JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

# APPLICATION OF GIS TO IDENTIFY DISASTER PRONE AREAS FOR DEVELOPING PREPAREDNESS PLAN FOR FLOOD .MANAGEMENT IN KOLHAPUR CITY

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***Abstract**:* Floods are natural disasters which cause a huge impact on human beings and the environment. The floods in an urban area are the result of uncontrolled urban development, encroachment in river flood plain, rapid population growth, and deforestation etc. The floods of 2005 and 2019 in Kolhapur are one of the most destructive and harmful floods observed till date in history. In this study, Karveer Tehsil of Kolhapur district of Maharashtra is studied. The Panchaganga river flows through the study area. This study is carried out to understand the factors involved in disaster land use land cover change in flood plains of the Panchaganga River. It aims to find out flood-prone areas and areas suitable for flood shelters.

**Keywords:** Disaster Management, Flood Management Plan, GIS, Hazard Prone Areas, Preparedness plan

## I. INTRODUCTION

Floods have been one of the most vulnerable disasters in the past few decades, heavily affecting the natural environment and urban infrastructure (Marchand et al. 2009; Pradhan & Youssef 2011; Taylor et al. 2011; Dawod et al. 2012). According to the World Bank (2005) out of the total earth's surface, more than one-third surface which is populated by nearly 81.9% of the total world's population is affected by floods during 1993-2003. In 1994-2004, Asia witnessed one-third of the total 1,562 flood disasters worldwide killing nearly 60,000 people. India is one of the oldest civilizations in the world having rich cultural and environmental values. India has been vulnerable to natural and manmade disasters because of its unique geo-climatic and socio-economic conditions.

According to National Flood Commission, India's high risk and vulnerability to floods are signified by the fact that out of a total geographical area (TGA) of 329 million hectares about 40 million hectares are prone to floods. On an average, life loss is about 1590, and loss in financial terms is 13,000 million.(Levy et al., 2005). In year 1977, number of deaths were as high as 11,316 due to floods. The frequency of major floods is more than once in five years (NDMA, 2019).

According to Water Resource Department, Maharashtra is up to certain extent prone to drought and floods. Out of the total geographical area of Maharashtra, 40% of the area is drought-prone and 7% is flood-prone. The Kolhapur district of Maharashtra has been experiencing large urban floods for a long time. It is situated in the basin of Krishna, i.e., near the Panchaganga river and in Aug 2005 and Aug 2019 due to heavy rainfall and encroachments in the flood plain, the district experienced the most destructive flood in history. Other severe floods were observed in 1989 and 1994. According to Kolhapur Disaster Management Authority, nearly 188 riverside villages are prone to flood and Karveer Tehsil is one of the most affected areas by the flood.

Effective management and strategy are required for flood disaster management. Preparing hazard-prone area maps and finding suitable areas for flood shelters is an important part of proper management of future flooding events (Asare-Kyei et al., 2015). Geographic Information System (GIS) is extremely useful and powerful tools in hazard management. Geographic Information System (GIS) has become very popular approach and it is widely used for practical problems.

## II. STUDY AREA

Karveer is a taluka or tehsil, in the district of Kolhapur district, in Maharashtra state with a total population of 10,37,713. There are 2,27,202 houses in the tehsil of Karveer. It is also located at an altitude of 554m. The dominant climatic phenomena is the monsoons called the South-West (June to September) with a monsoon rainfall of Avg 2,913.82mm. During the floods of 2019, Bawada Tehsil of Kolhapur received the highest amount of rainfall i.e., 5500mm while Shirol has the lowest rainfall of 535mm.

In 2019, Karveer tehsil received 1,608.37 mm of rainfall, which due to climatic and geographical reasons turned out to be the major hazard for a resident of Karveer. The soils of the district can be divided into three broad zones. (i) The Western zone of heavy rainfall, which is covered with laterite soils: (ii) The Central part with assured rainfall, which is covered with fertile, well-drained brownish soils of neutral reaction and (iii) the dry Eastern zone with precarious rainfall, which is covered with medium black soils of varying-depth.

## III. METHODOLOGY

This section gives an outline of the research methodology. It discusses different surveys conducted, sampling techniques, and sample distribution problem Identification, study the different parameter of management and also explore tool for analysis and different technique. From this analysis-built aim and objective for the further study area and define scope for the study. Then analysis of the output data of DBMS and analyze the outcome using GIS from which easy to generate preference map. It will help Decision maker to making decision for preparedness of disaster management planning easily so the vulnerability of disaster can be reduced.

## IV. ANALYSIS USING GIS

### 4.1 Contour analysis:

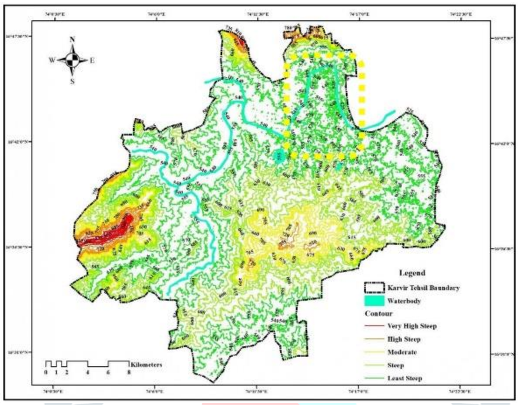


Figure 1: Contour map of Karveer

Contour map is the example of the topographical map which shows the data of valley, hills, stiffness and gentleness of the slop. Here contour map help prepare to understand the changes in elevation as level differences. The surface elevation is generally referred as the high above sea level in meters. Lower elevation i.e., Least slop is very high for the flood risk as, area at least slop get submerged quickly. Along the river of Karveer tahsil are covered with similar reduced levels of contours intervalles therefore there are more chances of the flooding as water remains stagnant. As shown in fig 1 the lowest contour level observed in the study area is 525m while the highest observed is 840m which forms the parts of hills in the south western part of study area. The analysis of contour clearly shows the flood plain of Panchaganga river is at 555m of contours.

### 4.2 Watershed Analysis

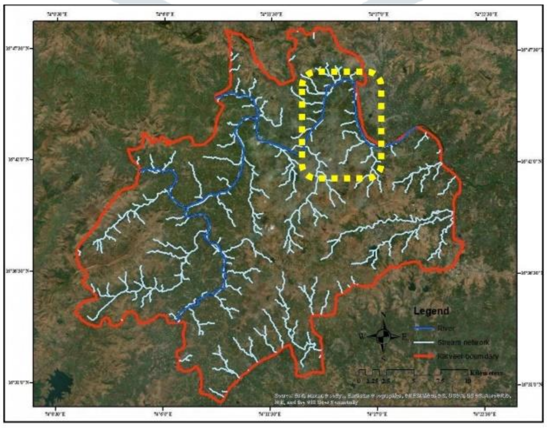


Figure 2: Watershed map of Karveer

Watershed analysis is carried out using hydrological analysis in ArcGIS using watershed and flood toolbox. Maximum watershed Density i.e., the area shown in sky blue color of the fig 2 is observed in the low-lying areas near to Panchaganga river while minimum density of watershed is towards to the high slope areas i.e., hills in the south western side of study area. Urban growth of Karveer tahsil increase toward the Panchaganga river and also at present its under high demand for construction activities therefore this results in vanishing of natural streams and that contributes increased runoff. This increase runoff along with soil from hills deposits in Jayanti nala and it goes towards the

Panchaganga River. This study area has major natural bodies like Rankala lake, Kaneri lake, Kalamba lake, Kavalan lake. In Karveer tahsil, when Jayanti nala meets to Panchaganga river width of the Jayanti Nala stream become very less and Panchaganga river also unable to take this increased outfall. Hence, it causes inundation of the surrounding areas along the Jayanti Nala.

### 4.3 Slope Analysis

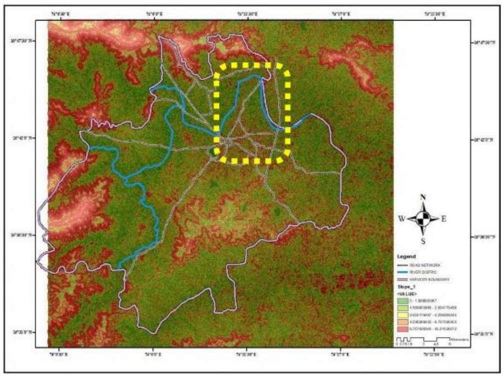


Figure 3: Slope map of Karveer

Slope analysis map indicating the topography of an area along with an analysis of topographical features. The slope is rate of change in elevation. Lower slope has high flood risk as water flow from areas with the higher slope to lower slope. Hence the area with lower slope gets inundated. Initially of runoff increases as the slop increases. In study area the slop of 1.5 to 4.5 degree is observed in maximum areas. The highest observed slope in the study area is 45.03 degree. The flood plain of Panchaganga river lies in between the of 0 to 1.5 degrees while the study areas average slope is in between 1.1 to 2.1 degrees which indicates that study area is quite flat and it can easily undergo flooding.

### 4.4 Zone Prone to Disasters

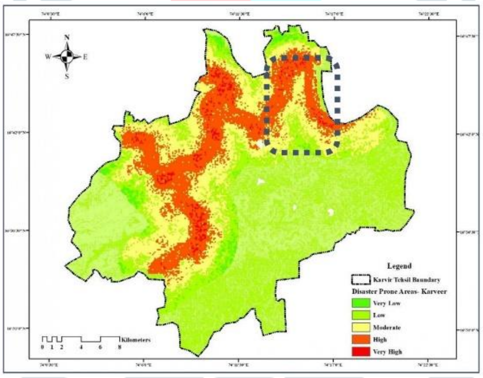


Figure 4: Disaster prone map of Karveer

Our analysis classified whole Karveer tehsil into five classes namely very high prone, high prone, moderately prone, low prone and very low prone areas to disasters based on the multi criteria analysis. Out of the total 249 zones in Karveer out of which only 171 zones are having less than 10% area prone to disaster, 39 zones are under moderately prone to disaster class having prone area in between 11% to 50%. The zones which have more than 40% area are classified as high prone areas to disaster and there is total 39 zones are under the highly prone area category. As shown in fig 4 the red color shows the areas which are very high prone to disasters and the areas shown in the light green shows the area which are very low prone to disasters. The fig 5 shows the villages having % of areas to prone to disasters.

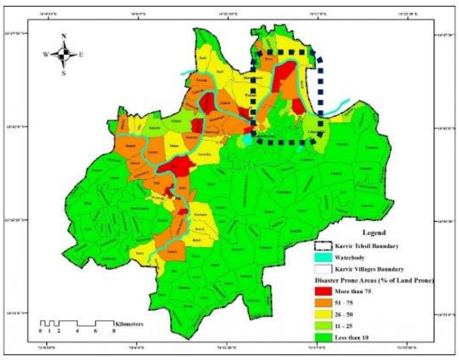


Figure5: Disaster prone map of Karveer in percentage

## V. RECOMMENDATIONS

### 5.1 Proposing Emergency Shelter Location Areas

The finding of suitable shelters comes under the preparedness phase of disaster management. Shelter finding is very tedious process during the disaster hence finding the suitable shelter and planning them in phase manner will lead us to better manage the disaster.

### 5.2 Flood Plain Zoning of Panchaganga River

Flood plain are categorized into three classes and with the help of the highest flood line we carried out buffer analysis to demarcate the zones. The basic concept of flood plain zoning is to regulate land use in the flood plains to restrict the damage caused by floods. Flood plain zoning, therefore, aims at determining the locations and the extent of areas for developmental activities in such a fashion that the damage is reduced to a minimum. It, therefore, envisages laying down limitations on development of both the unprotected as well as protected areas. To prevent indiscriminate growth in the unprotected areas, borders of zones in which developmental activities would be prohibited must be set up. Only those types of development activities that won't result in significant damage if the protective measures fail can be permitted in protected areas. Zoning is not a remedy for existing situations, although, it will definitely help in minimizing flood damage in new developments.

The zones which we considered according to NDMA,

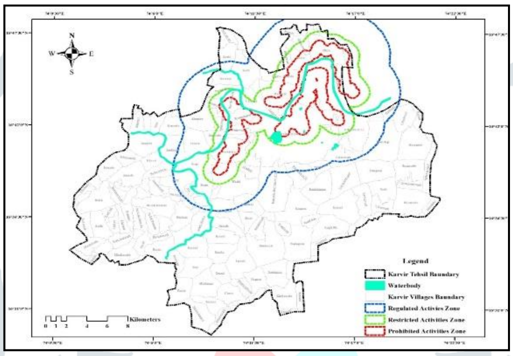


Figure 6: Proposed flood plain zoning of Panchaganga river

i. Prohibited activities zones: up to 500 meters from the highest flood level in past 50 years
ii. Restricted activities zone: Outer limit of prohibited zone to 1 kilometre
iii. Regulated activities zone: Outer limit of restricted zone to 3 kilometres

### 5.3 Structural Measures in Flood Prone Areas

As shown in fig 7 following provisions will be incorporated by the state governments/SDMAs/local bodies in the building bye-laws for buildings in flood prone areas: Plinth levels of all buildings should be 0.6 m above the drainage/flood submersion lines. In the areas liable to floods, all the buildings should preferably be double and multiple stories. Wherever there are single story buildings, a stairway will invariably be provided to the roofs so that temporary shelter can be taken there. The roof levels of the single-story buildings and the first-floor level in double-story buildings will be above 100-year flood levels so that the human beings and movable property can be temporarily sheltered there during periods of danger on account of floods.

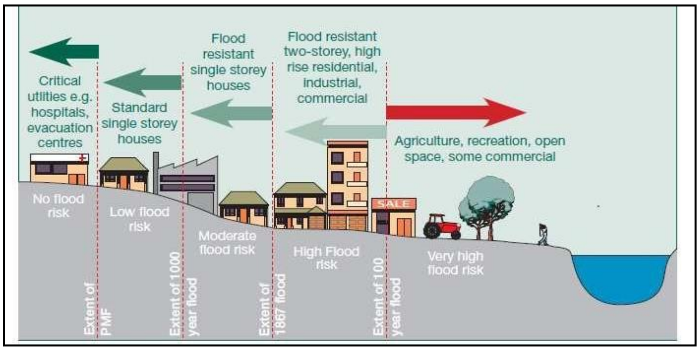


Figure 7: Schematic Representation of flood related measure along flood plain.

Source: (Lal et al., 2020)

**5.4 Removing the Bottlenecks of Panchaganga River**

Broad Embankment building along the river helps to maintain low level of sedimentation which prevent overflow of water over embankments. The state's "Rebuild Kerala" plan includes this approach as well, according to the Keralan administration. The Keralan government is certain that Kuttanad, the state's rice bowl located below sea level, can repeat the initiative and its core principles. Kuttanad and surrounding areas in the Kottayam and Alappuzha districts were submerged for weeks during last year's floods.

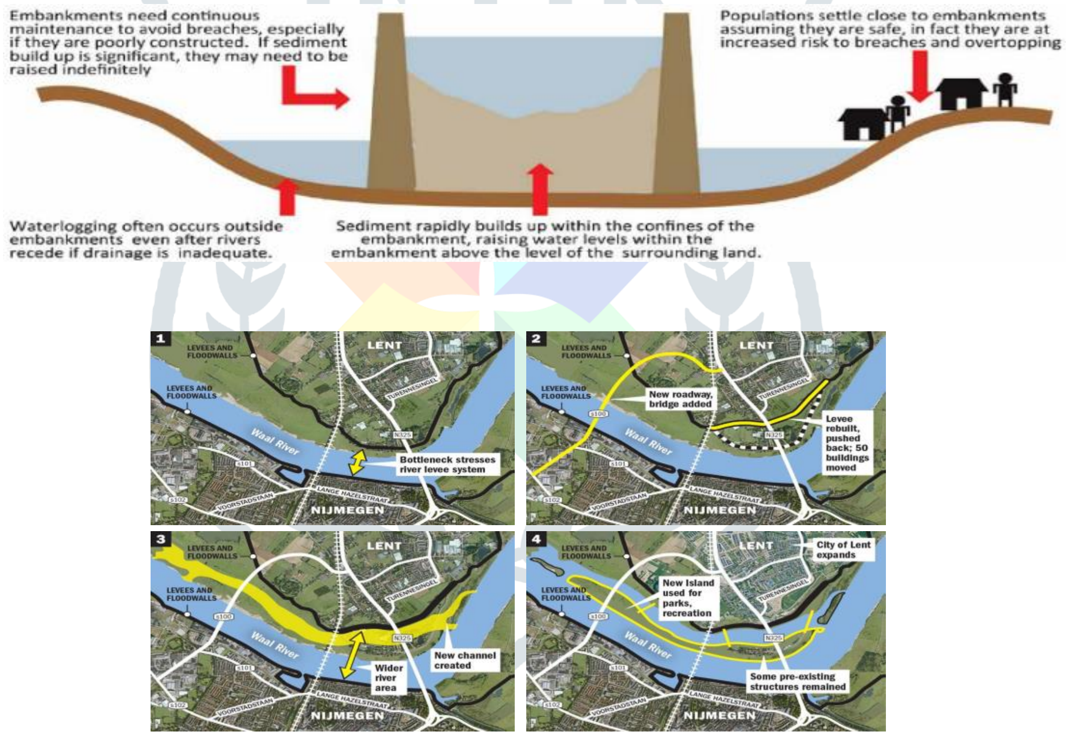


Figure 8: Example of river embankment and flood mitigation measures in Kerala

Source: (Chinnasamy et al., 2020)

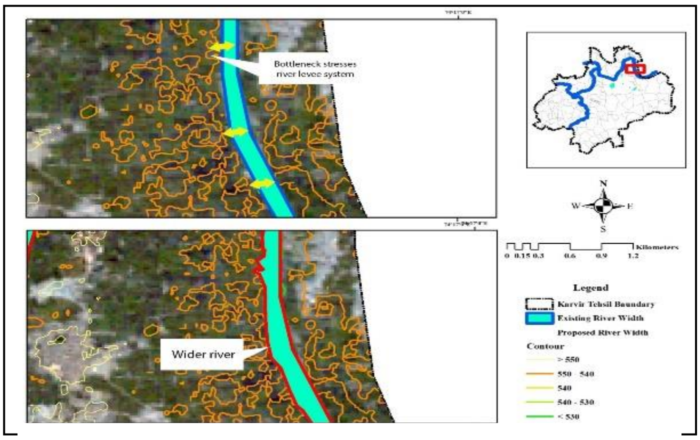


Figure 9: Proposed River width increase-1

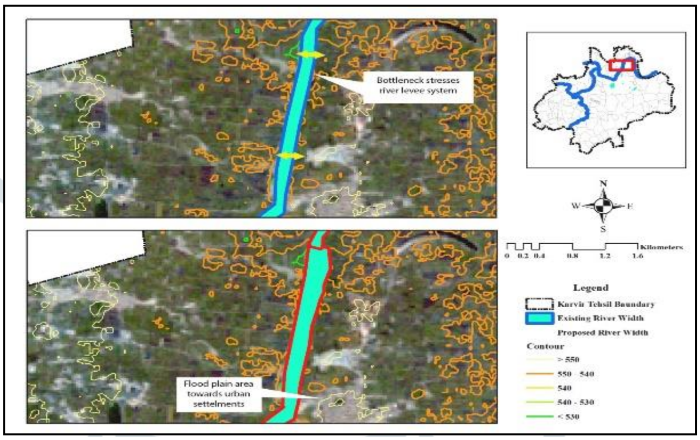


Figure 10: Proposed River width increase - 2

As shown in fig 8 first image shows how the decreased river width cause the high risk of flooding because of the embankment hence in the second image river width is increased and ultimately the embankment along river is also increased. Due to the less river width the sediment rapidly builds up within the confines of the embankment, raising water levels within the embankment above the level of the surrounding land hence we increased the river width with minimal embankments which results in water rising over a larger area during flood and sediments this builds up over time but stays constant up to certain point and ultimately reduced the chances of flooding.

## VI. CONCLUSION:

The disaster-prone areas must be given high importance and the identified areas suitable for flood shelters need to be prepared and should be kept updated with the latest information of disasters. The human settlement encroachment along the river plain caused the high risk of flooding and lead to the lower embankment of the river. Based on the results of this research study of disasters of Karveer Tehsil from Kolhapur district, it can be concluded that GIS, techniques provide the best potential and provide sufficient reliable results required for effective flood management. This comprehensive methodology developed for mapping flood-prone areas and suitable shelter areas can be easily replicated to any river basins and can be handled by person having no knowledge of GIS or new GIS users. The study strongly supports that the remotely sensed data can be very valuable to operational users for flood-related emergency responses and proved to be efficient enough for preparedness and emergency response in case of flood.

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