.04
paldi	172.47	15.34
Stadium	36.89	2.45
Vasna	56.52	4.85
Gandhigram North	179.73	14.2

Table : 2 Total Surface Runoff

2. Slope

Slope is another indicator responsible for flood, which is taken into consideration. The slope function calculates the maximum rate of change between each cell and its neighbors, for example, the steepest downhill descent for the cell. Every cell in the output raster has a slope value. The lower the slope value flatter the terrain and the higher the slope value steeper the terrain. The output slope dataset can be calculated as percent or degree of slope.

Slope map is generated based on contour line in Arc GIS platform. There are five categories of slope are identified and calculated as degree unit. Figure 2 (b) indicates that, northwest and middle part of the city mostly flat and northeast and southwest part is covered by hilly area. In the results, most of the study area falls under slope category less than 0.50, which covered 90% of the total study area. This is highly flood vulnerable zone in western part of Ahmedabad city due to low-lying area.

3. Population Density

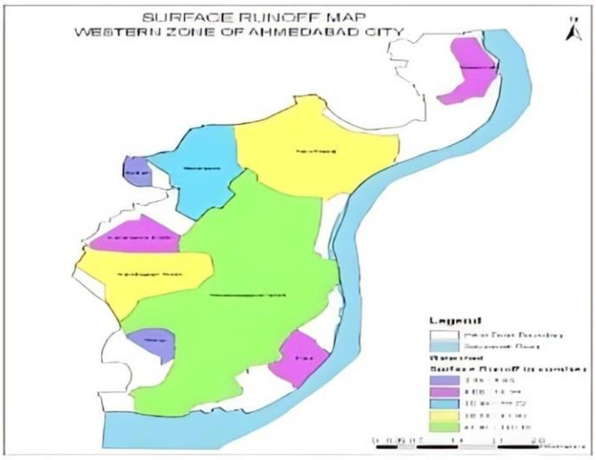
It is one of the most powerful indicators for flood vulnerability mapping. It indicates the ratio of total population in a given area (Chandna, 2010). Importance has given to this indicator that higher the density, flood vulnerability is also high. Because more people will be affected and chances of property lose are more, daily activity will be stopping (Mundhe, 2008). The present research, population density calculated as ward wise. In western zone of Ahmedabad city, there are nine wards out of them New Wadaj ward has the highest population density that is 28453 persons per square kilometer due to concentration of market and satisfactory transport facilities. Lowest population density recorded in Gandhigram and Navrangpura ward that is 9655 and 9174 respectively indicated in Figure 2 (c).

4. Drainage Density

Drainage density is a measure of stream spacing (Langbein, 1947). Drainage density reflects basin's geology and climate. Basins underlines by resistant, permeable materials have low drainage density basins underlines by weak, impermeable materials have high drainage density (Strahler, 1958). For the same geology and slope angle, humid regions tend to have lower density due to growth of thick vegetation that promotes infiltration. Arid region would have tended to have higher density given in the same geology.

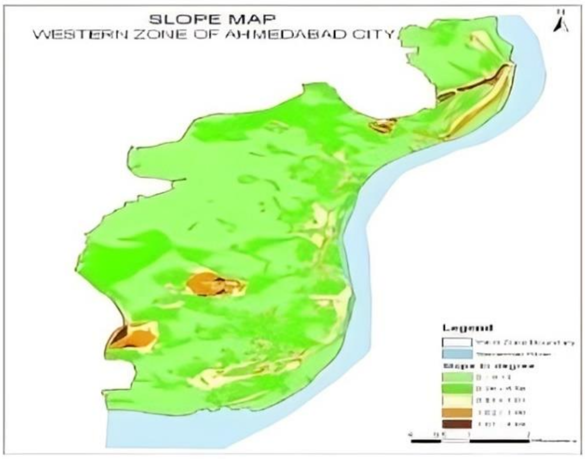
$$\text{Drainage density} = \frac{\text{Total length of streams within a Catchment/watershed (sq. km)}}{\text{Total area of the Catchment/ watershed (sq. km)}}$$

A high value of drainage density indicates a relatively high density of streams and thus a rapid storm process. The study area comprises in to nine catchments like Navrangpura South, Gandhigram South, Naranpura, New Wadaj, Sabarmati, Paldi, Stadium, Vasna and Gandhigram North. Highest drainage density found in Vasna and Naranpura catchment that is 2.50 and 2.43 per hectare respectively in city and lowest in Stadium and Sabarmati catchment area. Moreover, moderate in Gandhigram south, Navrangpura and New Wadaj catchment area mentioned in Figure 2 (d)



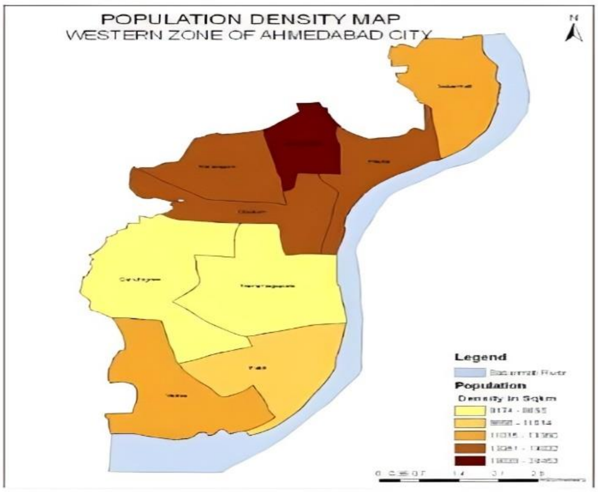
(a) Surface Runoff Map of Ahmedabad city

Figure : 2(a) Surface Runoff Map



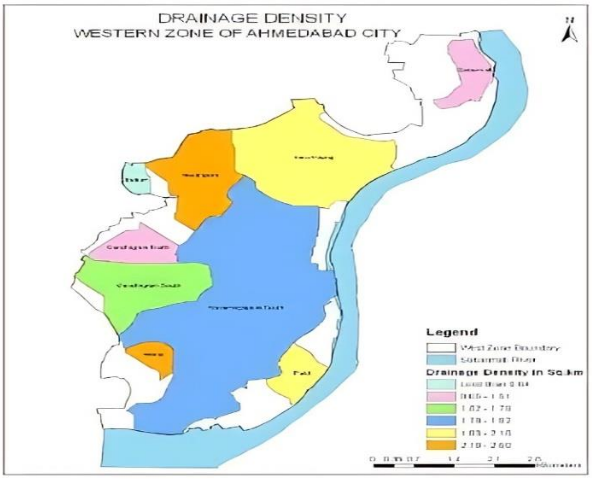
(b) Slope Map of Study Area

Figure : 2(b) Slope Map



(c) Population Density Map of Study Area

Figure : 2(c) Population Density Map



(d) Drainage Density Map of Study Area

Figure : 2(d) Drainage Density Map

IV. Result and Conclusions

FLOOD VULNERABILITY ZONE

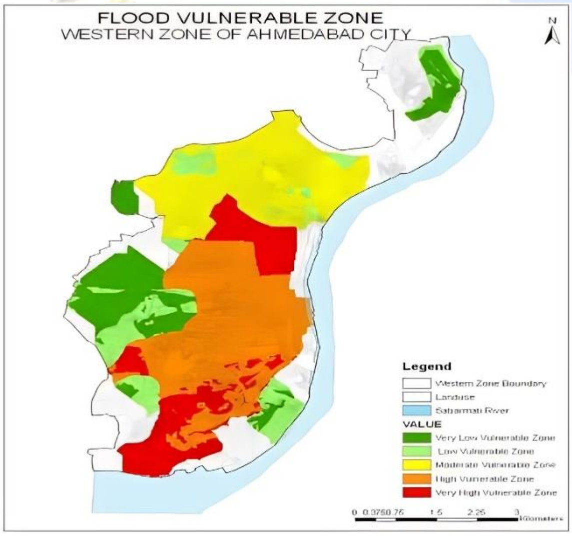


Figure 3 Flood vulnerability map

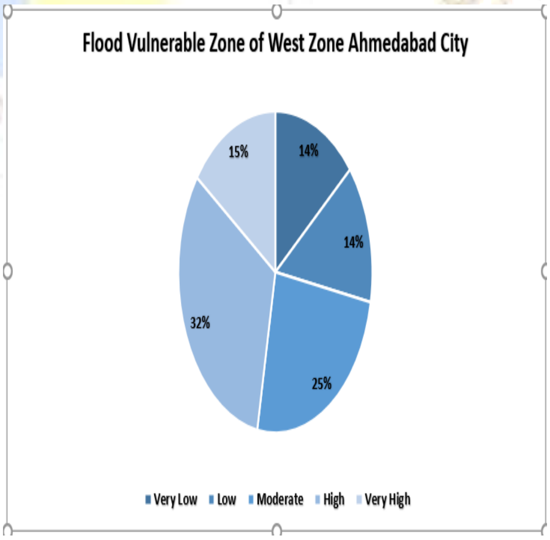


Figure 4 Flood vulnerable zone

This study shows that due to pattern of land use, closeness with river, low lying and compact housing some areas like Ambawadi, Sabarmati, Paldi, Wadaj, Vasna etc. are highly vulnerable to the flood. This topographical, demographical, morphological data, maps and charts are the representation of Remote sensing and GIS based data which can help local planning authorities and organization to identify risky areas and to take proper decision at time of risk.

V. ACKNOWLEDGMENT

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VI. REFFERENCE

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