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Flood Prediction and Susceptibility Mapping of Chalakudy Tehsil Using ARCGIS

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Abstract: *Floods, which are water-driven natural disasters, have catastrophic consequences. They momentarily flood previously dry areas and wreak enormous devastation, including loss of life, property destruction, and infrastructure damage. Between June 1st and August 19th, 2018, Kerala had an exceptional amount of rainfall which resulted in severe flooding. Chalakudy, a locality profoundly impacted by the surging Chalakudy River, was one of the areas most severely damaged. The disaster led to a devastating loss of 433 lives throughout Kerala, with Chalakudy alone experiencing more than 100 deaths. The effect on Chalakudy was significant. The flooding engulfed residential neighborhoods, agricultural regions, and crucial infrastructure, causing disruption to transportation networks and hindering rescue operations. Additionally, Chalakudy saw a significant economic impact, with the agricultural sector incurring losses amounting to more than $50 million USD. In addition, vital infrastructure such as roads, bridges, and buildings suffered significant damage, exacerbating the difficulties experienced by the afflicted populations. These floods were not individual occurrences, but rather a component of a more extensive predicament in Kerala. Over 800,000 individuals were forced to leave their homes, and the region suffered infrastructure damages amounting to nearly $3 billion USD. Given the severity of this calamitous incident, it is imperative to enhance flood management methods and disaster preparedness measures in Chalakudy without delay. This work seeks to enhance these endeavors by utilizing Geographic Information Systems (GIS) methodologies to detect flood-prone regions and provide accurate flood inundation maps for Chalakudy Tehsil. By gaining a deeper comprehension of flooding phenomena and employing ArcGIS's unit hydrograph method for predictive modeling, we can effectively reduce risks and boost disaster preparedness planning in the region.*

Key Word: *Flood, ArcGIS, ArcGIS Pro.*

I.INTRODUCTION

1.1. General Background Of Study

Floods, the predominant natural calamities encountered by several nations globally, occur when a significant quantity of water infiltrates a once-arid land region. A flood can be caused by a variety of events, including intense rainfall, storms, river and dam overflows, climate change, and insufficient planning and development. Urban floods are a direct consequence of inadequate planning and development methods. Ancient civilizations, such as those located around the Euphrates, Tigris, Nile, and Indus rivers, chose to dwell close to these river valleys and bodies of water because of the fertile soil, access to water, and advantages for transportation. This demonstrates the significant growth opportunities offered by river plains. Nevertheless, because of the increasing human population, settlements began to encroach upon these areas, resulting in unregulated and inadequately designed development that gradually impeded the natural drainage system.

Urbanization, which involves the transformation of natural landscapes through the construction of buildings, infrastructure, and transportation systems, has had a significant impact on both urban and rural regions. Human modifications to the natural drainage system in the quest for growth have led to a range of calamities, with flooding being the most extreme. Urbanization is not the primary cause of floods; other factors that contribute to floods include deforestation, population expansion, climate change, and rising sea levels. These variables intensify the effects of floods, and future projections suggest an increase in the population vulnerable to flooding.

Urban areas, which have a high concentration of impermeable surfaces such as asphalt, concrete, and bricks, are especially prone to flash floods when there is heavy rainfall over a short period of time. Floods occur when the current drainage system cannot handle the considerably increased runoff in these places. To minimize these dangers, it is highly advisable to utilize suitable flood management technology and practices.

Nepal, an adjacent nation to India, utilized Geographic Information System (GIS) technology during the 2015 earthquake. During the emergency, the government employed the Geographic Information System (GIS) to pinpoint individuals who were in vulnerable situations, thereby directing emergency responders to provide assistance to them.

Impacted individuals. The government, acknowledging the importance of technology, took proactive measures to create a post-disaster need assessment report. This paper highlighted the importance of implementing a range of strategies for urban revitalization, such as hazard mapping, participatory planning, risk-sensitive urban planning, rapid urban expansion studies, and assisted management.

Floods have had a significant and far-reaching effect on millions of people worldwide. Among the countries most vulnerable to floods, India ranks 14th in terms of the frequency and severity of natural catastrophes. India's vast 7500-kilometer coastline is susceptible to tropical storms that originate in the Bay of Bengal and the Arabian Sea. According to the National Disaster Management Authority, 40 million hectares of India's entire geographical area are susceptible to flooding. Due to the repetitive occurrence of flooding, different government departments have incorporated appropriate technologies into their efforts to avoid, prepare for, respond to, and recover from disasters.GIS, a system with the ability to display topographic characteristics based on geographic coordinates (latitude and longitude) and elevation, is essential for disaster preparedness and response planning. GIS played a crucial role in emergency response,planning, and analysis during cyclones like Hud-Hud, Gaja, Amphan, and Nisarga that affected India between 2019 and 2022.

The Odisha State Disaster Management Authority utilized GIS-based satellite remote sensing to analyze and assess the 1999 floods. The Flood GIS played a crucial role at different phases by helping officials determine the best locations for multipurpose food shelters and pinpointing vulnerable areas to start rescue operations. To improve future readiness, the system underwent ongoing enhancements, including the development of vulnerability maps at the district and gram panchayat levels.

1.2. Study Area

Chalakudy Taluk is positioned in the Thrissur district of Kerala, India. It is placed in the southwestern region of the country. The taluk is distinguished by its close proximity to the Chalakudy River basin. The Chalakudy Taluk is located at roughly 10.3017° N latitude and 76.3319° E longitude. The purpose of the current study is to create flood hazard risk zone maps for the Chalakudy Taluk using ArcGIS and the Analytic Hierarchy Process (AHP). The figure below displays the border map of Chalakudy Thaluk. The study involves analyzing various parameters to identify areas with a high risk, including elevation, land use, slope, geology, rainfall intensity, and flow accumulation. In order to create the risk zone map a weighted technique is utilized. By utilizing these simulated maps, we can identify various strategies to mitigate the risk and severity of flooding in the Chalakudy Thaluk.

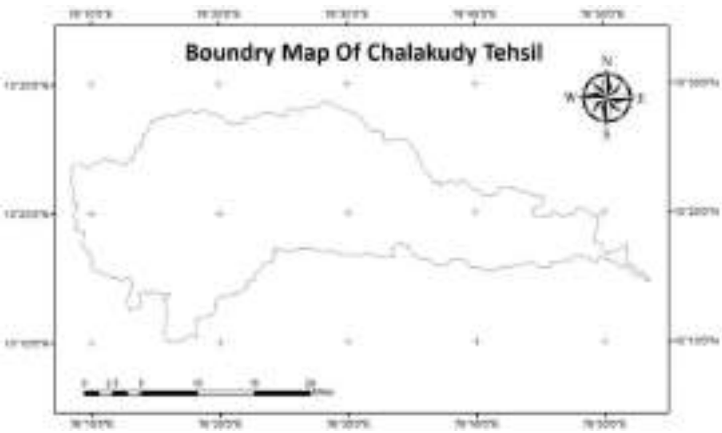

Fig. 1. The map of the study area – Chalakudy Tehsil

1.3. Scope And Objective of The Project

The basic objectives of this project are:
i) To create a map of an area susceptible to flooding using MCDA-AHP.
ii) Flood prediction

The primary scope of this project is:
i) Flood Detection and Mapping
ii) Risk Assessment
iii) Early Warning System
iv)Community Engagement
v)Data Sharing
vi)Adaptive Strategies

II. LITERATURE REVIEW

The Karuvannur River Basin Study conducted in 2021, directed by Lakshmi R, Neeraja P S, Hemandvishnu T C, Muhammed Favas P, and Deepak B, aims to analyze the danger of flooding in the Chalakudy river basin located in Thrissur, Kerala, India. Floods are a widespread global catastrophe, and improving our understanding of flood risks and areas prone to damage is essential for more efficient prevention and management. India experiences a substantial proportion of deaths caused by floods, highlighting the need for up-to-date risk mapping, as demonstrated by the recent flooding in Kerala. In order to tackle this issue, the study's objective is to develop a flood risk assessment map for the Chalakudy river basin. This will be achieved by utilizing rainfall data from 2018 and 2019 to simulate flood conditions, along with other relevant datasets. The integration of vulnerability and hazard maps is achieved by utilizing Geographic Information System (GIS) methodologies in conjunction with the Analytical Hierarchy Process (AHP). Hazard maps are created using the Analytic Hierarchy Process (AHP), which involves comparing several characteristics such as slope, drainage density, and rainfall. These comparisons are done in pairs to produce the maps. Meanwhile, vulnerability maps are created using criteria such as population density, road network density, and land use. The risk map generated reveals elevated danger zones predominantly located in the central west and southeast regions of the basin, which corresponds to the information reported in local publications.

The Chalakudy River Basin Study in 2022, led by Shinto M. D., Chinnamma M. A., and Deepa Davis, aims to map the floodplain and provide warning levels for potential floods in the Chalakudy River basin. Floods are highly hazardous global calamities that pose substantial risks to both human lives and ecosystems. Floods in India significantly contribute to a considerable proportion of the worldwide death rate. Kerala saw extensive floods between June 1st and August 19th, 2018 due to heavy rainfall, impacting five million individuals and leading to 433 deaths. Efficient flood prediction and management technologies are crucial for reducing these consequences. This study provides a comprehensive examination of the occurrence of intense flood occurrences in the Chalakudy River watershed between 2018 and 2021. The process of mapping the floodplain of the Chalakudy River basin involves the utilization of HEC-RAS and ARCGIS software. Initially, the inundated areas are identified by employing the Google Earth Engine. Moreover, the study establishes the flood warning thresholds for the Chalakudy River and different areas by utilizing real data and doing field investigations.

III. METHODOLOGY

3.1. To Create Map Of An Area Susceptible To Flooding

The objective of this project is to utilize GIS and other supporting tools and technologies to generate a flood inundation map and flood forecast for the designated research area, which is prone to flooding. The objectives of the project encompass the interpretation of areas susceptible to flooding, the identification of zones at high risk of flooding, and conducting studies to anticipate floods. These The goals were achieved by employing GIS, MCDA, mathematical calculations, and hydrological modeling methodologies. The techniques employed in this investigation are thoroughly elucidated in this chapter.

In order to determine the areas prone to floods and the structures within them, it is important to utilize Geographical Information System (GIS) technology along with the relevant data. Furthermore, the data will be employed to analyze the existing drainage system and predict floods utilizing mathematical equations and unit hydrographs.

The study and its accompanying maps can aid in making informed decisions regarding the optimal locations for construction and the areas where development should be encouraged, particularly in terms of distinctive landscape architecture. The catastrophe management department will employ the findings to formulate the search and rescue operation and the cleanup measures.

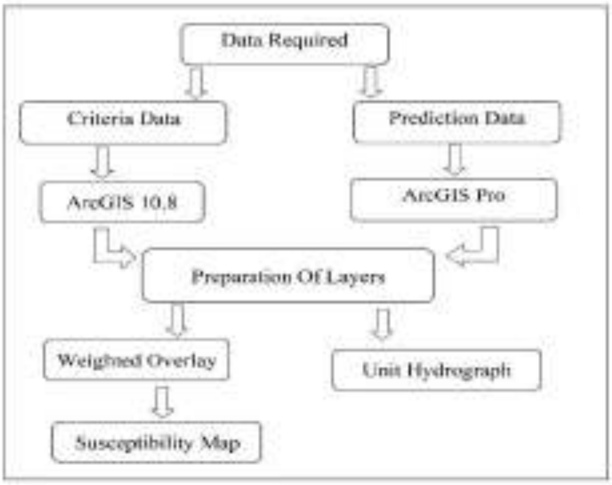

Fig. 2. Figure showing project workflow.

Multi-Criteria Decision Analysis

This study employed a Geographic Information System (GIS)-based Analytic Hierarchy Process (AHP) technique to pinpoint regions in Chalakudy Taluk that are prone to flooding. GIS, short for geographic information system, is an advanced technology that allows us to map and analyze geographical and spatial data using various tools in order to provide spatial solutions. GIS techniques were employed in natural disaster management studies to assess risk, identify danger zones, visually represent spatial information, and yield highly accurate outcomes. After reviewing multiple articles from high-impact journals, the GIS-AAHP Multi Criteria Decision Analysis (MCDA) strategy was selected as the most appropriate approach. For my research, I integrated the Analytic Hierarchy Process (AHP) methodology with Geographic Information System (GIS) technology to identify the areas at risk of flooding in the study area, considering multiple parameters.

The analytical hierarchy process (AHP) is a systematic approach that utilizes mathematical and psychological principles to effectively organize and comprehend complex decision-making scenarios. It was designed by Thomas L. Saaty in the 1970s. The AHP (Analytical Hierarchy Process) is proposed as a systematic approach to determining priorities and allocating appropriate weights to each criterion. The criteria are systematically compared in pairs using the Analytical Hierarchy Process (AHP).

Based on Saaty's fundamental scale, the criteria are assigned a ranking. The Flood Prone Buildings map is generated by combining the criteria and assigning them the appropriate weighting. The pairwise comparison matrix is normalized in order to determine the weight of each condition. The criteria in ESRI's ArcGIS 10.8 software are subjected to a weighted overlay analysis by applying the weights. Buildings situated in these areas have been evaluated as being susceptible to flooding.

The study's criteria were chosen based on socioeconomic and environmental factors. Subsequently, considering the selected characteristics, each criterion was evaluated on a scale ranging from 1 to 5. The AHP technique was used to produce a pairwise comparison matrix. This matrix was then normalized, and the weighted standards were derived using information from the literature review and professional judgment. The consistency ratio was evaluated, and it is required to be less than 0.10. The weighted criteria were applied once a consistent value had been acquired. The following are the processes for computing the Analytic Hierarchy Process (AHP).

A pairwise comparison matrix is constructed by assessing the criterion on a scale of 1 to 9. This matrix is used to ascertain the relative significance of the criteria.

Table 1. Saaty's Fundamental Scale.

Intensity	Importance	Explanation
1	Equal importance	Two activities contribute equally to objective
2	Moderate importance	Experience and judgment slightly favor one activity over another
3	Strong importance	One activity is greatly preferred over another by experience and judgment
4	Very strong importance	A particularly strong preference for one activity over another is seen in practice
5	Extreme importance	Highest level of affirmation is used to describe the evidence preferring one action over another

a) Computation of the consistency vector, consistency measure, and eigenvalue (λmax) of the criteria

$$\begin{bmatrix} C11 & C12 & C1 \\ C21 & C22 & C23 \\ C31 & C32 & C33 \end{bmatrix} \times \begin{bmatrix} W11 \\ W22 \\ W33 \end{bmatrix} = \begin{bmatrix} Cv11 & Cv12 & Cv13 \\ Cv21 & Cv22 & Cv23 \\ Cv31 & Cv32 & Cv33 \end{bmatrix} \quad (1)$$

Where,
C = Criteria
W = Weight
Cv = Consistency Vector
Ratio is calculated to arrive at the eigenvalue (λmax)

$$R = \sum(Cv \div W) \quad (2)$$
$$\lambda max = (\sum R) \div n \quad (3)$$
$$CI = (\lambda max - n) \div (n - 1) \quad (4)$$
$$CR = CI \div RI \quad (5)$$

Where,
R = Ratio
n = no of criteria
CI = Consistency Index
CR = Consistency Ratio

Table 2. Consistency Ratio Random Number Index by Saaty

n	RI
1	0
2	0
3	0.52
4	0.89
5	1.12
6	1.26
7	1.36
8	1.41
9	1.46
10	1.49
11	1.52
12	1.54
13	1.56

CR < 0.1, acceptable

CR = 0.1 unacceptable

Criteria Used

The purpose of this research is to determine the flood risk zones within the study region utilizing GIS techniques in conjunction with an AHP multi-criteria decision approach. Elevation, slope, soil information, rainfall information, flow buildup, inundated highways, and land use are among the elements taken into account in this study to determine inundation risk zones. Environmental and socioeconomic aspects were taken into consideration when choosing these criteria. The environmental criteria include elevation, slope, soil information, rainfall information, and flow accumulation. Inundated roads and land utilization are socioeconomic issues that were taken into account in this study. Due to increased urbanization and rising land prices, the poor population began forming settlements in and near flood-prone areas. The criteria are briefed below:

- Elevation Range
- Degree of slope
- Maximum quantity of rainfall distribution in the research area
- Flow accumulation in the research area was calculated from the DEM.
- Soil data is sorted as per their infiltration capacity.
- Distance to Inundated Roads.

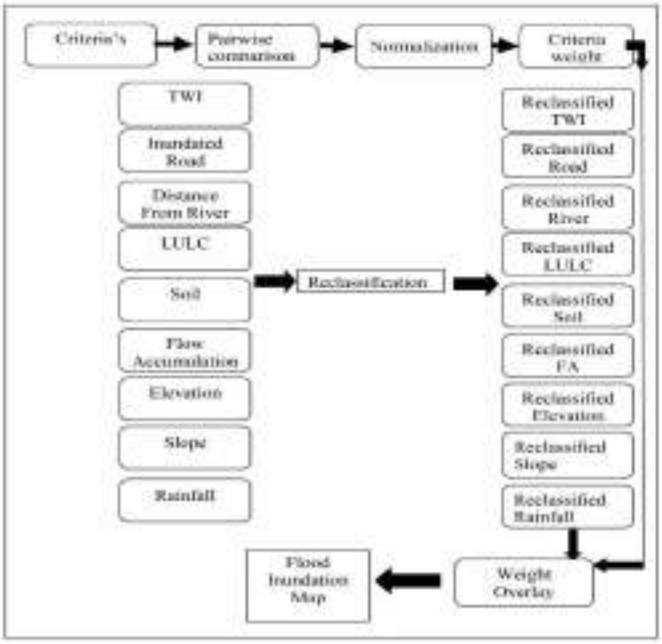

Fig. 3. Methodology of MCDA

Software Used

ArcGIS 10.8 was the GIS application used for this study. The Environmental Systems Research Institute (ESRI) maintains ArcGIS, a geographic information system for working with maps and geographic data. Spreadsheets from Microsoft Excel, part of the Microsoft Office software suite, were applied to calculate AHP scores. Spatial data not accessible from any other sources was extracted using Google Earth Pro. The project report's references are organized and referenced using the software EndNote.

Data Used

Table 3. Data Used

Chalakudy thaluk boundary	Maps of India
Rainfall	Chirps
Road map	Open street map
DEM	USGS
River	Bhuvan, ISRO
Soil	Soil Survey of India

3.2. Flood Prediction by Unit Hydrograph

Software Used

For this part of the project, we use ArcGIS Pro 10.4 to create a unit hydrograph.

Geographically Distributed Unit Hydrograph

Flood prediction was accomplished by developing a unit hydrograph, which served as the foundation for undertaking thorough spatial studies within a Geographic Information System (GIS) such as ArcGIS. This methodological framework involves a systematic procedure specifically developed to guarantee precision and dependability in flood prediction models.

This approach involves five fundamental procedures for generating GDUH: preconditioning the elevation model (DEM), delineating the watershed, creating the velocity field, producing the isochrone map, and forming the unit hydrograph. The GIS platform is used as the main tool for manipulating and analyzing project data, which includes acquiring and importing Digital Elevation Models (DEMs), land cover data, and hydrological parameters. These datasets collectively offer crucial information about the terrain's topography, land cover, and hydrological aspects. This information is essential for future flood prediction and spatial analytic activities. These procedures are essential to the technique, as they guide the production of the unit hydrograph and enable the precise prediction of flood dynamics.

An essential component of the process entails the identification and resolution of sinks, which are low-lying areas that obstruct the normal flow of water. A rigorous effort is made to minimize the impact of floods on prediction accuracy. All sinks with elevations below the z-limit and lower than their lowest neighboring point are filled up to the level of their pour points. This guarantees the continuous movement of water throughout the terrain, reducing errors in flood simulation.

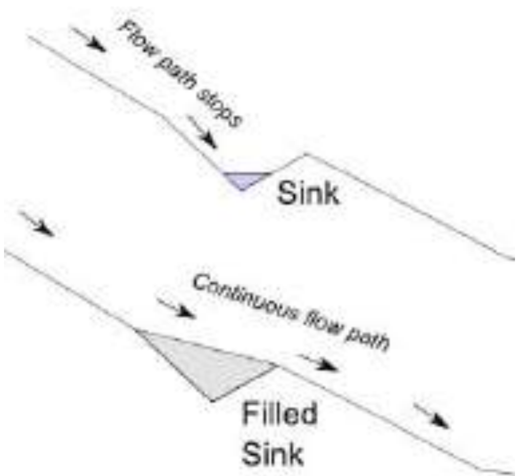

Fig. 4. Schematic representation of the sink filling procedure

Establishing the velocity field is a vital stage in the process. This entails ascertaining the orientation and aggregation of water movement inside the Digital Elevation Model (DEM). The Spatial Analyst extension employs tools like "Flow Direction" and "Flow Accumulation" to achieve this objective. The maximum number of flow directions is limited to eight, which guarantees a proper depiction of flow dynamics inside the model.

In addition, flow accumulation analysis is performed to precisely identify the specific locations of streams by determining the areas with the highest water accumulation. This information is extremely important for clearly defining potential flood risk zones and identifying regions that are prone to rapid runoff. The snap pour point study provides additional depth by determining the lowest temperature at which a liquid can flow, referred to as the pour point. Comprehending these thresholds is crucial for effectively forecasting flood dynamics.

In addition, isochrones maps are created to visually represent the areas that can be reached within a specific amount of time from a chosen starting point. These maps offer useful insights into the duration of transit over the landscape, making it easier to identify places that are prone to flooding and assisting in the creation of strategies for managing floods. By incorporating these methods into a complete approach, flood prediction models can be improved, resulting in more precise and efficient flood management and mitigation endeavors.

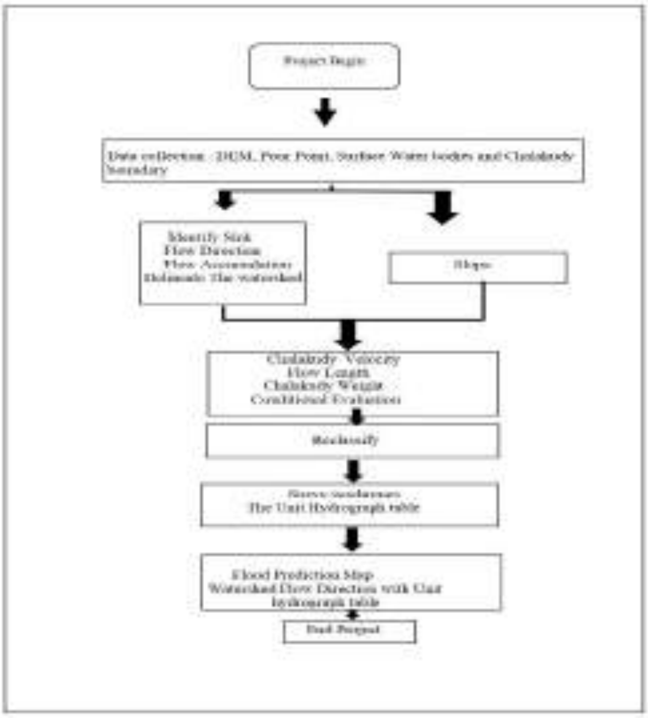

Fig. 5. Methodology of Flood prediction.

IV.RESULTS

4.1. Flood Risk Mapping Using Mcda

Criteria Evalaution and Reclassification

The study utilized eight key parameters to determine the areas at risk of flooding, as outlined in Section 3.1.2.1. The information obtained from publications published in high impact factor journals and the development criteria outlined in the Master Plan for the DDA (MPD 2041) are classified based on distance range and other relevant characteristics. The following flow chart illustrates the criteria utilized in this analysis. The environmental and socioeconomic parameters used in this study are closely linked to the flood risks prior to, during, and after a flood event.

Table 4. Criteria with suitability level

Criteria	Unit	Suitability Level				
		1	2	3	4	5
TWI	Levels	2.5	5	10	15	20

Elevation	m	20	40	60	80	100
Slope	%	5	15	25	40	85
Precipitation	mm	350	335	325		
Flow Accumulation		160000	125000	95000	65000	35000
DistanceFrom Roads	m	10	20	30	40	50
Land use	Type	Built up	Marshland	Agriculture	Open Spaces	Waterbody
Distance From River	m	100	200	300	400	500
Soil Type	Type	Acid Saline Soil	Coastal Soil	Alluvium Soil	Laterite Soil	Forest Soil

Suitability Level

1- Very Low
2- Low
3- Moderate
4- High
5- Very High

Topographic Wetness Index

The topographic wetness index (TWI), often referred to as the compound topographic index (CTI), is a unitless measure utilized to evaluate the impact of land features on hydrological processes and the fluctuation of soil moisture. The concept involves the integration of both the slope and the upstream contributing area, measured per unit width perpendicular to the direction of flow. The Total Water Index (TWI) exhibits a strong correlation with soil characteristics, including horizon depth, silt percentage, organic matter content, and phosphorus levels. The calculation involves taking the natural logarithm of the ratio between the upslope area and the tangent of the slope. The development of TWI occurred as part of the TOPMODEL runoff model by Beven and Kirkby

$$\ln \frac{a}{tanb}$$

Where,
a is the local upslope area during through a certain point per unit contour length
tan b is the local slope in radians.

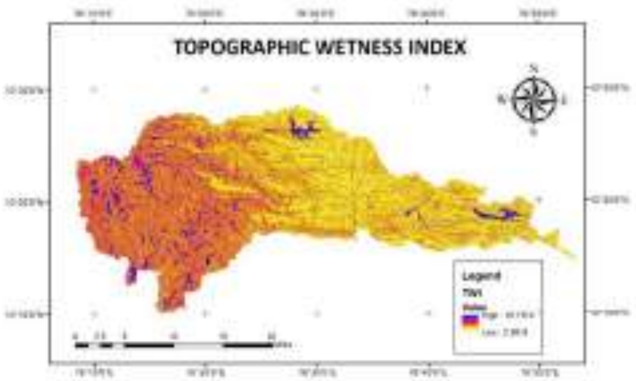

Fig. 6. TWI - Flood Risk Classification

Elevation

Elevation is employed as an environmental element in this study to determine the areas that are flooded. The stability of a terrain is significantly impacted by the height of the surrounding area. In areas with higher elevation and steeper slopes, surface runoff is enhanced, which helps to minimize water accumulation. Low-lying areas are susceptible to flooding due to their limited capacity for surface drainage, and the level terrain is especially prone to waterlogging. Regions characterized by low elevation or a lack of significant topographical variation are more prone to the occurrence of flooding. The research site is situated in close proximity to the seashore and exhibits a predominantly level topography, with little variations in height. The elevation of the research area ranges from -23 to 1186 meters. Based on the study, areas with a variation in elevation of less than 5 meters are considered highly hazardous, whereas those with a variation in elevation of over 40 meters are considered quite safe (Aggarwal et al., 2009, pp. 145–158). The specific categorization of the range of elevations for this criterion is displayed in Table 6. The classification indicates the level of food danger in the research area based on its elevation.

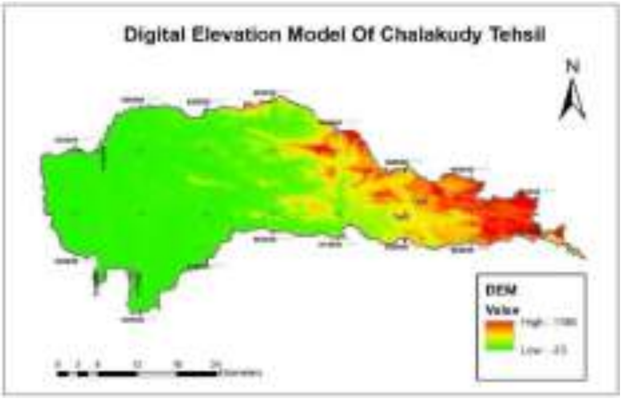

Fig. 7. Elevation-Flood Risk Classification

Slope

The slope is a significant component that considerably influences the direction and volume of surface runoff that reaches a drainage system. The ArcToolbox's slope generating capabilities are utilized to determine the slope from DEM raster data in the ArcMap software. Regions characterized by depressions, low altitudes, and gentle gradients invariably exhibit a propensity to accumulate water. Unlike nominal slopes, which have a tendency to absorb water, higher slopes have the potential to enhance surface runoff. Highly inclined slopes are less susceptible to floods compared to gently inclined slopes. In this study, slopes that have a significant degree of inclination are classified as exceptionally secure regions, whereas slopes with an inclination range of 5 degrees are classified as areas with a very high likelihood of flooding.

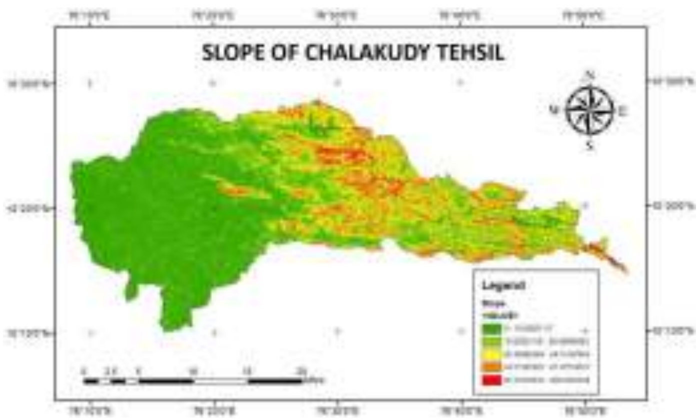

Fig. 8.Slope-Flood Risk Classification

Rainfall

Precipitation, specifically rainfall, is the primary factor responsible for causing floods in all locations, regardless of other contributing factors. If the natural drainage system is sufficiently capable of removing water during a cloud burst, flooding will be prevented. However, in developed areas, the natural drainage systems are excessively utilized, hence diminishing their capacity to effectively drain the runoff resulting from a sudden heavy downpour. The likelihood of flooding in a region increases in proportion to the amount of drainage there. The quantity of runoff is influenced by the quantity of precipitation a location has received. The highest amount of rainfall in the study area was observed in October and November. The greatest daily rainfall range in the research area is determined and extrapolated. In order to construct a seamless raster of rainfall data, the data is interpolated using a technique called inverse distance weighting (IDW).

Fig. 9. Rainfall -Flood Risk Classification

Land Use Land Cover

Land Use Land Cover refers to the classification and description of the different types of land and how it is being utilized.When determining the flood risk zone for a certain area, the land use and land cover of the area are essential elements. The land use of a region not only indicates how the land is utilized but also provides insights into its stability and surface infiltration rates. During a rainstorm event, water has the ability to penetrate and be retained by the specific land use, which in this case is agricultural, as well as the vegetation cover. Agricultural area should have permeable soil to facilitate water absorption. The vulnerability to floods is heightened by the exposed, desolate terrains, which also contribute to the rapid flow of water following a downpour. The urban built-up zone is the most secure land use due to its impermeable surface, which leads to substantial runoff. This is the specific location indicated by the surface of impermeable concrete. Buildings, highways, and slum areas diminish the soil's capacity to absorb water and enhance the amount of runoff. Conversely, areas with preexisting bodies of water are considered to be more hazardous due to their propensity for rapid rainwater accumulation. The user's text is a single period.The flood risk classification is conducted in accordance with established criteria.

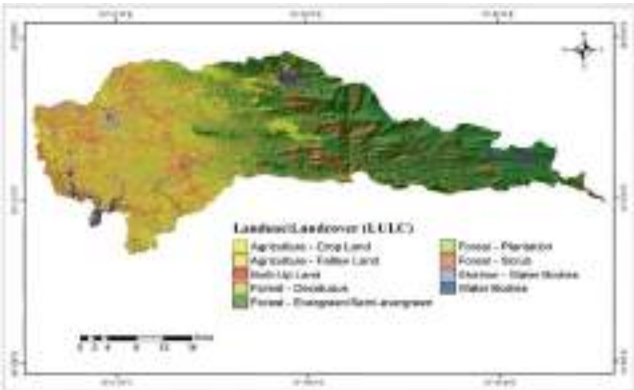

Fig.10. Land Use Land Cover

Distance From River

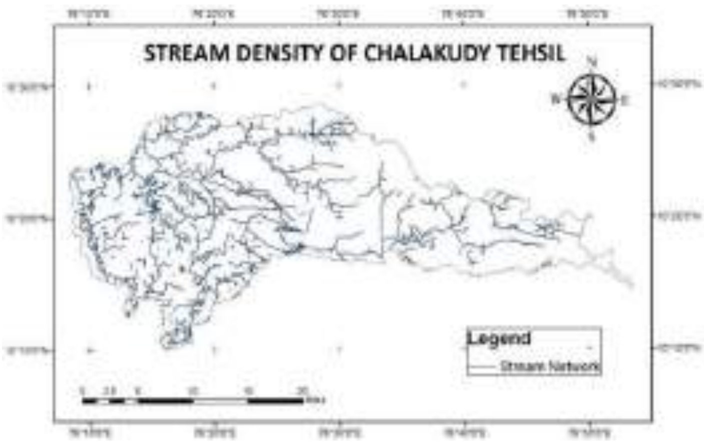

Fig. 11. Stream Density - Flood Risk Classification

Fig. 12. Distance from River Classification

Fig. 13. Streams overlaid

The proximity to rivers is a determining factor in assessing the level of flood risk, as locations that are closer to rivers are considered to have a higher risk. Mapping the distance from rivers allows for the identification of flood-prone areas, which is essential for assessing the potential impact of floods. This information is crucial for emergency planning as it helps to highlight areas that require evacuation or protective measures. Additionally, understanding the proximity to rivers is important for guiding infrastructure development, as it helps to avoid constructing in high-risk flood zones. By being aware of the distance from rivers, communities can take proactive measures to prepare for floods and ensure their safety.

Distance From Road

Highways are a crucial social determinant that must be taken into account in this investigation. This study categorizes areas that are located far from flooded roads as "very safe," while areas that are close to flooded roads are classified as experiencing "extreme risk." The thresholds for these classifications are determined based on the likelihood of rapid flooding during rainfall or storm events.

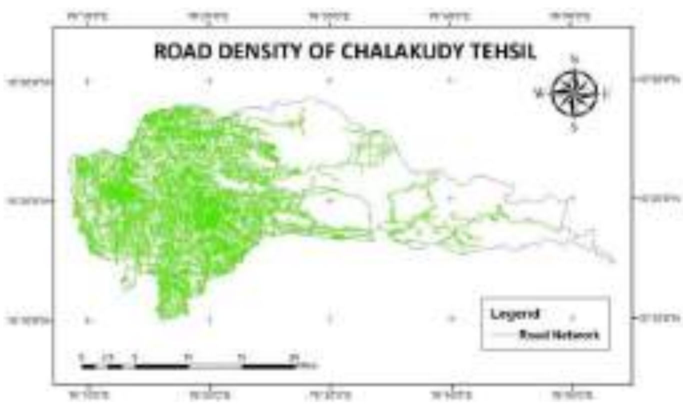

Fig. 14. Road Density -Flood Risk Classification

Fig. 15. Distance From Road Classification

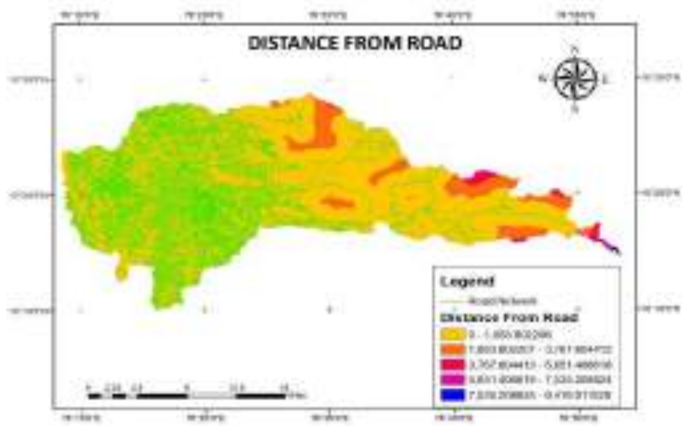

Fig.16. Overlaid Roads

Drainage Density

Drainage density refers to the measure of the total length of streams within a certain area.Drainage density is a significant environmental characteristic used to determine flood-prone areas. Flow Accumulation illustrates the probable course of streams or rivers in a particular area, indicating that precipitation will collect in this section. The Digital Elevation Model (DEM) is utilized to calculate the flow accumulation. The precision of the Digital Elevation Model (DEM) utilized in this investigation is 30 meters. The sink and fill tools in ArcGIS are utilized to rectify the slight depression inaccuracies in the Digital Elevation Model (DEM). The sinks in the digital elevation model (DEM) are identified using the Sink tool available in the Hydrology section of ArcToolbox. The DEM is utilized to identify the locations of sinks, which are then filled using the fill tool found in the ArcToolbox Hydrology. The flow direction Hydrology tool from the ArcToolbox is employed to ascertain the direction in which water will flow from one cell to another. The Flow Accumulation Hydrology tool from the ArcToolbox is utilized to determine the catchment areas that contribute to certain spots on the Digital Elevation Model (DEM). Adjei-Darko, 2017. The region with the minimum flow accumulation ranging from 0 to 35000 is classified as extremely secure, whereas the region with the maximum flow accumulation value ranging from 95000 to 125000 is classified as high-risk.

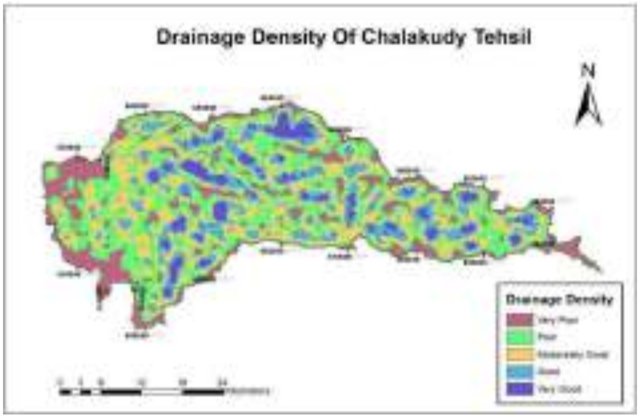

Fig. 17. Drainage Density - Flood Risk Classification

Soil Type

Soil is employed as an additional environmental parameter in this study to determine the flood-affected area. The soil's qualities can be determined by analyzing its texture, moisture content, and infiltration rate. The ability of an area to handle excess water and the resulting impacts of flooding are governed by the soil's capacity for infiltration. Clayey soils have low porosity and result in increased runoff, whereas sandy soil has high water absorption capacity, leading to reduced runoff. This study indicates that regions with clayey soils have a higher probability of experiencing a flood in the near future. The study area is characterized by loamy soil, clayey soil, sandy soil, or other comparable properties. The soil data for the study was provided by the Soil Survey of India agency. As per the Hydrologic Soil Group guidelines published by NRCS, sandy soil has an infiltration capacity ranging from 0.15 to

The precipitation rate is 0.3 inches per hour, according to Wikipedia in 2021. Regions characterized by sandy soils are classified as having a moderate level of risk and are assigned a weight of 3. Only a negligible amount of water, less than 0.05 inches, can infiltrate the Marshland during an hour of rainfall. Impervious surfaces encompass the remaining surface types. Locations characterized by sandy soils are classified as having a moderate level of danger and assigned a weight of 3. The Marshland has a limited capacity to absorb rainfall, specifically less than 0.05 inches per hour.

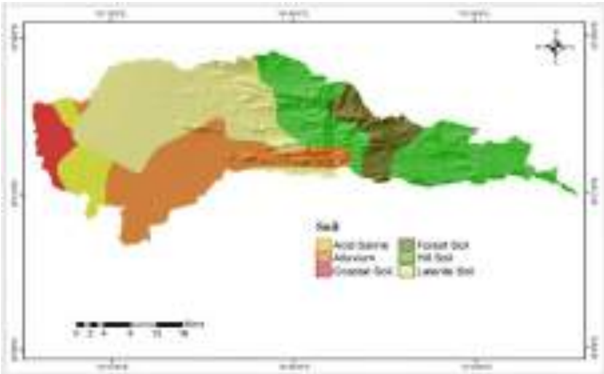

Fig. 18. Displays the classification of flood risk based on soil type.

The Analytical Hierarchy Process (Ahp)

The Analytical Hierarchy Process (AHP) is a method within the field of Multi Criteria Decision Analysis (MCDA) that was developed by Thomas Saaty. It is used to determine the relative importance or weightage of each criterion. This method was employed to calculate a weighting coefficient based on a comparison between two items. The process of comparing paired components involved utilizing a 9-point scale derived from Saaty's measure of relative importance to assign values to each individual piece.

Table 5. Presents Saaty's Scale of Relative Importance.

Definition	Relative Importance
Equal Importance	1
Moderate Importance	3
Strong Importance	5
Very Strong Importance	7
Extreme Importance	9
Intermediate Values	2, 4, 6, 8
Inverse Comparison	1/3, 1/5, 1/7, 1/9

Table 6. Displays the Pairwise Comparison matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1.00	0.33	0.33	0.33	0.20	0.14	0.14	0.14	0.11
C2	3.00	1.00	1.00	1.00	0.20	0.14	0.14	0.14	0.11
C3	3.00	1.00	1.00	1.00	0.20	0.14	0.14	0.14	0.11
C4	3.00	1.00	1.00	1.00	0.20	0.14	0.14	0.14	0.11

C5	5.00	5.00	5.00	5.00	1.00	0.20	0.20	0.20	0.11
C6	7.00	7.00	7.00	7.00	5.00	1.00	1.00	1.00	0.11
C7	7.00	7.00	7.00	7.00	5.00	1.00	1.00	1.00	0.11
C8	7.00	7.00	7.00	7.00	5.00	1.00	1.00	1.00	0.11
C9	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	1.00

Table 7. Displays the Normalized Pairwise matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	Criteria weights
C1	0.022	0.008	0.008	0.008	0.007	0.011	0.011	0.011	0.058	0.01
C2	0.066	0.026	0.026	0.026	0.007	0.011	0.011	0.011	0.058	0.02
C3	0.066	0.026	0.026	0.026	0.007	0.011	0.011	0.011	0.058	0.02
C4	0.066	0.026	0.026	0.026	0.007	0.011	0.011	0.011	0.058	0.02
C5	0.110	0.130	0.130	0.130	0.038	0.015	0.015	0.015	0.058	0.05
C6	0.155	0.182	0.182	0.182	0.193	0.078	0.078	0.078	0.078	0.12
C7	0.155	0.182	0.182	0.182	0.193	0.078	0.078	0.078	0.078	0.12
C8	0.155	0.182	0.182	0.182	0.193	0.078	0.078	0.078	0.078	0.12
C9	0.200	0.234	0.234	0.234	0.348	0.704	0.704	0.704	0.531	0.60

C1 refers to the TWI (Topographic Wetness Index), C2 represents an inundated road, C3 indicates the distance from a river, C4 stands for Land Use and Land Cover (LULC), and C5 represents the soil,C6 represents flow accumulation, C7 represents elevation, C8 represents slope, and C9 represents rainfall.

The value of λmax is 7.42.

The consistency index is 0.07

The consistency ratio is 0.05.

The formulas provided in section 3.1.1 of this document are utilized to compute the maximum value, confidence interval, and confidence range. Applying Saaty's standard rule, the consistency ratio was computed as 0.05, indicating that the weighted value for the criteria was derived consistently, as it is lower than the threshold of 0.10.

Weighted Overlay Analysis

Weighted Overlay Analysis refers to a method of combining many layers of data by assigning weights to each layer and then calculating a composite score based on these weights.

In the preceding section, the AHP methodology was employed to ascertain the appropriate weights to assign to each criterion. This part use the ArcGIS program to generate a weighted overlay map and perform a weighted overlay analysis.

The 'Weighted Overlay' tool is found in the Overlay section of the Spatial Analysis Tools in the Arc Toolbox. It is utilized for conducting weighted overlay analysis. The weighted overlay tool superimposes numerous rasters by utilizing a standard measuring scale and assigning a weight to each raster based on its importance (ESRI, 2008).

In the present study, the AHP approach was employed to ascertain the individual weights for each of the seven criteria.

Table 8. Displays the Weight of the Criteria.

Criteria	Weights
Elevation	12%
Slope	12%
Rainfall	60%
Flow Accumulation	12%
Soil	5%

Distance from Road	2%
Land use	2 %
Distance from River	2%
TWI	1%

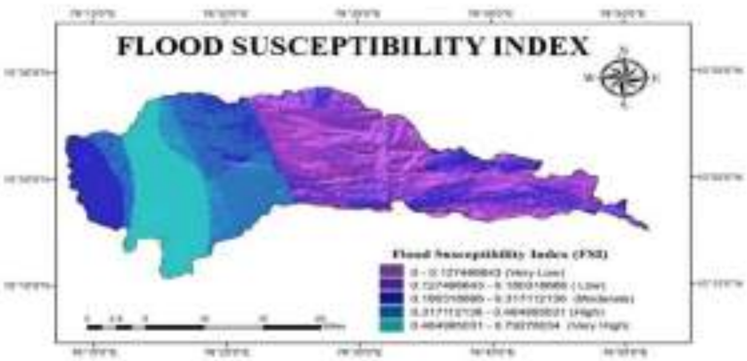

Fig 19 : Displays the Flood Susceptibility Index (FSI).

The tools were executed and the resultant map produced was named the Weighted Overlay Map. This map displays the areas within the study region that are at danger of flooding. The graphic above clearly indicates that the bottom edge of the research area is associated with a higher risk. Additionally, the GIS Weighted Overlay tool generates moderate risk zones within the chosen range.

Conclusive Outcome

A flood susceptibility map was generated by employing a weighted overlay analysis approach in conjunction with the Multi Criteria Decision Analysis, AHP methodology. The MCDA technique incorporated a range of socioeconomic and environmental elements. The study considered seven criteria: elevation, slope, rainfall, soil, flow buildup, land use and land cover, and historically inundated highways.

Table 9. Displays the Flood Susceptibility area as determined by the Multi-Criteria Decision Analysis (MCDA).

Study Area	Percentage Covered
Very Low	42%
Low	11%
Moderate	10%
High	13%
Very High	24%

The results indicate that 42% of the entire study region is categorized as Very Low, while 11% is classified as Low, and 10% is considered Moderate. Additionally, 13% is labeled as High, and 24% is designated as Very High. High-risk zones include both low-lying terrain and built-up regions, which worsen vulnerability to flooding because of insufficient drainage systems. To tackle this problem, it is necessary to develop a well-thought-out strategy and provide resources to improve facilities and infrastructure.

It is crucial to accelerate the execution of infrastructure improvements, especially during monsoon seasons, in order to reduce the effects of flooding. The methods provided in this study can greatly benefit municipal authorities by helping them identify priority regions for infrastructure development. Although the natural landscape may appear unaffected, the presence of low-lying depressions and sinks poses a widespread danger that is often overlooked until heavy rainfall reveals their vulnerability to flooding. As a result, the infrastructure, which includes buildings, roads, and trains, is put at risk during these occurrences.

This chapter provides a detailed explanation of the methodology used and presents the conclusions, which contribute to a thorough comprehension of flood risk assessment. By employing this data, disaster management authorities may strategically distribute resources for flood preparedness and mitigation endeavors. The system considers multiple elements that affect flooding, such as land use patterns, soil composition, and historical precipitation data, to ensure a comprehensive approach to predicting floods.

Mitigation Methods

The study's findings suggest that a significant section of the study area is classified into different risk categories. More precisely, approximately 53% of the entire area is categorized as having a low probability of flooding, while 32% is deemed to have a moderate likelihood, leaving 15% identified as having a high danger. It is important to highlight that high-risk locations include both low-lying land and developed areas, which worsens vulnerability because of insufficient drainage infrastructure. This highlights the region's vulnerability to flooding. Given these vulnerabilities, it is crucial to adopt customized mitigation strategies and solutions that directly tackle the unique issues encountered by the community.

An essential element of flood mitigation involves the development of durable infrastructure specifically engineered to endure and minimize the consequences of flood occurrences. Chalakudy can invest in structural solutions, such dams, dikes, and storm surge barriers, to safeguard susceptible areas, drawing inspiration from successful programs like the Netherlands' large network of flood defenses. To reduce the risk of flooding and protect important infrastructure and livelihoods, the region can improve drainage systems, build embankments, and install flood barriers.

In addition, nature-based solutions provide a sustainable and efficient method for reducing the impact of floods by utilizing the natural resilience of ecosystems to absorb and mitigate floodwaters. Wetland restoration, reforestation of mangroves, and the establishment of green spaces can effectively absorb surplus water, minimize runoff, and alleviate the consequences of floods. An instance of this is the rehabilitation of the Kissimmee River watershed in Florida, USA, which entailed the rejuvenation of wetlands and natural floodplains, leading to higher resistance to floods and increased biodiversity.

Community participation and capacity building are crucial components of flood mitigation programs, as they empower residents to proactively adopt measures and participate in activities related to disaster preparedness. Implementing community-based early warning systems, organizing training sessions on emergency response protocols, and cultivating a culture of resilience can enhance the community's capacity to manage flood occurrences. Nations such as Bangladesh, which experience frequent flooding, have effectively implemented community-driven efforts, such as the Cyclone Preparedness Program, to strengthen disaster resilience at the local level.

Moreover, the incorporation of green infrastructure into urban planning can effectively control stormwater runoff and mitigate the potential for floods in metropolitan regions. Sustainable drainage systems, permeable pavements, and green roofs have the ability to absorb precipitation, reduce the impact of urban heat islands, and improve the overall ability of cities to withstand and recover from challenges. Cities like Singapore have implemented inventive strategies, such as the "ABC Waters" initiative, which combines water management with urban planning to create dynamic and flood-resistant areas.

To strengthen its resilience to flood disasters and develop a sustainable future, the region of Chalakudy can adopt a comprehensive approach to flood mitigation. This approach would involve implementing both structural and non-structural measures that are specifically suited to address the problems encountered by the region. By engaging in proactive planning, investing in resilient infrastructure, and empowering communities, it is feasible to traverse the intricacies of flood risk with greater effectiveness and guarantee the safety and well-being of its citizens for future generations.

Flood Prediction Using Geographically Distributed Unit Hydrograph (Gduh)

The Geographically Distributed Unit Hydrograph (GDUH) methodology involves a sequence of carefully linked procedures to obtain a thorough understanding of hydrological processes within a watershed. The method commences by preparing the elevation model, acquired from ISRO's Geoportal Bhuvan, which acts as the fundamental dataset for future analysis. The Digital Elevation Model (DEM) undergoes rigorous preprocessing to correct typical mistakes such as sinks, which might hinder accurate identification of flow direction.

After refining the DEM, the process of delineating the watershed begins using ArcGIS Pro Hydrology tools and Python scripts. Defining the border is crucial in order to examine hydrological processes within a certain area. Identifying pour points, which indicate the regions with the highest flow accumulation, is crucial for accurately determining the boundaries of the watershed.

Therefore, it is crucial to develop a velocity field in order to accurately anticipate the movement of floodwater and determine the amount of time it will take for the entire area to be flooded. Utilizing the methods proposed by Maidment et al., the velocity field is accurately computed by taking into account the local slope and the upstream area that contributes to it. This technique, which is distributed in space, ensures a detailed understanding of the movement patterns of flow, taking into account differences in the physical features of the land and characteristics of the watershed.

Cell velocities are calculated by applying a formula that combines slope, contributing area, and average watershed values. By making statistical adjustments to the model parameters based on observed data, the accuracy of predicting the velocity field is improved. Assumptions are made about the average velocity and model coefficients to simplify the calculation process. These assumptions are carefully chosen to strike a compromise between computing efficiency and accuracy.

Isochrone maps, which depict lines of consistent travel time, are a crucial tool for understanding the temporal patterns of water flow in a watershed. By utilizing the velocity field, isochrone maps enable the computation of flow duration and length, offering vital insights into the spatiotemporal distribution of hydrological processes. By dividing the total duration of flow into distinct time intervals, usually lasting around 30 minutes, isochrone zones are created to aid in the creation of a unit hydrograph.

The unit hydrograph, a key tool in hydrological study, is obtained by a rigorous process that combines spatially distributed data and temporal factors. The ordinate values of the unit hydrograph are calculated by considering the incremental areas between isochrones. This provides a detailed representation of how runoff changes over time. The comprehensive approach guarantees that the unit hydrograph precisely represents the hydrological features of the watershed, facilitating well-informed decision-making in water resource management and flood mitigation endeavors.

A comprehensive flowchart illustrating the sequential procedure for creating a unit hydrograph using the spatially dispersed technique offers a clear guide for professionals, making it easier to apply the GDSUH methodology in practical situations. The GDSUH methodology provides a strong framework for analyzing and modeling hydrological processes at different scales by combining modern GIS techniques, statistical analysis, and hydrological principles.

Digital Elevation Model (Dem) With Watershed Boundary

A Digital Elevation Model (DEM) is a raster representation of the Earth’s bare ground surface, which does not include trees, buildings, or other surface items. These raster grids are aligned with the vertical datum and offer comprehensive topographic data. The resolution of a Digital Elevation Model (DEM) is controlled by the size of its grid cells. This directly affects the level of detail in the data file. Smaller grid spacing leads to higher resolution and more detailed information.

Applications of Digital Elevation Models are diverse and encompass a wide range including Hydrology and mass movement modeling employ Digital Elevation Models (DEMs) to replicate the movement of water, drainage patterns, and possible dangers including avalanches and landslides.Digital Elevation Models (DEMs) play a crucial role in the estimation of soil wetness, allowing for the computation of Cartographic Depth to Water Indexes for the investigation of soil moisture. Relief maps are generated by utilizing Digital Elevation Models (DEMs) to visually represent the elevation and topographical features of a terrain. These maps serve the purpose of facilitating geography education, promoting tourism, and enhancing disaster preparedness.

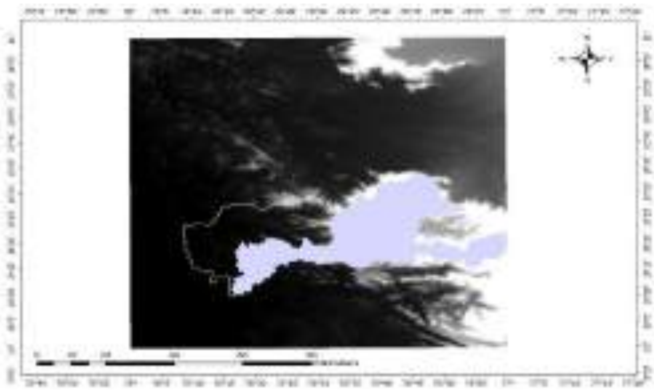

Fig 20 : Digital Elevation Model (DEM) depicting the boundary of a watershed.

Flow Accumulation

The flow accumulation map is a crucial element in hydrological analysis, providing vital information on the dynamics of watersheds and the patterns of water distribution. Its main purpose is to define specific spots within a smaller watershed where water accumulates, showing the comparative amount of runoff coming from nearby regions. This categorization enables the identification of crucial areas for water management and methods to reduce flooding, allowing stakeholders to allocate resources efficiently. Additionally, the flow accumulation map is crucial in evaluating flood risk by revealing the patterns of drainage and identifying locations that are susceptible to flooding. The integration of this system with other spatial datasets, such as Digital Elevation Models and land cover data, allows for a comprehensive understanding of the characteristics of a watershed. This enhances the investigation of hydrological processes. This complete viewpoint influences the process of making decisions in land use planning and infrastructure development, directing the adoption of sustainable practices and resilient infrastructure designs. The flow accumulation map is a crucial tool in hydrological research, playing a vital role in advancing knowledge and developing effective strategies for managing watersheds and mitigating floods.

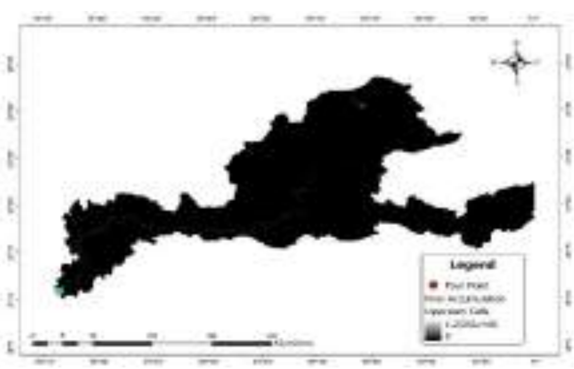

Fig 21 :Displays a Flow Accumulation Map of a sub-watershed with a pour point.

Flow Direction Map

Integrating a flow direction map into the analytical process of sub-watershed delineation is a crucial tool for understanding the complex routes of water flow. Firstly, these cartographic representations accurately outline the paths of water movement within the smaller watershed, giving a detailed visual representation of hydrological patterns. This comprehensive cartography captures the intricate interaction between geographical characteristics and water-related activities, enabling a sophisticated comprehension of how watersheds function. Furthermore, incorporating filled sink areas into the flow direction map enhances its accuracy and dependability by accounting for specific low-lying places where water collects.

The careful examination of the details of the terrain highlights the accuracy of the map in representing the actual movement of water in space. In addition, the action of filling sinks clarifies the patterns of water circulation, untangling the intricate nature of hydrology within sub-watersheds. This method enhances interpretive clarity by efficiently minimizing the confounding influence of depressions and illuminating the fundamental channels of water flow. In the end, the use of flow direction maps goes beyond simple cartographic depiction and plays a crucial role in influencing decisions related to watershed management. The spatially precise portrayals provide valuable insights that enable stakeholders to develop well-informed strategies for the sustainable management and preservation of water resources. Essentially, the flow direction map is a crucial tool in watershed management, enhancing decision-making with increased accuracy and effectiveness.

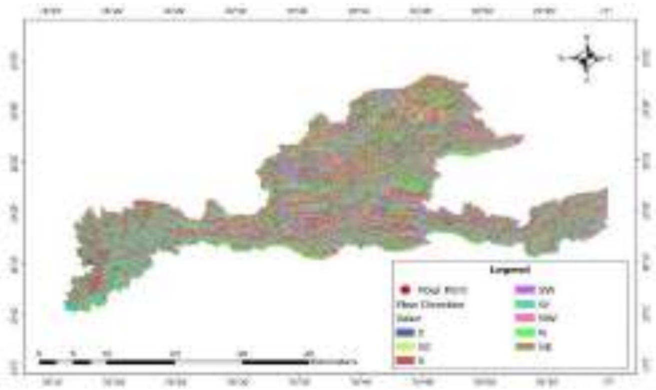

Fig 22 : Displays a map indicating the direction of flow inside the sub-watershed, taking into account the presence of filled sinks.

Slope Map

When using the unit hydrograph method for flood forecasting, the incorporation of slope maps becomes highly significant. These maps clearly illustrate the different slopes of the land in the research region. The significance lies in the fact that steeper slopes suggest more rapid water movement in the corresponding direction. By incorporating these slope maps with datasets that include elevation and water flow information, a more extensive comprehension of flood propagation patterns arises. This comprehensive strategy enables stakeholders to pinpoint susceptible regions within the watershed, hence simplifying the creation of specific actions to reduce or prevent negative impacts. As a result, incorporating slope maps into flood prediction models improves their precision, allowing decision-makers to take proactive measures in addressing flood-related issues and reducing threats to both human lives and property.

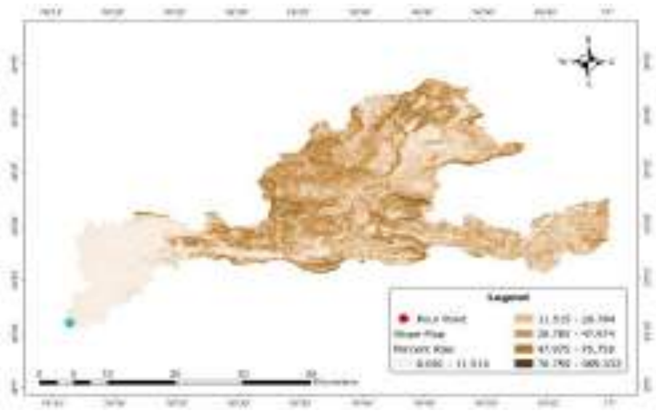

Fig 23: Topographic gradient map of the designated region

Geographical Arrangement

The spatial arrangement of velocity within the sub-watershed is a crucial part of hydrological study, providing valuable information about the fluctuation of water speed across various areas. This distribution represents a range of flow velocities, from 0.02 m/s to 2.0 m/s, which indicates a variety of water movement dynamics. The existence of a minimum velocity of 0.02 m/s indicates the presence of places with sluggish or motionless water conditions, whilst a maximum velocity of 2.0 m/s signifies regions with rapid water flow or strong flow intensity. Gaining a full understanding of this velocity distribution is crucial for evaluating water flow dynamics. This understanding allows stakeholders to pinpoint locations that are prone to floods as a result of high velocities and probable erosion. Within the framework of managing watersheds, this knowledge is crucial for developing efficient flood prevention techniques and protecting against the negative effects of increased water flow.

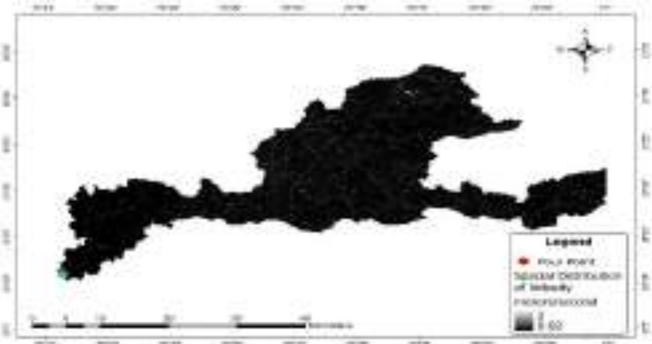

Fig 24 : Displays the Spatial Distribution of Velocity.

Time Map of The Sub-Watershed

The time map is a crucial cartographic tool that precisely reveals the temporal aspect of water movement within a sub-watershed. It provides detailed information about the length of water transit throughout the terrain. The main purpose of this tool is to provide a detailed representation of the time it takes to travel from different locations within the watershed to a specific outlet. This allows for a better understanding of how hydrological processes change over time. The understanding of water circulation patterns and flood propagation processes within the watershed is greatly enhanced by this temporal cartography. The time map is a valuable tool for identifying locations with long-term water retention or high susceptibility to sudden flooding by analyzing the temporal patterns of water flow. By visualizing journey times, stakeholders may clearly identify discrepancies in water flow rates, allowing them to highlight places that are at risk of flooding and develop specific plans to mitigate these risks. Therefore, the time map is a crucial tool in watershed management, enabling well-informed decision-making by providing a detailed representation of temporal hydrological dynamics.

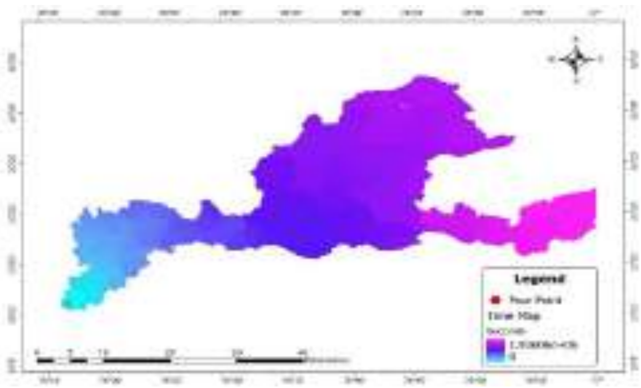

Fig 25: Displays a chronological representation of the sub-watershed.

Distribution of Isochrones in Seconds

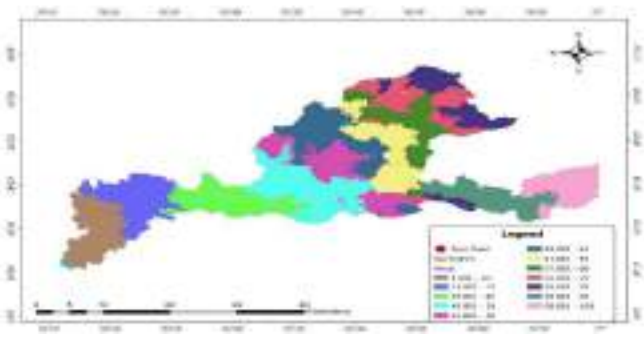

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Fig 26 : Displays the Spatial Distribution of isochrones in seconds within the research area

The arrangement of isochrones in seconds within the study region is an important analytical framework for understanding the timing of water movement and flood propagation. The isochrones depict the time it takes for water to travel from different locations in the study area to a certain outlet. They visually show how hydrological processes are distributed over time in the watershed. Through a thorough understanding of isochrones, stakeholders can identify places with different travel durations, allowing them to pinpoint probable flood courses or areas prone to water accumulation. Furthermore, dividing the study region into specific zones based on transit time intervals aided by isochrones allows for a detailed analysis of flood propagation dynamics. This approach systematically reveals the intricate spatial and temporal aspects of flood events, providing decision-makers with the essential information to develop specific measures for mitigating their impact. Therefore, incorporating isochrones into the analytical framework not only improves our comprehension of temporal hydrological dynamics but also provides a strong basis for implementing evidence-based watershed management methods.

Analysis Of Geographically Distributed Unit Hydrograph

Through the hydrograph analysis, we have gained valuable insights about the use of unit hydrographs in predicting floods in the study area. The results indicate that the highest discharge recorded in the hydrograph, which reached 38 m^3/s, represents a major flood occurrence in the watershed. The peak discharge observed indicates a significant increase in the rate of flow, suggesting the possibility of widespread flooding and possible dangers downstream.

Furthermore, the significance of comprehending the temporal dynamics of flood occurrences is emphasized by the fact that the descending limb touches at 8 hours, indicating the duration of the event. Unit hydrograph analysis is a useful tool for flood forecasting and emergency response planning since it allows authorities to predict the length of flood impacts and allocate resources accordingly.

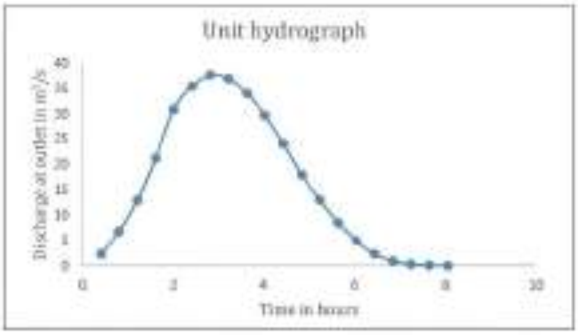

Fig 27: Displays a Unit Hydrograph.

In addition, examining other characteristics of the hydrograph offers additional understanding of flood dynamics. The Rising Limb indicates the start of enhanced flow, typically indicating the commencement of precipitation or snowmelt that adds to the runoff. The receding floodwaters, as shown by the Falling Limb, provide crucial insights into the likelihood of downstream flooding diminishing. Baseflow patterns offer valuable information on the movement of groundwater in the watershed, which in turn affects the way streamflow behaves during flood events. Gaining comprehension of Response Time aids in more precise anticipation of the timing and size of flood episodes. By analyzing the Shape of the hydrograph, valuable information about the watershed’s features can be obtained, which can then be used to inform the creation of specific flood prevention techniques.

The results highlight the usefulness of unit hydrographs as an important tool for predicting floods in the research area. Through the examination of different characteristics of hydrographs, individuals involved can get a thorough comprehension of flood patterns and establish proactive strategies to reduce flood hazards and improve the resilience of the community. By conducting ongoing research and refining unit hydrograph approaches, stakeholders can better their flood forecasting capabilities, leading to more effective flood control measures and improved public safety.

Constraints

The resulting unit hydrograph may not attain complete accuracy due to many reasons. For example, the model uses a straightforward translation method, assuming that the flow speed is the same at all locations. This limits its usefulness to small watersheds with modest storage impacts. In addition, the spatially dispersed unit hydrograph assumes a constant time to base, regardless of differences in storm strength, which may not adequately represent real-world conditions. The velocity profile is spatially variable and depends on local constant variables such as slope and flow accumulation, which are not uniform across the entire watershed

Although there are certain limits, this approach has advantages, such as the ability to consider differences in rainfall within isochrone zones when generating direct runoff hydrographs. Furthermore, it utilizes GIS technology to offer significant observations on the movement patterns throughout the watershed. Although there are certain drawbacks, this approach offers a hopeful alternative that decreases the need for manual coding or large information regarding rainfall and soil in order to forecast floods in the Chalakudy watershed.

V.CONCLUSION

The region of Chalakudy has consistently experienced flooding during rainstorms, reflecting the greater worldwide issue of managing urban floods. This problem transcends geographical boundaries, enveloping multiple cities, states, and countries across the globe. The impact of this phenomenon is significant, going beyond just material losses to undermine social activity, cultural legacy, material assets, and economic resources. Adding to these difficulties is the escalating influence of climate change, intensifying the seriousness and occurrence of natural calamities, such as floods.

To address these urgent problems, it is crucial to take proactive steps to reduce the hazards associated with floods. Although it may be impractical to fully restore flood-prone lands to their original condition, it is necessary to investigate other approaches to make these areas safer and more resilient for the people living there. The use of Geographic Information System (GIS) technology in conducting thorough flood risk assessments is emphasized by respected organizations such as the World Meteorological Organization (WMO) and the Global Water Partnership (GWP). The integration of geographical data and analytical techniques allows for a more comprehensive comprehension of the intricate elements that contribute to flood vulnerability, encompassing historical hazard records and future development plans.

The study’s numerical results, obtained using GIS-based studies and unit hydrograph modeling, offer precise and quantitative understanding of flood dynamics in Chalakudy. The analysis of flood susceptibility zones indicates that 42% of the entire research region is categorized as Very Low, while 11% is classed as Low, and 10% is considered Moderate. In addition, 13% is classified as High, while 24% is classified as Very High. High-risk zones include both low-lying terrain and built-up areas, which worsens vulnerability to flooding because of insufficient drainage systems. To tackle this problem, it is necessary to engage in strategic planning and allocate resources to improve facilities and infrastructure.

Furthermore, the utilization of unit hydrographs in flood forecasting has provided valuable understanding of the time-related patterns of flood occurrences. A peak flow of 38 m^3/s indicates a major flood event in the watershed, suggesting the possibility of widespread flooding and downstream flood risks. The event’s duration, marked by the falling limb reaching 8 hours, highlights the significance of comprehending the temporal dynamics of flood occurrences for efficient planning of emergency response and allocation of resources.

Examining additional characteristics of hydrographs, such as ascending and descending sections, patterns of baseflow, the time it takes for a hydrograph to react, and the overall shape of the hydrograph, enhances our comprehension of flood dynamics and provides valuable insights for implementing preventative measures to mitigate their impact. Through the utilization of interdisciplinary methods and the promotion of collaboration among many stakeholders, we may establish resilient communities that are more capable of withstanding the difficulties presented by flooding and other climate-related dangers.

Ultimately, this study emphasizes the urgent need for collaborative efforts to tackle the complex issues presented by floods in the Chalakudy watershed and other areas. Through the utilization of GIS technology, unit hydrograph analysis, and interdisciplinary collaboration, we may create comprehensive approaches to improve flood resilience, safeguard livelihoods, and defend the well-being of our communities. As we manage the intricacies of an ever more unpredictable climatic future, let us take advantage of this chance to construct a more robust and environmentally friendly world for future generations.

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