Geospatial Approach for the Assessment and Analysis of Flood Risk in the region of Nanjangud town, Mysore District, Karnataka, India

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Abstract. Flooding in urban and rural areas is one of the utmost challenges to human safety. Destruction of the properties is the main issue in urban areas and damage to the agriculture practices in the rural area. Flood risk is rising significantly all over the globe. The regional water cycle and water resource availability are governed by the rainfall event, which is a fundamental meteorological parameter. The objective of the study is to examine the rainfall variability for 25 years from the period from 1995 to 2020 for monthly and annual rainfalls in the part of Nanjangud taluk, Mysore district, Karnataka. During the last three years that is 2017 to 2019 during the southwest monsoon, it is noted that the severity of flood increased in the surrounding of Nanjangud town, due to the heavy rainfall and excess amount of water released has augmented the inflow source of flooding. The assimilation of Remotely Sensing (RS) and Geographical Information System (GIS) is capable to generate a sequence of thematic maps that were helpful to create geospatial data for demarcating flood hazard areas. This study discusses the probable flood risk-prone regions of the Kabini river basin near Nanjangud town based on the multi-ring buffered layer analysis. The buffered layers created for the radius of 250m, 500m 750m, and 1000m were overlaid on the Sentinel-2 satellite image and topographic map to delineate the flood-affected region. To calculate the slope and drainage density, the SRTM DEM data was used. Structural and nonstructural practices are proposed in this study can be implemented to reduce the probability of the effect of floods.

Keywords: Rainfall, Flooding, Remote Sensing, GIS, Sentinel-2.

1 Introduction

The world has witnessed and experienced severe floods for the past 40 years or so. These floods causing huge losses such as human life, damage to infrastructure, disturbed economic activities, forests, and lands [3]. There are several natural disasters, one of the common natural disasters is floods [11]. This is mainly due to urbanization, increased population leading to unbalancing of the world leads to the natural disaster. It is estimated that the population rate is doubled from the 1960s to 2000, and so many settlements are prone to natural hazards. The flood is the excess flow of water over the carrying channel. It is also defined as an
occurrence due to extreme hydrological characteristics such as runoff events [10]. Flood is classified as river flood, coastal flood and, urban flood. The hydrological events such as excess rainfall and runoff volumes within a river valley are called river floods. The occurrence of storms, surges, waves, wind, currents, tides and rainfall leads to coastal flooding. Urban sprawl in the vicinity of streams or channels leads to urban floods [10]. Apart from urban flood and coastal flooding, river flooding is the most destructive and harmful. It spreads more than catchment areas with heavy rainfall, runoff makes flooding destruct within less period [12]. The river flooding is governed by extreme rainfall and excess runoff higher than the terrain's engrossed capacity [7]. The developmental activities along with the national flow of rivers cause this excess runoff. River flooding is an outcome of human activities that come to the natural environment such as overexploitation, natural resources, uncontrolled population growth, and so on [4]. Remote sensing (RS) and geographic information system (GIS) advancements have altered hydrology and flood management, making each stage easier to execute [16]. One of the most critical criteria in flood vulnerability mapping is the distance from the river. Due to the higher rainfall, river levels will rise causing an excess of water in the areas neighboring the river bank [19]. For the analysis it better to be adopting Digital Elevation Model (DEM) as one of the input, the available DEM’s such as Shuttle Radar Topography Mission (SRTM) DEMs (30m and 90m) an Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) DEMs (30m) [5]. SRTM DEM data can be used for flat, high elevation, and mountainous regions [15], and also for the slope analysis [18]. The precise mapping of flood-prone areas could act as an early warning system.

2 Material and Methodology

The satellite image is used to create the flood vulnerability map, and additional data was acquired from the following sources: (i) Sentinel 2A satellite Image downloaded from the website USGS (https://earthexplorer.usgs.gov) (ii) 90 m spatial resolution SRTM DEM data as it is freely available and (iii) monthly rainfall data from 1995 to 2019 collected from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bengaluru. The methodology Fig 2 adopted in the analysis is related to the mapping of the flood risk and is focused on GIS vectorization of the river was buffered choosing 0.5, 1.0, 1.5 kilometer of buffer distance on either side of the river channel.
Figure 2. Flowchart for flooded area extraction

3 Rainfall

Significant challenges are faced in urban areas as well as rural areas by the flood. The destruction of properties, agricultural land, and loss of life are the major effects of the flood [1]. Flood arises in an urban area when extreme convective rainfall occurs that is greater than the capability of the urban drainage system [13]. Studying the drainage systems and flood patterns of various rainfall events widely reveals particular problems and conceivable solutions. This will be an outcome of improved planning and alertness for natural calamities [9]. Excess rainfall over and over again results in causing flood events which results in destruction activities [4]. Nevertheless, a considerate of the intensity of occurrence of such immense events both for planning and designing disaster purposes. It is often restricted by data availability at the chosen sequential and spatial data. The Monthly rainfall data is interpreted from 1995 to 2019 from collected from KSNDMC. A comprehensive study has been made by plotting the graphs of rainfall. The raingauge station is situated in (12° 6’57.49”N, 76°40’35.02”E) in Nanjangud town. The monthly rainfall data has been considered for the analysis in the study area. In the last three years, it is noted that the increase in the rainfall and inflow of water in the Kabini River is affecting the part of Nanjangud town.

The rainfall data collected for the last 25 years were represented in Fig 1. A smaller amount of 1mm of the minimum average rainfall of rainfall occurred in January. The graphs created using the rainfall input illustrate the annual precipitation of rainfall and represent the variations during the pre-monsoon, post-monsoon, and Monsoon. The 25 years rainfall data is interpreted statistically and used to understand the probability of flood period. The highest rainfall recorded 349 mm and 243 mm in May in the years 2017 and 2018. The stimulation of the monsoon period, which has directed to huge rainfall recorded 370 mm during August 2019 caused the ‘flash flood’, which affected the vehicular movement blocking the NH-766 that is National Highway of Mysuru-Nanjangud (star of mysore.com 11 Aug 2018). The outflow from Kabini Dam in H.D. Kote district. Due to the
flash flood agriculture and transportation were affected owing to waterlogging (New Indian express August 10, 2019). It is noted from June to September that is The overall annual rainfall is highest during the South-West monsoon. It is witnessed that the rainfall event continuously increased in the last three years table 2 and graphically represented in Fig 4, Fig 5, and Fig 6. The extreme annual rainfall of 1275 mm happened in 2017, causing a heavy flood.

Annual rainfall that occurred in the Nanjangud town is represented in the graphs for accessing flood vulnerability. According to Fig 3, it reveals that premonsoon the months that is from January to April, and the post-monsoon months November and December are less flood susceptible months. The months which receive more than 200 mm of rainfall are prone to flood [14]. Graphical representation, reveals that heavy rain mainly happened in May, August, September, and October. Flood water increased nearly 3 feet deep all around the Kabini river during the period of Southwest monsoon Fig 3 Nanjundeshwara temple, which is at a distance of 0.35 km from measurement.

Figure 3. Mysore Nanjangud Highway (NH 766) August 11, 2018  
(Source: https://starofmysore.com)

Figure 4. Monthly Average rainfall data 1995 to 2019 (Source: KSNDMC)
Figure 5. Monthly Average rainfall data 2017 (Source: KSNDMC)

Figure 6. Monthly Average rainfall data 2018 (Source: KSNDMC)
Identification of flood risk zones

In the fundamental stage to assess the flood vulnerability, it was essential to inspect a pivotal factor relationship with flooding and the development of flood risk zone maps that provides critical support for flood risk management [14] [20]. Diverse flood-controlling factors are used in this study. To delineate the possible flood risk zones, from the buffered river channel elevation, slope, and drainage density are considered. The elevation is a key aspect of flood incidence, as river water constantly flows to lower terrestrial areas from high relief regions [8]. The elevation ranges from 645 to 725m respectively on either side of the river basin. Interpretation of DEM reveals the flood occurrences in the low land areas of elevation. These findings are in line with earlier researchers, which establish a lower possibility of flood incidence at greater altitude areas and a greater possibility of submerging in low-lying regions.

Figure 7. Monthly Average rainfall data 2019(Source: KSNDMC)

Figure 8. Digital Elevation Model of the study area
The occurrence of flooding is regulated by the slope, as the lowland area has a strong influence by flood as in the rainy season [6]. A lower slope gradient has been recorded to have higher chances of flooding. The slope gradient controls the process of infiltration. An accumulative gradient drops the development of infiltration and rises the surface overflow, because of the effect of an overwhelming amount of water becomes stagnant in the regions with a sudden descent gradient and creates flood conditions [14]. The slope study says that around 80% of the area is having lower slope gradient classes.

![Slope map of the study area](image1)

**Figure 9.** Slope map of the study area

Drainage density is a well-thought-out crucial component of flooding [2]. The greater prospect of flooding is intensely associated with a greater drainage population as it argues near to a more surface overflow. In this study it is noted, the drainage density for flooding has a direct association. Flooding risks increase as drainage density increases and decrease as drainage density decreases.

![Drainage density map of the study area](image2)

**Figure 10.** The drainage density map of the study area
For flood hazard mapping, the choice of flood control factors is an essential step that is subjected to the natural and physical characteristics of the region. ArcGIS was used in this work to create the appropriate multi-ring buffer layer. To conclusive the flooding area, the buffer distance from either side of the river plays an important role.

According to earlier studies, the areas closest to these rivers are most get disturbed by floods due to excess runoff. The buffer analysis tool in GIS software was used to create this map, which included 5 buffer categories. The distance intervals carried with <250, 500, 750, and 1000 m. The mid-point (average) is used to calculate the 1-kilometer buffer distance. The 250 m and 1000 m buffer distances were determined by the flooded area's minimum and maximum widths, respectively. The low-risk zone is demarcated by a buffer distance of >1000 m, the medium flood risk zone is defined by a buffer distance of 500-750 m, and the higher flood risk zones are defined by a buffer distance of 500 m on either side of the river channel that falls between lower and higher heights. By overlaying the boundary of the buffer zone it is noticed the village Basavanapura, Hejjige, Nanjangud town, Mullur, Chikkaiahnachatra have prone to higher effects of the flood when there is an excess of water in river compare to the other adjoining villages near to the river bank.

![Figure 11. The flood Buffer zone of the study area](image)

5 Conclusions

GIS and RS tool shows the potential of quick analysis if sufficient data are provided. Some models can be used to predict the flood in advance. In the present study, the flood risk zone map prepared using Geospatial
technology has piloted in a new era of spatial planning, allowing for the implementation of preventative measures. The data of Rainfall, Digital Elevation Model (DEM), and slope were utilized to define flood risk zones. The lower elevated area with a lesser percentage of the slope with higher drainage density. Also, there were four stages of buffer analysis carried out such as the distance intervals carried with <250, 500, 750, and 1000 m. The buffer distance of 500m on either side of the Kapila river which is closer to the urban settlement of Nanjagud Town and the village’s Basavanapura, Hejige, Nanjangud village, Mullur, Chikkaiahnachatra comes under higher prone to get affected by the flood. To evaluate this analysis there are many data constraints. Buffer zones from the water bodies is not an appropriate factor of the analysis in some places, because some places might be located in slightly higher place or bank protection area even though the areas are along rivers. With more detailed ground data, future analysis would be conducted.

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