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An Innovative Method for Flood Susceptibility Mapping Integrated MCDM-WOA Model with Geospatial Techniques and Remote Sensing Data – An ArcGIS based Approach

Kamuju.Narasayya

Scientist, Central water and Power Research Station, Pune, Maharashtra, India

ABSTRACT: In recent years, human populations have increasingly faced a rising number of natural hazards, with flooding being among the most frequent and devastating. This study focuses on addressing the growing concern of flood hazards by developing flood susceptibility zone maps for the Mun-River catchment area of Purna-River basin, Maharashtra, India. Utilizing the Multi-Criteria Decision-Making (MCDM) approach, specifically the Weighted Overlay Analysis (WOA), alongside Remote Sensing (RS) and Geographic Information System (GIS) tools. The research aims to identify and delineate regions within the catchment that are most prone to flooding. Several key parameters, including physiographic features, climatic conditions and land use/land cover (LU/LC) were utilized in this study to assess flood susceptibility zones. Thematic maps representing each of these parameters were generated using data from various sources. These thematic layers were then integrated and analyzed within ArcGIS software using the Weighted Overlay method. By assigning different weights to each parameter based on their relative influence on flood susceptibility, the study was able to accurately identify areas at high risk of flooding. This comprehensive approach ensures that multiple factors contributing to flood hazards are considered, providing a more robust and precise flood hazard assessment. The resulting flood susceptibility map was categorized into five distinct risk zones: very high, high, moderate, low, and very low flood risk. Each zone represents varying levels of vulnerability to potential flood events. The flood susceptibility map reveals a substantial portion of the catchment, approximately 32%, is categorized as being in the very high flood-risk zone, with an additional 24.4% classified as high-risk. Furthermore, 23.5% of the area falls under moderate flood risk, leaving only 7.4% of the catchment considered relatively safe and free from significant flood hazards.

KEYWORDS: Flood Susceptibility, Weighted Overlay Analysis, Remote Sensing, Euclidian Distance, Precipitation

I. INTRODUCTION & LITERATURE SURVEY

Flood danger refers to the probability of a flood of a specific magnitude occurring in a particular location within a given time period. Identifying and assessing flood-prone areas is crucial for effective flood management and mitigation efforts, as complete protection against flooding is not achievable [1]. Flood vulnerability analysis is crucial for effective land-use planning in flood-prone areas. It produces easy-to-interpret maps and charts, enabling planners to quickly identify high-risk zones and prioritize mitigation efforts. Floods are among the most frequent and destructive natural disasters worldwide, alongside others like earthquakes, tsunamis, landslides, and tropical storms. While many countries face these natural hazards, they are also increasingly vulnerable to man-made disasters [2]. Although, floods are a common natural hazard, prevention and mitigation of it can be facilitated by flood susceptibility mapping [3]. India, with its diverse topography and climate, is highly vulnerable to natural hazards, with 85% of its land exposed to various risks. Of its 28 states, 22 are classified as multi-hazard zones. India ranks as the second most flood-affected country globally, accounting for one-fifth of all flood-related deaths. During the monsoon season (June–September), the country receives 75% of its annual rainfall, leading to widespread river flooding, sediment build-up, and drainage issues. Annually, floods impact over 8 million hectares of land and affect around 32 million people. According to the Central Water Commission, nearly 37 million hectares, or one-eighth of India's geographical area, are vulnerable to flooding during the monsoon [4].

Rachna and Joisy developed a flood vulnerability map for the Vamanapuram River Basin by considering several contributing factors, including annual rainfall, watershed size, slope, river and stream gradients, drainage density, soil type, land use, communication networks, and infrastructure. These parameters were used to assess and identify areas at risk of flooding within the basin [5]. Saini and Kaushik used GIS to determine the danger and vulnerability of flood hazards in the Ghaggar Basin, India. The research attempted to develop a Flood Risk Index (FRI) based on hydrology, slope, soil composition, drainage density, landform, and land usage [6]. Thilagavathi et al. [7] and Punithavathi et al. [8] have performed flood risk assessment or flood hazard zonation studies based on different parameters. Recent advancements in geospatial technologies have greatly enhanced the ability to monitor and mitigate flood risks. Tools like Geographic Information Systems (GIS) and remote sensing (RS) now offer advanced techniques for analyzing flood-prone areas, including stream channel mapping, watershed delineation, and elevation data analysis. These technologies provide critical information that helps decision-makers develop and implement effective flood management strategies in vulnerable regions [9]. Remote Sensing (RS) plays a vital role in flood visualization and risk management. Combined with Geographic Information Systems (GIS), these technologies offer a more efficient and effective means of recording, storing, processing, analyzing, and visualizing data to identify potential flood-prone areas. This study employs an ensemble approach to highlight the effectiveness of GIS-based flood modeling.

The Weighted Overlay Analysis (WOA) technique is integrated with RS and GIS tools to accurately predict flood probabilities and assess risk areas. Several variables influence the occurrence of floods within a watershed, making it essential to identify flood catchment areas when investigating floodplains. Key factors include physical and natural elements such as elevation, slope, aspect, slope curvature, lithology, topographic position index, and rainfall. Additionally, hydrological factors like drainage density, proximity to rivers, topographic wetness index, and stream power index play crucial roles. Human disturbance factors, such as land use changes and infrastructure development, also contribute to altering the flood dynamics within the region [10-13]. Recently, several methods and models have been used to study flood hazards. The widely applied methods and models for flood hazard mapping are Logistic Regression (LR) [13-16], Weights of Evidence (WofE) [17], Support Vector Machine (SVM) [18-19], Random Forest (RF) [20-22], Frequency Ratio (FR) [23]. In addition to these models, Multi-Criteria Decision-Making techniques such as the analytic hierarchy process (AHP) [24] and the Analytic Network Process (ANP), which is an extended version of the AHP and consider as a more appropriate approach for complex decision problems can also be used for flood hazard mapping [25-26].

The integration of GIS and Multi-Criteria Decision-Making (MCDM) techniques has been widely applied in spatial modeling and disaster analysis for natural hazards like floods. This combination allows for the effective evaluation of multiple factors influencing flood risks, leading to more accurate and informed assessments of flood-prone areas [27-29]. Preventing floods is complicated, but their occurrence can be predicted and partially controlled using appropriate methods and measures [30-31]. Access to accurate and up-to-date information is crucial for preventing floods or minimizing their damaging impacts. A critical resource in this effort is a flood potential map, which identifies areas at risk and helps guide mitigation and preparedness strategies [32]. Morphological changes caused by human activities can have a significant impact on changing the conditions for floods [33]. Current flood control measures have proven insufficient in addressing flood-related issues effectively. While it may not be possible to completely eliminate flood risks, implementing a robust flood forecasting system and effective management strategies can significantly reduce potential damages and enhance community resilience [34,35]. Flood zoning provides valuable information regarding the nature of the floods, their effects on the floodplain, and determining the riparian zone [36].

GIS is an effective tool for analyzing complex events like floods across different spatial and temporal scales. It has been widely used for spatial analysis to identify flood zones. Additionally, integrating remote sensing data with advanced modeling techniques, such as data mining and machine learning, can significantly enhance the accuracy of identifying flood-prone areas, providing better insights for flood risk management [37]. The primary objective of this study is to explore the application of Remote Sensing (RS), Geographical Information Systems (GIS), and the Weighted Overlay Analysis (WOA) methodology for flood susceptibility analysis and mapping in the Mun-River catchment. By integrating these advanced geospatial techniques, the study aims to assess flood-prone areas with greater accuracy. Various thematic datasets such as Elevation, Slope, and Distance to river (Euclidian Distance), Flow Length, Land use-Land cover (LU-LC) and Precipitation have been generated as inputs for the WOA. These datasets help classify different areas based on their flood susceptibility. Through the Weighted Overlay method, each thematic layer is assigned a specific weight based on its influence on flood occurrence. For instance, areas with steep slopes or proximity to rivers may receive higher weights due to their higher flood risk. This approach enables the creation of a

flood susceptibility map, which provides critical insights into areas that are most vulnerable to flooding. This map serves as a valuable tool for local planners and policymakers, enabling them to prioritize flood prevention and mitigation strategies in the Mun-River catchment.

II. STUDY AREA

The Mun-River catchment, located within the Purna-River basin in Maharashtra, India, is geographically positioned between approximately 20.2°N to 21.3°N latitude and 76.7°E to 77.8°E longitude. The Mun-River catchment covers an area of approximately 2425 square kilometres, and its hydrological network plays a significant role in the broader Purna basin. The region experiences an average annual rainfall ranging from 800 mm to 1,100 mm, predominantly during the monsoon season, which significantly influences the area's hydrology. The Mun River, a major tributary of the Purna River, along with smaller tributaries such as the Mus-river, Vishwamitri and Borgaon rivers, contributes to the region's water flow dynamics. The catchment is characterized by a variety of soil types, including black cotton soils (Vertisols), which are prevalent due to the region's basaltic origin, as well as alluvial soils along the river banks. The region supports agricultural activities, primarily cotton and soybean cultivation, and the varying topography includes gentle slopes to flat plains, with some hilly areas in the upper reaches. The Mun River has some small-scale water regulation structures, including Shirla-Dam, Utawali-Dam, Nirguna-Dam and Paras-Barrage, constructed primarily for irrigation and flood management.

III. MATERIALS AND MEHODOLOGY

3.1 Datasets Used

In this study, various thematic maps were developed to generate a comprehensive flood hazard map. These maps included key parameters such as elevation, slope, river proximity, gridded annual rainfall, flow length, and Land Use-Land Cover (LU-LC). The thematic maps were created using ArcGIS 10.8 software tools, which allowed for the integration and spatial analysis of these factors. Elevation, slope, river distance, and flow length were derived from the Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) with a spatial resolution of 30 meters, obtained from the USGS Earth Explorer website. The Land Use-Land Cover map, representing data from 2016, was sourced from the Bhuvan-ISRO web portal.

Additionally, gridded annual rainfall data spanning nearly 20 years from 2004 to 2023 was downloaded from the Indian Meteorological Department (IMD-Pune). This data was pre-processed to generate average annual rainfall grids for each year. Using ArcGIS's spatial analyst tool and the Inverse Distance Weighting (IDW) interpolation method, a final gridded rainfall map was prepared for integration into the model. These thematic layers collectively contributed to the accurate identification of flood hazard zones, providing critical insights for flood risk management.

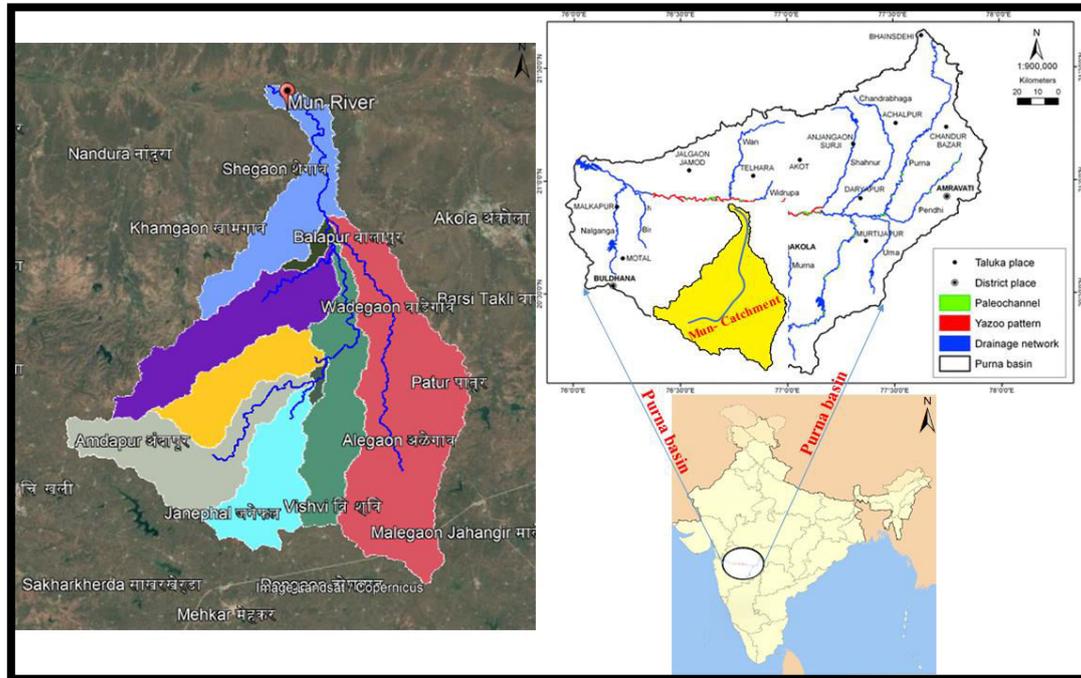


Fig. 1: Location Map of Study Area – Mun-River Catchment

3.2 Proposed Process

In this study, Flood Susceptibility Mapping (FSM) was conducted using an innovative approach based on the Multi-Criteria Decision-Making (MCDM) method, specifically employing a Weighted Overlay Analysis (WOA) model in four key stages:

- **Data Collection and Thematic Map Preparation:** The first stage involved gathering various datasets from the study area to create thematic maps, such as Elevation, Slope, River Distance (Euclidian Distance), Rainfall distribution, and Land Use-Land Cover (LU-LC). These maps represent essential factors influencing flood susceptibility.
- **Reclassification of Thematic Maps:** The thematic maps were then reclassified using the *Reclassify* tool in ArcGIS. This process standardized the data into uniform categories, making it easier to analyze and integrate the different parameters for flood risk assessment.
- **Application of Weighted Overlay Analysis (WOA):** The Weighted Overlay Analysis (WOA) model was used to generate a flood hazard map. This method assigns different weights to each reclassified thematic layer based on its relative influence on flood risk. The Inverse Distance Weighting (IDW) tool was also applied to spatially interpolate data, enhancing the accuracy of flood zone identification.
- **Final Flood Susceptibility Map (FSM):** In the final stage, the flood hazard map was combined with the Land Use-Land Cover map to produce the Flood Susceptibility Map (FSM). This comprehensive map highlights areas at varying levels of flood risk, providing crucial information for disaster management and mitigation strategies in the region.

This approach leverages geospatial analysis and MCDM techniques to ensure a detailed and accurate representation of flood-prone areas, aiding local authorities in planning and preparedness efforts. The process of methodology shown in Figure 2.

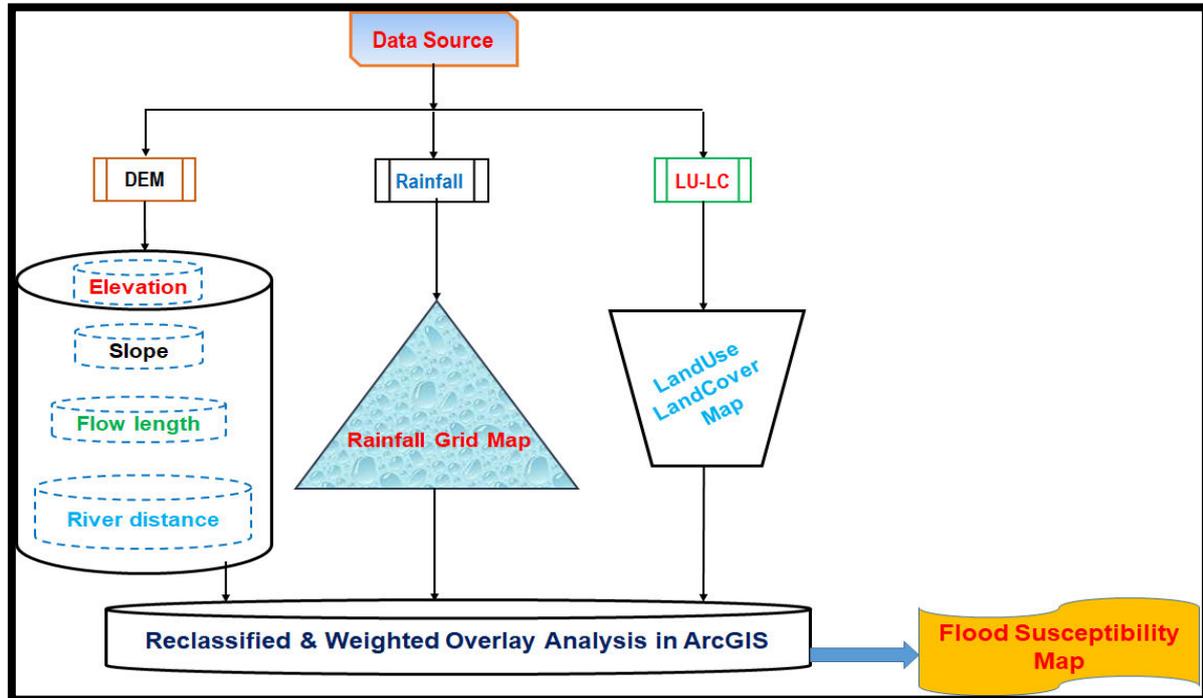


Fig 2: Methodology for the preparation of Flood Susceptibility Map

3.3 Weighted Overlay Analysis (WOA)

The Weighted Overlay Analysis (WOA) model offers a straightforward yet effective approach for identifying potential flood hazard areas. In this analysis, six key thematic factor maps were employed to assess flood risk. Each factor was assigned a numerical rating on a scale of 1 to 5, reflecting its relative significance in contributing to flood occurrence. These factors included topographical and environmental variables, and higher ratings were given to those with a greater impact on flood risk. Additionally, the classes within each factor were assigned different weights, with higher weightage indicating a stronger influence on flood susceptibility. By overlaying these weighted thematic layers within the ArcGIS platform using the weighted overlay method, a comprehensive flood hazard map was produced. This map effectively integrates the various factors to reveal areas of varying flood risk. The resulting flood hazard map was then classified into five distinct zones: very low, low, moderate, high, and very high hazard zones. This zonal division provides a clear, visual representation of areas with differing levels of flood susceptibility, offering valuable information for flood prevention, preparedness, and mitigation strategies.

3.4. Running Weighted Overlay Tool in ArcGIS Software

In the Weighted Overlay Analysis (WOA), each input raster layer's weight is multiplied by the corresponding cell values of that raster. Before conducting the WOA, all layers were reclassified, converted to raster format, and resampled to ensure that each pixel across the layers had the same size and consistent labeling. This standardization ensures uniformity across all the data layers, allowing for accurate overlay analysis. The entire process was performed within the ArcGIS platform using the Weighted Overlay Tool (WOT). Six key input layers were utilized as data for the overlay analysis, contributing to the final flood susceptibility mapping. This research uses the mathematical equation given below

$$RI = \sum W_i * R_j$$

Where, W denotes the weightage assigned to each layer and R, denotes the rank assigned to each theme within a layer. The 'i' represents the number of layers, and the 'j' represents the number of themes within each layer.

$$RI = W_1 * R_1 + W_2 * R_2 + W_3 * R_3 + W_4 * R_4 + W_5 * R_5 + W_6 * R_6$$

W1 × R1 weight and rank of Slope layer

W2 × R2 weight and rank of Flow Length layer

W3 × R3 weight and rank of River Distance (Euclidian Distance) layer

W4 × R4 weight and rank of Precipitation layer

W5 × R5 weight and rank of Land use-Land cover layer

W6 × R6 weight and rank of Elevation layer

These weighted factor maps were incorporated into a GIS platform and WOM analysis was used to create a flood hazard zonation map.

3.5 Flood Susceptibility Mapping (FSM)

Here are a few notable authors and their definitions or perspectives on Flood Susceptibility Mapping:

Rahmati et al. [38]: define “Flood susceptibility mapping is a process of assessing the spatial distribution of flood-prone areas based on a combination of environmental and hydrological factors using statistical and spatial analysis methods”.

Tehrany et al. [39]: defined that “Flood susceptibility mapping is the creation of a flood-prone map based on topographic, climatic, and hydrological characteristics of an area to help in disaster management and mitigation planning”.

Kazakis et al. [40]: stated that “Flood susceptibility mapping is a method of spatially estimating the likelihood of flood occurrences by combining various influencing factors in a geospatial platform”.

Pradhan [41]: “Flood susceptibility mapping involves the use of geospatial data to analyze and predict areas vulnerable to floods, based on key factors such as land use, topography, and drainage patterns”.

Moghadam et al. [42]: "Flood susceptibility mapping is a critical tool for identifying areas at risk of flooding by integrating various hydrological, meteorological, and geographic factors into a spatial analysis framework".

IV. RESULTS AND DISCUSSIONS

In this research study, an effort was made to conduct flood susceptibility zonation for the Mun River catchment within the Purna River basin. The analysis was based on six key influencing parameters: Elevation, Slope, River Distance, Flow Length, Annual Rainfall, and Land Use-Land Cover (LU-LC). These factors play a critical role in determining flood risk, as they directly impact the hydrological and topographical conditions of the catchment. For each parameter, detailed data was extracted, analyzed, and represented through thematic maps. These maps provide a comprehensive overview of how each factor contributes to flood susceptibility within the region. The following sections present a summary of the data and the generated maps, which form the basis for assessing and delineating flood-prone zones within the study area.

4.1 Elevation

For any geographic analysis, slope and elevation are critical geospatial parameters that significantly influence the assessment of flood risk. The use of high-precision topographic data enhances the predictive accuracy of flood analysis, making it a key factor in identifying flood-prone areas. Consequently, the elevation layer and its derivatives play a crucial role in accurately predicting regions susceptible to flooding [43]. The elevation class map, generated from the Digital Elevation Model (DEM), is categorized into five distinct classes, as illustrated in Figure 3. These classes provide a detailed understanding of the terrain, aiding in the identification of vulnerable areas. A 30 m resolution SRTM DEM dataset was analysed using ArcGIS 10.8 to create the Elevation map, which included filling sinks and extracting continuous flat regions to establish flow consistency.

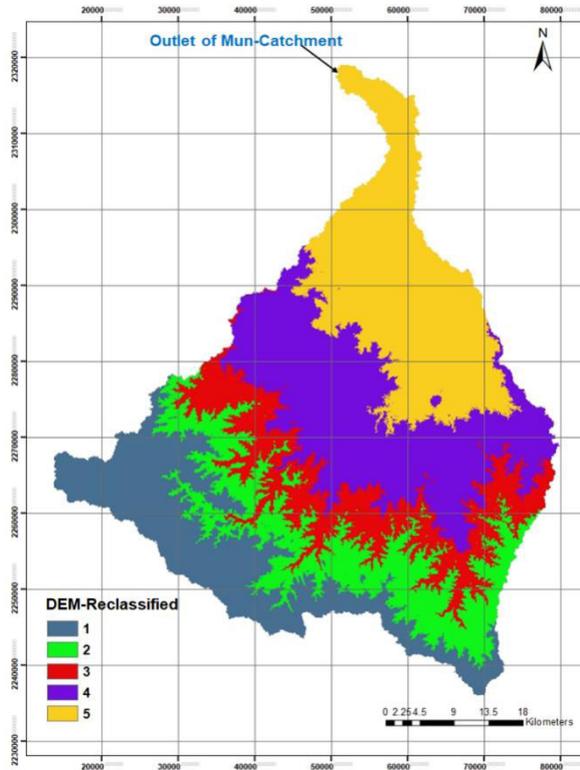


Fig.3: Reclassified Elevation Map

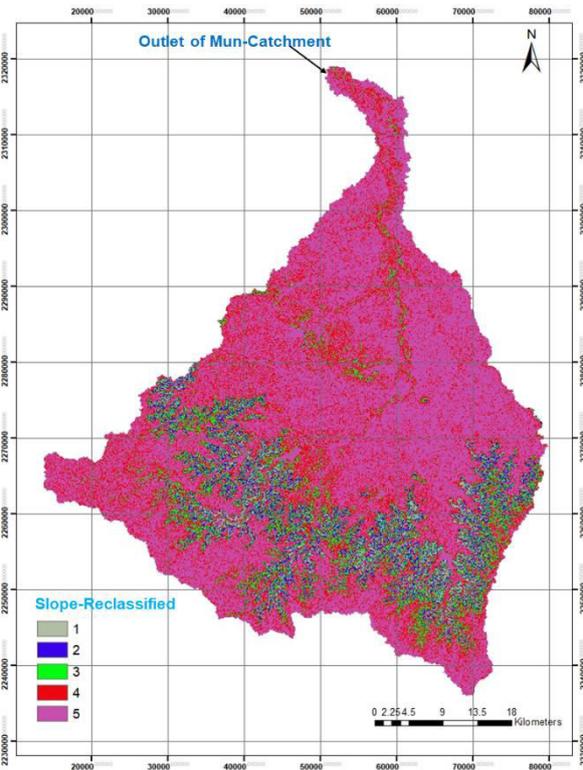


Fig.4: Reclassified Slope map

4.2 Slope Map

The elevation differential, between two points are separated by a unit distance is referred to as slope. The slope is the most critical factor for flooding due to its direct influence on surface runoff in watersheds. The effect of slope on the occurrence of devastating floods is related to runoff speed [44]. So that, on slopes with high slopes, the speed of water penetration is much lower, this will increase the speed and flow of water. The slope map of the study area is based on the Digital Elevation Model and is classified into 5 classes as shown in figure 4. The majority of flood-prone areas have low surface slopes and are situated in low-elevation places.

4.3 River Distance (Euclidian Distance)

Distance from the river is an important and influential factor in reducing or intensifying the occurrence of floods [45] because the areas adjacent to the river are more prone to floods. In this study, the river distance network was extracted using a Digital Elevation Model in conjunction with the Arc Hydro integration tool within ArcGIS. Subsequently, a layer representing the distance from the river was created using the Euclidean distance tool. The proximity to the drainage network significantly influences the occurrence and spread of riverine floods. Areas located far from streams tend to experience lower flooding risks, while regions in close proximity to rivers are more susceptible to periodic flooding events. According to Pradhan [46], areas situated within 90 metres of the drainage network have a high flood risk. Similar to research that follow the approach, regions closer to the drainage network are much more likely to flood, so flood-prone zones of the study area are delineated accordingly. Distance to drainage network values are categorised into five classes in this study, ranging from very low to very high as shown in figure 5.

4.4 Flow length

Flow length is a key criterion in flood hazard mapping, representing the distance that water travels from a point on the terrain to the nearest drainage outlet, such as a river or stream. It helps in understanding surface runoff dynamics, with shorter flow lengths indicating quicker water accumulation in drainage outlets, potentially increasing flood risk. Calculated using Digital Elevation Models in GIS software, flow length is integrated with other factors like slope and land use to create comprehensive flood hazard maps. This analysis aids in identifying areas most vulnerable to flooding and informs flood risk management strategies. The reclassified Flow Length map as shown in figure 6.

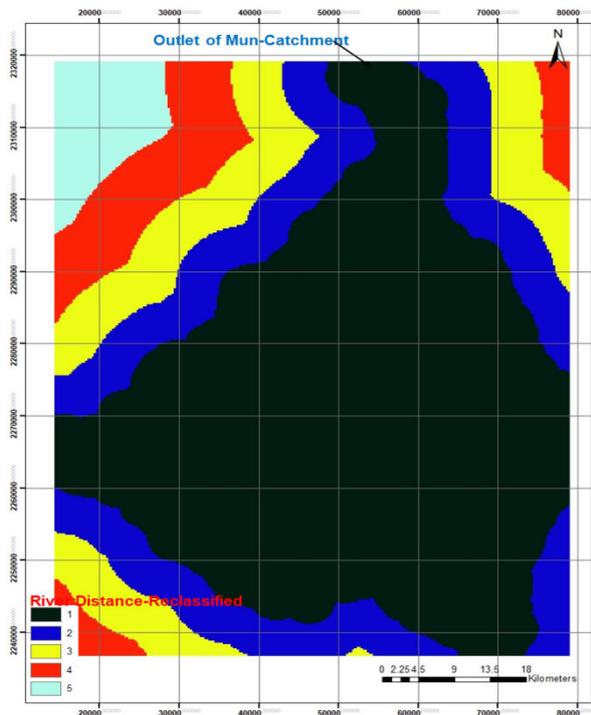


Fig.5: Reclassified River Distance Map

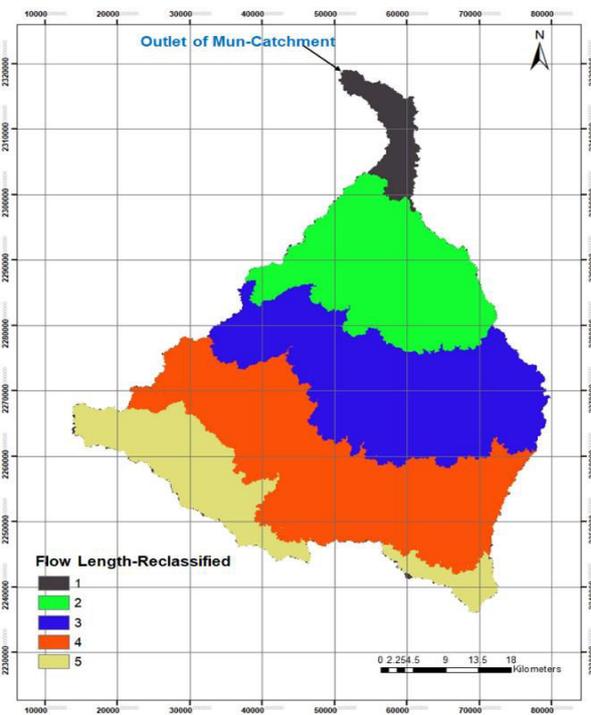


Fig.6: Reclassified Flow length map

4.5 LandUse-LandCover (LU-LC)

Land use-Land cover plays an essential role in the flooding process and directly or indirectly affects some hydrological processes such as permeability, evapotranspiration, and runoff [47]. The land-use pattern of a region plays a crucial role in influencing hydrological processes such as surface runoff, infiltration, and evapotranspiration. These factors determine how water is absorbed or flows across the terrain. As a result, land use is a key parameter in flood susceptibility mapping, as it directly impacts a region's vulnerability to flooding by shaping how water moves and is retained across various land cover types. Understanding land-use patterns helps predict flood risks more accurately, making it essential for effective flood management and planning. The primary land use-land cover (LU-LC) categories identified in the study area include Forest, Agricultural land, Built-up areas, Fallow Wasteland, and Water bodies, as illustrated in Figure 7. These categories have been classified into five distinct classes: Class 1 represents Built-up areas, Class 2 denotes Agricultural land, Class 3 covers Fallow wasteland, Class 4 corresponds to Forested areas, and Class 5 identifies Water bodies. These classifications play a crucial role in determining flood susceptibility, as each land use type has a different impact on water flow, absorption, and flood risk within the region.

4.6 Precipitation

Heavy rainfall is one of the primary causes of flooding, as extreme precipitation leads to significant surface runoff when water cannot quickly infiltrate the ground. In this study, a rainfall grid map layer was developed using 20 years of data (2003 to 2023) collected from the Indian Meteorological Department (IMD) in Pune. Rainfall amounts were categorized into five classes: 758-789 mm, 789-809 mm, 809-825 mm, 825-841 mm, and 841-865 mm, as shown in Figure 8.

The areas were ranked based on their flood susceptibility:

- Rank 1: Areas with minimal influence and low vulnerability to flooding (758-789 mm)
- Rank 2: Zones with slight impact and low flood risk (789-809 mm)
- Rank 3: Moderately affected areas with moderate flood vulnerability (809-825 mm)
- Rank 4: Areas with significant influence and high vulnerability to flooding (825-841 mm)
- Rank 5: Regions experiencing the highest influence and very high risk of flooding (841-865 mm)

As rainfall intensity increases, so does the likelihood of flooding, with higher-ranked areas being at a much greater risk.

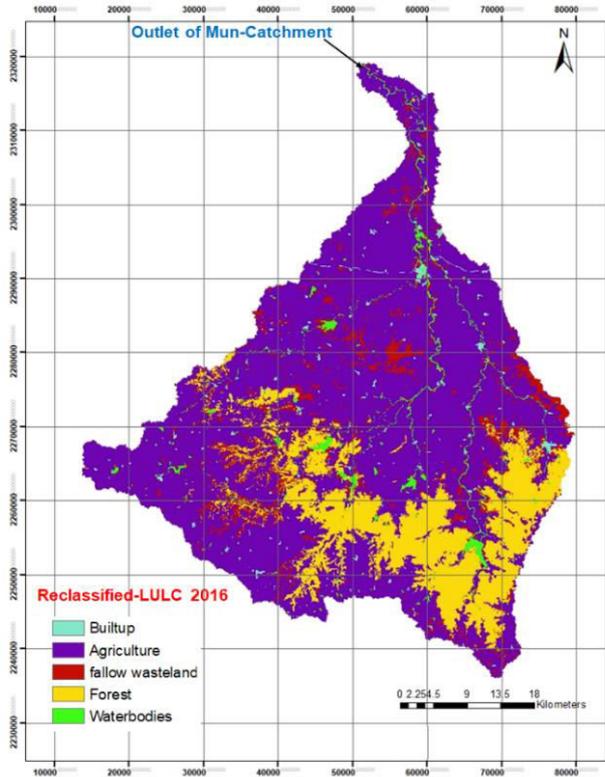


Fig.7: Reclassified LU-LC Map

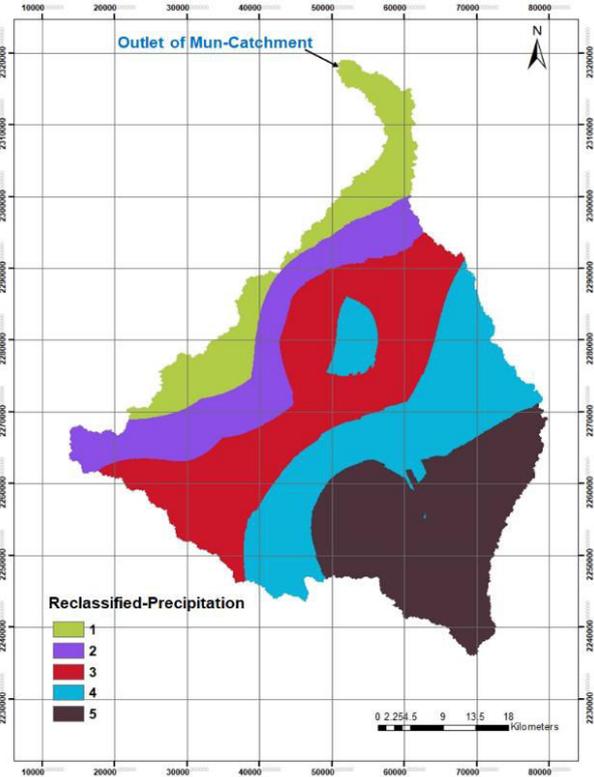


Fig.8: Reclassified Precipitation map

4.7 Flood Hazard Susceptibility Zone Map

Flood hazard zonation assessment, is very crucial for rational management of watershed [48]. A flood hazard susceptibility zonation map was developed using the Weighted Overlay Index (WOI) approach, with ranking assigned to various thematic layers on a GIS platform. The ranking and weight values for each layer are provided in the accompanying table. The resulting flood hazard map is categorized into five levels of flood susceptibility: Very Low, Low, Moderate, High, and Very High, offering a detailed view of areas vulnerable to flooding. The flood susceptibility analysis revealed that approximately 179 sq. km of the area falls under the very low flood-prone category, while around 304 sq. km is classified as low flood-prone. The moderately flood-prone zone covers about 567 sq. km, and the high-risk flood-prone area spans 595 sq. km. The most vulnerable region, the very high-risk flood zone, encompasses approximately 768 sq. km, indicating a significant portion of the study area at risk of severe flooding.

Flood susceptibility map may help to take proper flood measures to reduce the risk and vulnerability [49]. The results of the study closely align with the general understanding of flood-prone regions within the Mun-River catchment area. A significant portion of the catchment, 32%, falls within the very high flood-risk zone, while 24.4% is classified as a high-risk zone. Additionally, 23.5% of the total area is categorized as being at moderate risk, with only 7.4% of the catchment considered to be in a safe zone, free from major flood risk. The areas identified as highly susceptible to flooding in this study include Patur, Balapur, Buldana, Wadegaon, and Degaon, with the Paras Thermal Power Station also falling within the very high flood risk zone. Several important towns, such as Atali, Ambetaki, Ambikapur, Jawala, Kanheri Gawali, and Sasti, are similarly located in these high-risk flood zones. The right bank of the Mun-River is particularly vulnerable, as highlighted in Figure 11. This high susceptibility to floods underscores the need for targeted mitigation efforts and flood management plans in these areas, especially for critical infrastructure like the power station and major towns that could face significant damage during flood events.

Several locations, including Lokhanda, Pala, Shirla, Ghuti, Mundefal, Undri, Selgaon, Warud, Januana, Khamkhed, and Karankhed, are classified as being under moderate flood risk. In addition to these areas, two important dam-reservoirs, the Kawala Reservoir and the Haralkhed Reservoir, also fall within the moderate flood risk zone. These regions, while

not as vulnerable as high-risk areas, still require careful monitoring and flood management strategies to mitigate potential damage during periods of heavy rainfall or elevated water levels. Also Nagpur-Chatrapati Sambhaji Nagar highway flooded moderately.

In the upper portion of the catchment, as depicted in Figure 11, several areas fall under low to very low flood risk zones. Locations such as Vairagad, Kusumba, Nimkhed, and Maharkhed are categorized as having low to very low flood susceptibility within the Mun-River catchment, making them relatively safer compared to other regions, though continued monitoring is essential to maintain flood preparedness. The approach introduced in this study, using a limited number of variables, has proven effective in consistently estimating flood susceptibility. In the study area, the most significant factors contributing to flood occurrence were identified as slope, drainage patterns, and Land use-Land cover (LU-LC), with rainfall conditions also playing a critical role. The Weighted Overlay Analysis (WOA) in ArcGIS was instrumental in generating a flood risk zone map. Adjusting the weight or influence of the factors could result in a different output map. The weightings and rankings used in this study were determined based on field evidence, logical reasoning, and consultations with subject matter experts. Flood susceptibility map is an important tool for flood risk management and priority areas are defined for detailed studies [50].

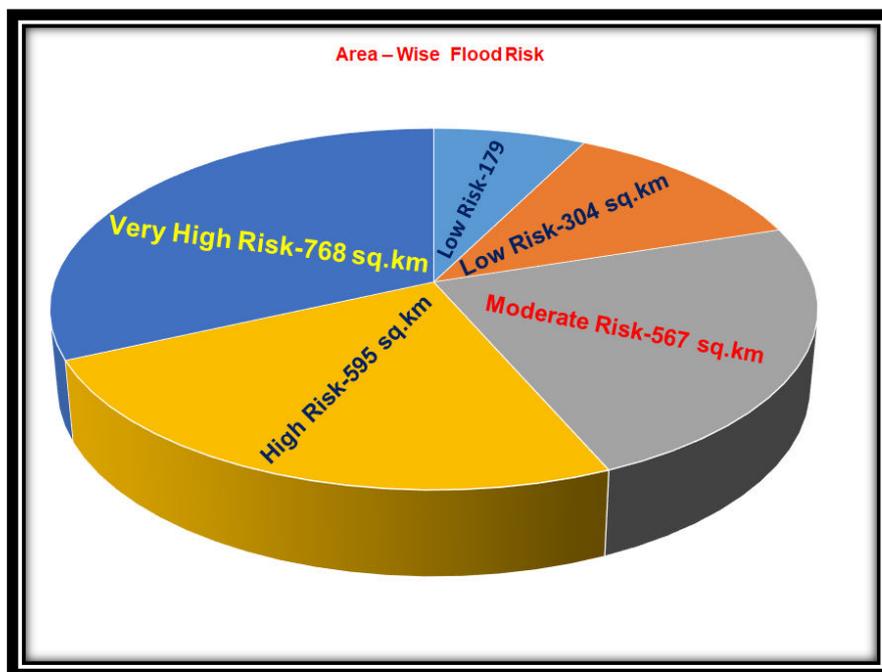


Fig.9: A graphs indicated Flood Risk Zones based on the Area-wise

Figure 9 shows the pie chart depicts the area-wise flood risk distribution within Mun-River catchment region. The chart is divided into five segments, each representing a different level of flood risk: very high risk (768 sq.km), high risk (595 sq.km), moderate risk (567 sq.km), low risk (304 sq.km), and very low risk (179 sq.km). The largest segment, representing very high risk, indicates that a significant portion of the region faces a substantial threat of flooding. Figure 10 is a bar graph illustrates the percentage-wise flood risk distribution and is divided into five categories representing different levels of flood risk. The length of each bar indicates the percentage of the region falling within that category. The very high-risk category has the longest bar, suggesting that a significant portion of the region faces a substantial threat of flooding. This information is crucial for policymakers, disaster management agencies, to prioritize flood mitigation strategies and develop effective response plans.

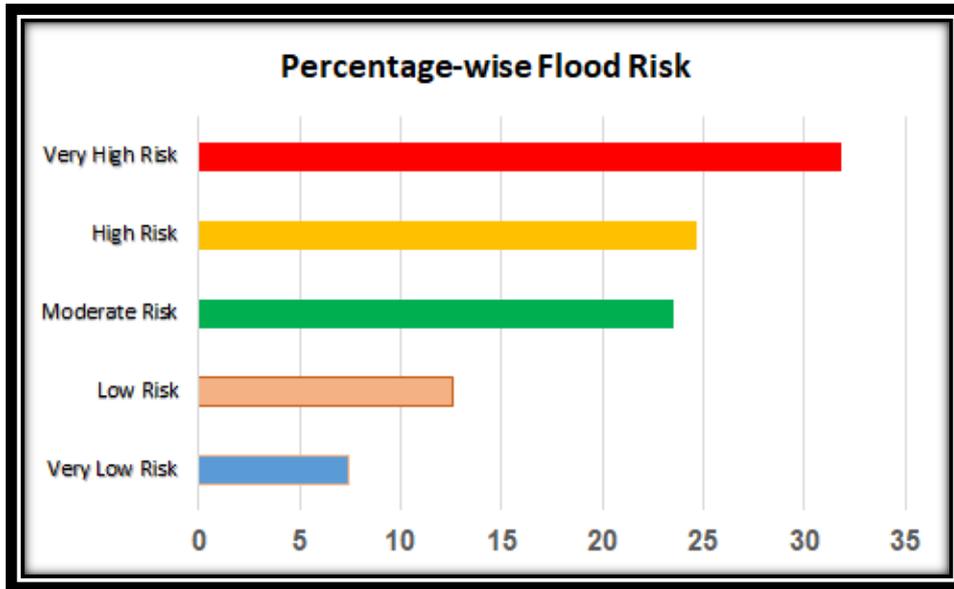


Fig. 10: A graph indicated Flood Risk Zones in percentage-wise

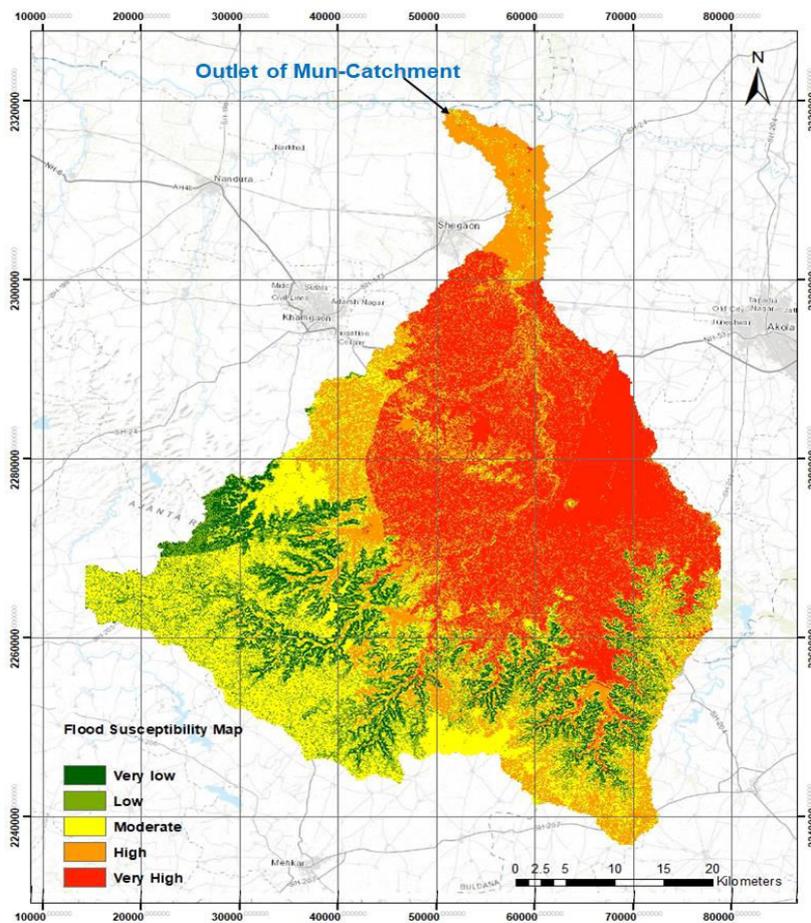


Figure 11: Flood susceptibility zonation map of Mun-River Catchment

V. CONCLUSIONS

This perspective highlights the crucial role that Remote Sensing and Geographical Information Systems play in flood hazard zonation mapping. The Weighted Overlay Analysis (WOA) method is a straight forward and effective approach for assessing potential flood hazard areas, enabling the integration of large, diverse datasets. Flood risks are influenced by multiple factors, requiring a well-structured and comprehensive plan. To accurately predict these complex phenomena, a systematic multi-criteria evaluation is essential, as it simplifies the process of managing and mitigating flood-related hazards. WOA is one such multi-criteria technique that yields accurate predictions, and it is used in this study.

GIS tools and research are valuable across numerous fields, particularly in emergency management. They have been widely utilized for visualization, modeling, and analyzing various aspects of disaster relief efforts, providing critical support at multiple levels and scales in responding to emergencies. Floods are natural events that cannot be entirely prevented. However, human activities are contributing to the increasing likelihood and intensity of major flood events. Factors such as **climate change**, which leads to higher rainfall rates and rising sea levels, along with inadequate river maintenance and unchecked development in floodplains, are diminishing the land's ability to manage and contain flood waters. As a result, both the magnitude and frequency of floods are expected to rise. Second, the number of residents and economic properties in flood-prone areas is increasing.

The research proposes a fast and cost-effective approach to using GIS for creating a flood threat map from existing data. This analysis utilized ArcGIS software tools to develop a flood hazard map, which can identify flood-prone areas. Such maps are invaluable for guiding the planning and execution of construction projects, helping to mitigate flood risks and prevent future flooding through better preparation and infrastructure development.

The flood susceptibility map generated in this study will be a valuable resource for disaster managers, planners, and local authorities, helping them gain a clearer understanding of flood-prone areas within the region. By identifying high-risk zones, this map enables authorities to take proactive steps toward flood preparedness, ensuring that vulnerable areas are adequately safeguarded. Additionally, the map is expected to guide various government agencies and stakeholders in implementing flood risk reduction strategies, informing urban planning, infrastructure development, and emergency response measures. This tool not only aids in current flood management but also supports long-term planning to minimize future risks.

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