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Flood Vulnerability Analysis of the part of Karad Region, Satara District, Maharashtra using Remote Sensing and Geographic Information System technique

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ABSTRACT

Karad City is situated on the bank of confluence of river Krishna & Koyana, which is severely flood prone area. The floodwaters enter the city through the roads and disrupt the infrastructure in the whole city. Furthermore, due to negligence of the authorities and unplanned growth of the city, the people living in the city have harnessed the natural flow of water by constructing unnecessary embankments in the river Koyna. Due to this reason now river koyna is flowing in the form of a narrow channel, which very easily over-flows during very minor flooding.

Flood Vulnerabilty Analysis has been done for the karad region of satara district, maharashtra using remote sensing and geographic information system technique. The aim of this study is to identify flood vulnerability zone by using GIS and RS technique and an attempt has been to demonstrat the application of remote sensing and GIS in order to map flood vulnerabilty area by utilizing ArcMap, and Erdas software. Flood vulnerabilty analysis of part the Karad Regian of Satara District, Maharashtra has been carried out with the objectives - Identify the Flood Prone area in the Koyana and Krishna river basin, Calculate surface runoff and Delineate flood sensitive areas. Delineate classified hazard Map, Evaluate the Flood affected area, Prepare the Flood Vulnerability Map by utilizing Remote Sensing and GIS technique. (C.J. Kumanan; S.M. Ramasamy)

The study is based on GIS and spatial technique is used for analysis and understanding of flood problem in Karad Tahsil. The flood affected areas of the different magnitude has been identified and mapped using Arc GIS software. The analysis is useful for local planning authority for identification of risk areas and taking proper decision in right moment. In the analysis causative factors for flooding in watershed are taken into account as annual rainfall, size of watershed, basin slope, drainage density of natural channels and land use. (Dinand Alkema; Farah Aziz.)

This study of flood vulnerable area determination in a part of Karad Tahsil is employed to illustrate the different approaches.

Keywords : GIS, Remote Sensing, Vulnerabilty, Spatial Analysis, ArcMap

1 INTRODUCTION

Natural disasters such as floods have constituted a major problem in many countries. In recent years, the growth of population and diffusion of settlement over hazardous areas have sharpened the impact of floods worldwide. Floods have caused immense economic and social losses, mainly as a unplanned urbanization, uncontrolled population density and not strictly inspected construction by authorities. Floods kill thousands of people and destroy billion of rupees worth habitat and property each year. In recent years, many regions in the world have experienced considerable changes in meteorological conditions and land use, which led to increased flood level and frequency.

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These extreme floods caused severe disasters such as loss of life, property and resources but these adverse effects can be prevented or at least, minimized and also the future development and planning might be more feasible if the occurrence and magnitude of the flood can be predicted and managed systematically. As it is known that floods often occurs when a rainstorm generates a large amount of runoff that overtops the banks of a watercourse and flows onto the flood and these high flows or floods generally cause damages and sometimes, injuries and deaths. Being the main part of floods, storm runoff in catchment is first of all critical so that it is important to construct a catchment disaster management to understand better flood risk in mountain areas. The formulation of a sustainable water management plan involves a multi- disciplinary scientific approach and profound study of the local region's characteristics. (Jensen, John R. 1975).

The main aim of this study is to generate a composite map for decision makers and identified flood vulnerable zone by using some effective factors causing flood. The study reviewed the role of GIS in decision-making and then outlined the evaluation approach for many criteria in decision process.

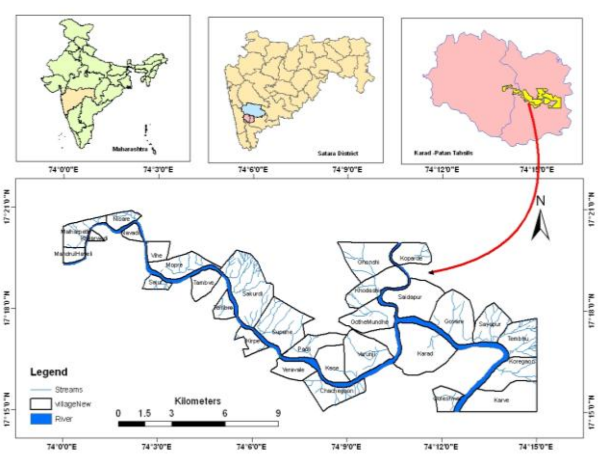

Figure 1: Location map of study area

In the analysis causative factors for flooding in watershed are taken into account as annual rainfall, size of watershed, basin slope, drainage density of natural channels and land use. This study of flood vulnerable area determination in a part of Karad Tahsil is employed to illustrate the differen approaches.

2. Study Area

The study area selected for the present study work is Karad Region, Satara district, Maharashtra state, India. The study area comprises Karad Tahsil of Satara district and some part of Patan Tahsil. The study area falls in survey of India Degree Sheet No. 43 K/3, southern side and lies between Latitude- 17^0 15′ N to 17^0 30′N and Longitude-74^0 E to 74^0 15′ E.

It is located on the bank of River Koyna, it cover an area of 100 Sq.Km, out of 6.33 Sq.Km area occupied by Koyana River. The study areas have 27 villages and Karad city and all are settlement on the bank of river. The average rainfall is 1118mm. The average elevation is 650 meters from mean sea level. The study area map is shown in figure 1.

3. Materials and Data Used

3.1 Spatial data:

1. Toposheets map - Toposheet No. 47 K/3 at 1:50,000 SOI (Survey of India).
2. Flood level map 2005 from PWD, Maharashtra Krishna Basin Development Corporation, Mumbai.
3. Flood Affected Village Boundary Map from PWD, Maharashtra Krishna Basin Development Corporation, Mumbai.
4. Landsat TM (Theamatic Mapper) Image from www.glcf.com.

3.2 Non Spatial data:

1. Daily rainfall data collection from IMD office, Pune from year 2005.
2. Census Data 2001-Satara District Gazetteers Office.

3.3 Software Used

ArcGIS Map 9.2. Erdas 9.1

4.0 Methodology

Weighting Overlay Method: In the method of spatial multi criteria analysis, the criteria weighted are given on the

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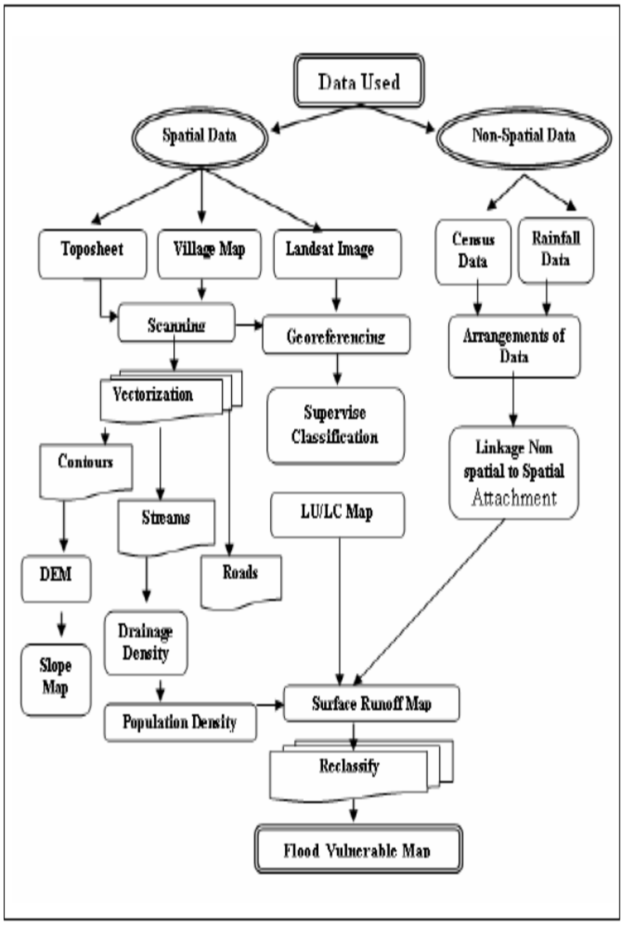

Figure 2: Flowchart Overall Methodology

basis of relative importance of assigned to evaluation criteria under consideration. The purpose of criteria weights is to express the importance of each criteria relative to other criteria. The derivation of weights is a central step in electing the decision weights, the input data can be organized in the form of a decision matrix. The methodology used in the study is shown below in figure 2.

5.0 Results and Conclusions

5.1 Flood Vulnerability Analysis

Identification of Flood Vulnerability Criteria:

Flood is every discrete natural and artificial hazard as well as disaster occurring almost every year in rainy season. It is a very complex process to understand and exactly identify cause. On the basis of availability of data and detail primary survey in the study region four major criteria's are considered for flood modeling and vulnerability mapping. (Ramani Bai; Dinand Alkema).

There are major four criteria to find out the urban flood vulnerability zone.

- Drainage density
- Population density
- Surface Runoff
- Slope Map

5.2 Draiange Density

Draiange density is a measure of stream spacing. The permeable rocks have low drainage density and impermeable rock have high drainage density. 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.

$$\textbf{Drainage Density} = \frac{\text{Total length of streams within a Catchment (Sq.Km)}}{\text{Total area of the Catchment (Sq.Km)}}$$

A high value of drainage density indicates a relatively high density of streams and thus a rapid flow of water. The study area comprises in to 6 basins. The drainage densities of the basins are shown below in table 1.

Sr. No	Name Of Basin	Basin Area (Sq.Km)	Stream Length (Sq.Km)	Drainage Density
1	A	6.53	17.53	2.68
2	B	7.95	18.73	2.36
3	C	15.05	15.07	1.00
4	D	18.63	7.46	0.46
5	E	27.48	3.74	0.14
6	F	25.30	12.94	0.51

Table 1: Drainage Density Table

The map (Fig. no.3) shows the drainage density of study

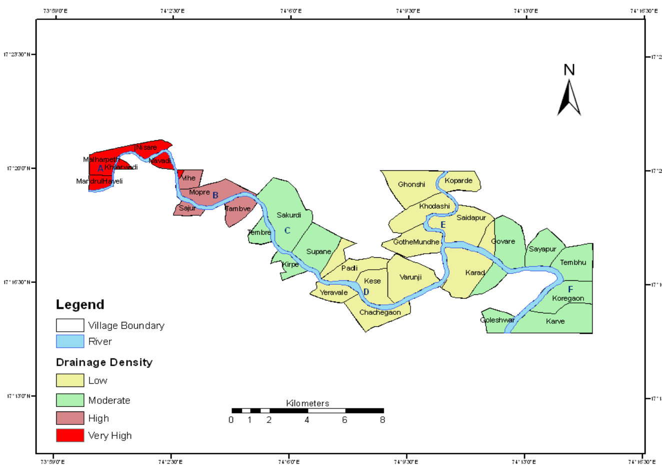

Figure 3: Draiange Density Map of Study Area

area. Drainage density is very high in A basin – include villages are Malhar peth, Naved, Nisare, Khilarwadi etc, High in B basin - Tambve, Sajur, Morpe etc, Moderate in C and F basin Sakudi, Kirpe, Karve, Koregaon etc, Lowest in D and E basin Paldi. Ghonshi, Koparde, Kese, Khondshi etc.

5.3 Population Density

It is one of the most powerful indicators for flood vulnerability mapping. It indicates the ratio of total population in given area. The density is directly proportional to the vulnerability. Because more people will be affected and

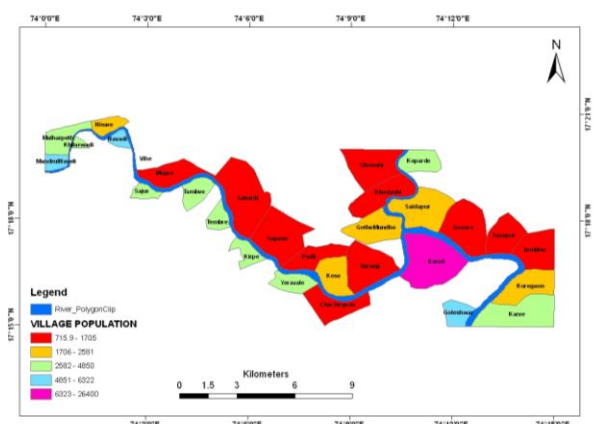

Fig 4 : Population density of study area

chances of property lose are more, daily routine will stop and it directly affect on economy of country. (Ramani Bai. et al) The village wise population data of study area is incorporated into map.

From the (Fig. no.4) the given map shows the population density is high in karad city as compare to other villages, Karve is second higher and then Malhar Peth, Saidapur. etc. Lowest Density is Khilarwadi, Navadi, and Nisare, etc.

5.4 Surface Runoff Estimations

To estimate surface runoff we have computed catchment basins and then converted to vector layer. By using this layer first clip the basins individually from supervise classified image and estimate the surfaces of various types according to that type, factors has used for the estimate surface runoff. Runoff can be estimated by rational method (C.J. Kumanan; S.M. Ramasamy et al).

Rational Formula Method

*In **Metric units***, this equation is expressed as

$$QP = 1/3.6\ CIA$$

Where, QP = Peak runoff (m^3/s)

C = Coefficient of runoff

A = Area of catchment drainage basin (Km^2)

I = Mean intensity of rainfall (mm/h) for a duration equal to time of Concentration

The map (Fig. no 5) shows that the Karve, Koregaon, Gote – Munde have highest runoff drainage density. Sajur, Goleshwar, Kirpe, Navadi, Saidapur, Khilarwadi etc. have lowest runoff drainage density.

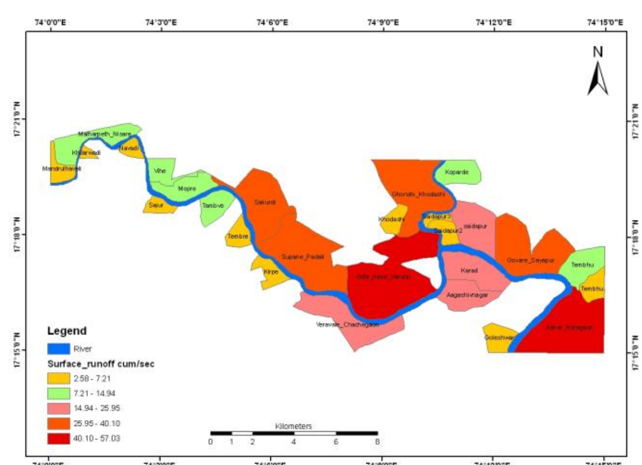

Figure 5: Surface Runoff Map of Study Area

5.5 Slope Map

Slope is an impression of the steepness of the terrain or slope is the rate of maximum change in z-value from each cell. The use of a z-factor is essential for correct slope calculations when the surface z units are expressed in units different from the ground x, y units. The output measurement units for slope can be in degrees or percentages. 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, every cell in the output raster has a slope value. The lower the slope value flatter the terrain and higher the slope value steeper the terrain. The output measurement values are in percent or in degree of slope (Jensen, John R. 2004; Dinand Alkema).

The map (fig no. 6) is showing that cyan colour indicating very low degree of slope comprises the study area. Some part of map ie.Northern has higher degree of slope.

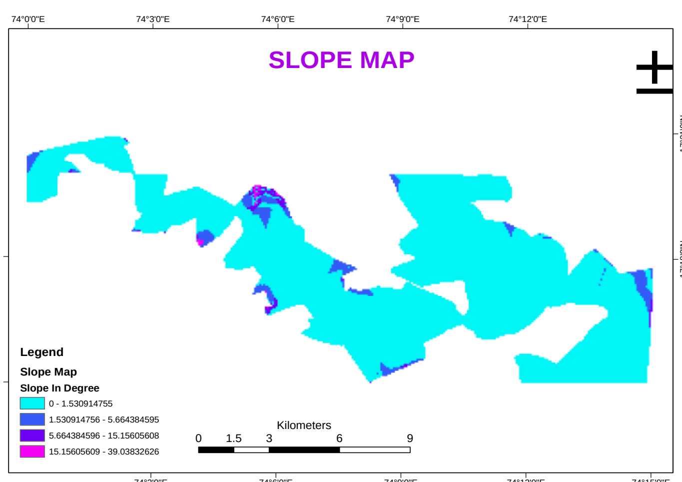

Figure 6: Slope Map of Study Area

5.6 Agriculture Loss Estimation

The map (Fig.no.7) shows that the Malharpeth, Mopre and Chachegaon has very high flood infected, in range of 102-155 Hectors/village and Mandrulhaveli,Vihe and Tembhu-Sayapur villages have low infected in range of 0 to17 hectors.

5.7.6 Landuse-Landcover Map

Landuse-Landcover Map of the study area shows use of land in study area of different purposes. This map shows agricultural, forest, built-up, water body, fallow land etc. distribution in the study area. This map is (Fig.No.8) easy to under stand overall distribution of total landuse-landcover patterns of study region.

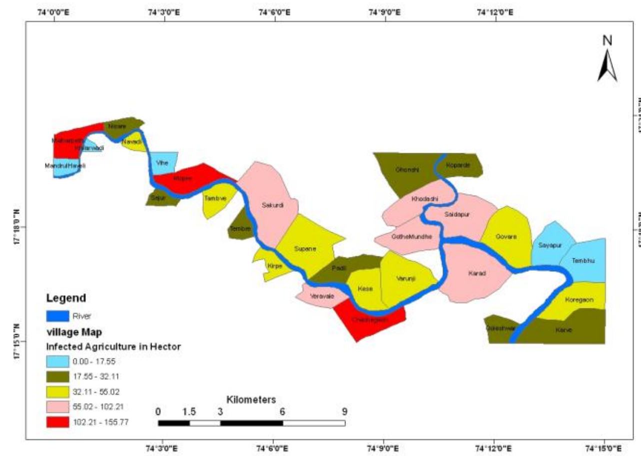

Figure 7: Agricultural infested map of Study Area

The total area of the study is 100 sq. km. Out of 34 Sq.Km the Agriculture land (34%), forest land is 32.41 Sq.Km (32.41%), settlement area is 1.49 Sq.Km (1.49%), fallow land area is 23.08 Sq.Km (23.08%) and waterbody is 9.02 Sq.Km. (9.02%).

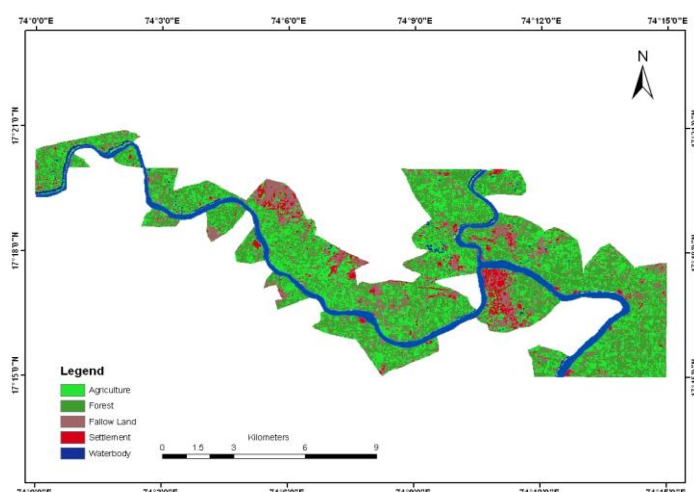

Figure 8: Landuse/Landcover Map of Study Area

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6.0 Results

Weighting Overlay Method

In the method of spatial multicriteria analysis, the criteria weightage is given on the basis of relative importance of assigned to evaluation criteria under consideration. The purpose of criteria weights is to express the importance of each criteria relative to other criteria. The derivation of weights is a central step in electing the decision weights, the input data can be organized in the form of a decision matrix or table (Sujata Biswas et.al).

Flood Vulnerability Analysis Map:

For the flood analysis, several themes like surface runoff map, population density map, drainage density and slope map has been taken in to consideration. The parameters affecting the flood are given weightage as shown in table 2.

Sr No.	Parameter	Applied Weight
1	Surface Runoff Map	**0.35**
2	Population density Map	**0.25**
3	Drainage density Map	**0.25**
4	Slope Map	**0.15**

Table 2: Weight table for Several Theme maps for Flood Vulnerability Analysis

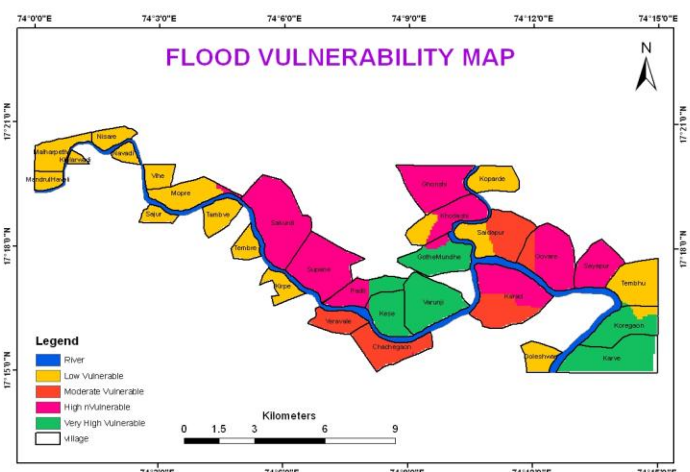

Fig 9: Flood Vulnerability Map of Study Area

The Village Vulnerability is divided into four classes.

- Very High Vulnerable
- High Vulnerable
- Moderate Vulnerable
- Low Vulnerable

The map (Fig. no. 9) shows the flood vulnerability of study area. Out of 27 villages, 4 villages are of very high vulnerable and include Karve, Koregaon, Gote, Munde, Varunji and Kese villages. 4 Villages are included in high vulnerable zone, these include the villages of Supane, Sakurdi, Padali, Ghonshi, Khodashi, Karad and Sayapur. The 6 villages are in moderate zone which includes Yeravale, Chachegaon, Saidapur.The last is low vulnerable zone has 6 basins which include the villages Kirpe, Tambve, Vihe Sajur, Mandrulhaveli and Nisare.

7.0 Conclusions

The study is based on GIS and spatial technique is used for analysis and understanding of flood problem in karad tahsil. The flood affected areas of the different magnitude has been identified and mapped using arc gis software. The analysis is useful for local planning authority for identification of risk areas and taking proper decision in right moment.

The flood vulnerability maps give insight and emergency services, a valuable tool for assessing flood risk. The information in database should be obtained with an interface should be automatic in disaster related studies. The study is useful in planning in future. It emphasizes on the importance of the requirement of drainage system and land use. With the given time and the limited knowledge with the data constraint this was an attempt to derive flood vulnerable zones.

- Most part of the study area is very high vulnerable to flooding.
- There is need for a broader and comprehensive program for managing flood in the study area.

- It can not be avoidable but it can be simplify by various technique.
- Physical control - by constructing wall, improving drainage system and construction by Planning.
- other preventive tools-
  - Effective planning for the growth of the city
  - Creation of a GIS database for flood prone area
  - Detailed flood risk mapping and zonation

8.0 Acknowledgements

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