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Flood Impact in Kerala: Exploring Susceptibility Models for Mitigation

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ABSTRACT: In order to improve flood mitigation techniques, this study explores several flood susceptibility models and explores the substantial effects of flooding in Kerala, India. This study assesses how well different flood susceptibility models predict and mitigate flood disasters by a thorough analysis of the body of research and case studies. In order to create effective flood mitigation techniques, the study highlights the necessity for customised approaches that take Kerala's particular geographic and climatic characteristics into consideration. Important conclusions and suggestions from this study can help disaster management agencies, urban planners, and legislators create stronger and sustainable flood control strategies for the area.

KEYWORDS: Resilience Sustainable practices, Disaster management, Policy recommendations

I. INTRODUCTION

Floods are becoming more severe and frequent, affecting more people than any other natural hazard. This is majorly due to changes in climate, land use, infrastructure, and population demographics According to United Nations Office for Disaster Risk Reduction (UNDRR), out of 7348 disaster events, 3254 flood events were recorded worldwide over a period of 20 years from 2000 to 2019. A total of 1.81 billion individuals or 23% of the world's population are found to be directly vulnerable to flood[1].

Kerala's climate is humid and tropical. The predominant climatic phenomena include the South-West monsoons from June to September and the North-East monsoons which last from October to December. The South-West monsoon is more significant as it produces 80% of the total annual rainfall. Kerala has an average annual precipitation of 3000 mm.

About 90% of the rainfall takes place during the monsoon months. The monsoon storms of high intensity causes heavy discharges in rivers and leads to floods. Kerala is highly prone to floods. It is a major and the most frequent hazard in the state. With about 14.8% of the area prone to flooding. Floods also lead to secondary disasters like landslides as was witnessed in the floods of 2018. About 50% of the land area of Kerala is moderately to severely drought prone. It is expected that impact of global climate change will increase the extreme rainfall and lead to urban flooding probability during the north-east monsoon period, shortage of water during peak summer months, an increase in urban temperature, as well as eroding of coasts along the populated coastline due to increasing sea-levels. Climate change is expected to increase the frequency and intensity of floods, droughts, and mudflows. Another impact being witnessed is, progressive coastal erosion which affects nearly 63% of the State's 580 km of coastline.[2]

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Map of flood affected villages in Kerala

II. AIM AND OBJECTIVE

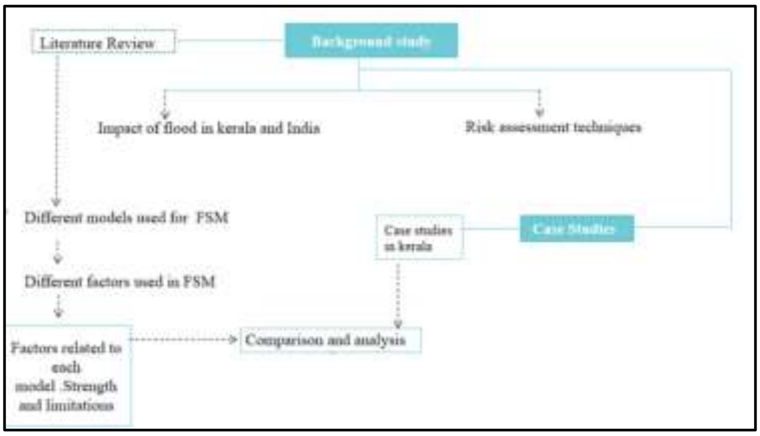
a.Aim

To study about the flood condition in kerala and to derive strength and weakness of flood susceptibility models.

b.Objectives

- The study aims to analyze Kerala flood history, climatic, geography types, and impacts across various regions and sectors.
- To Identify key factors contributing to flood susceptibility.
- To study about various models used for flood susceptibility.

III. METHODOLOGY



IV. NEED AND LIMITATION

a.Need

- FSM plays imp role in identifying flood-prone areas, land use planning, emergency preparedness, and disaster risk reduction [3].
- Reducing flood impacts, minimizing loss of life, property damage, and infrastructure damage.
- Strategies as they identify areas with the highest risk of flooding based on their physical characteristics.

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b.Limitation

- Less availability of dateset. Incomplete or inaccurate data can result in less accurate susceptibility assessments.
- The scale and resolution of data used in the modeling process affect the accuracy of the results.

V. HISTORY OF FLOODING IN KERALA

1907:Occurred during July and August. Kerala received175% higher than the normal rainfall. It was almost1780 mm rainfall. Idukki district received highest rainfall of 1380 mm.

1924: The Great Flood of 99' occurred in the month of July. This is mainly occurred due to opening of Sluice valves of Periyar dam without proper warning.Kerala received 3,368 mm of rain, 64% higher the normal which is highest rainfall of Kerala.

Districts mostly affected are Thrissur, Ernakulam, Iddukki, Kottayam,Alphuzza, Chittanad. Kundala Railway was destroyed, a huge mountain called Karinthiri Mala was washed away.

1961: It is occurred from 4 th June to 21 August.Kerala received 50% more than normal rainfall and therainfall is 2387mm. Chernvellor, Varapuzha Pakuthyand Kodangallur villages about 3500 acres, 3,803 acres,3,862 acres of land respectively got affected.

1974:Flood occurred in the months of July & august received2266 mm of rainfall. Idukki District received highest rainfall of 854 mm. More than 300 people died,thousands have been left homeless.

1992: Rains lasted on 10th -11th October. Due to this flood Alappuzha, Kollam, Trivandrum districts were completely affected. This is occurred due to influence of a well-marked low pressure over Madhya Pradesh.

2003: Flood occurred on 24th June. Kerala received 1722.6 mm rainfall. Caused due to heavy rains and Landslides. This flood affected 11 out of 14 districts (116 villages) and flood damaged 488 houses and 8members lost their life.

2013: Flood occurred during 1 st June to 8 th August,caused by landslides, flash floods and water logging in many places and 26/35 dams are opened.250 landslides had been reported. Kerala received a rainfall of 2561.2 mm. More than 20,000 houses got destroyed and 10,000 kms of road had been damaged and 30,000 people are moved to govt relief camps.

2016: The situation slightly improved in 2016, but Kasaragod was the only district to receive more than 2000 mm of rainfall. Ten districts out of 14 received a rainfall between 1055 mm – 1854 mm, while 3 districts are below 1000m. In result of dam filling to their maximum capacities these floods occurred.

2017: Increased in 2017 with 12 districts received rainfall between 1015 mm to 2120 mm. Deforestation is the mainly responsible for the phenomenon and climate change which caused this flood. More than 350people died and more than a million have evacuated over 4000 relief camps.

down pouring in Kerala during August and September in 2018 & 2019 have a widespread effect in socio economic lively hood of the people in Kerala. If had affected the people in different manner.Vast destruction caused by the flood and related natural calamities during the monsoon season has had a widespread affect, but the actual impacts are not yet revealed. While analyzing the effects of natural calamities on different socio-economic aspects of the people it is to be noticed that a permanent monitoring system is to be implemented to detect disaster prone geographical areas and rehabilitate the people from the risk ridden to the safe place.[4]

An aerial view as seen on 16 August 2018 of NH544 near Companypady metro station and some rural area

VI. SIGNIFICANCE AND IMPACT

The devastating floods and landslides caused extensive damage to houses, roads, railways, bridges, power supplies, communications networks, and other infrastructure; washed away crops and livestock and affected the lives and livelihoods of

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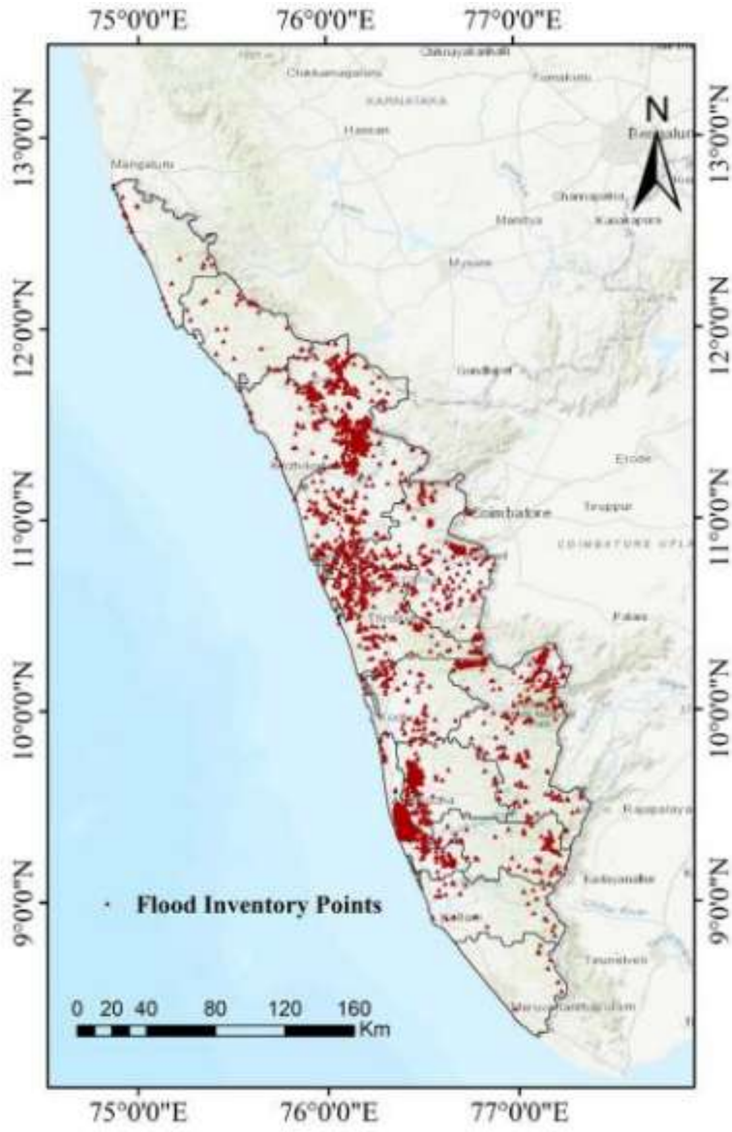
millions of people in the state. Early estimates by the government put recovery needs at about USD 3 billion; however, it was felt that a comprehensive assessment of damage, loss, and needs would amount to much more. The PDNA estimates the total damages to be around INR 10,557 crore and total losses to be around INR 16,163 crore amounting to a total disaster effects of around.The total estimated damage does not include damages to private buildings and properties including shops, showrooms, business units, private hospitals/educational institutions and private vehicles. It does not take into account losses incurred by private traders and business units and also damage, and loss suffered by Kochi airport, road transport and waterways[5].



Location of flood inventories in the study area

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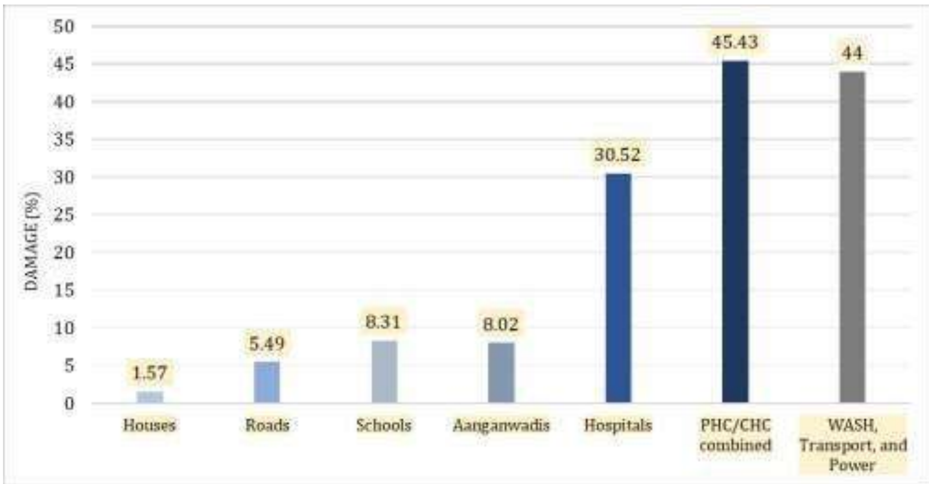
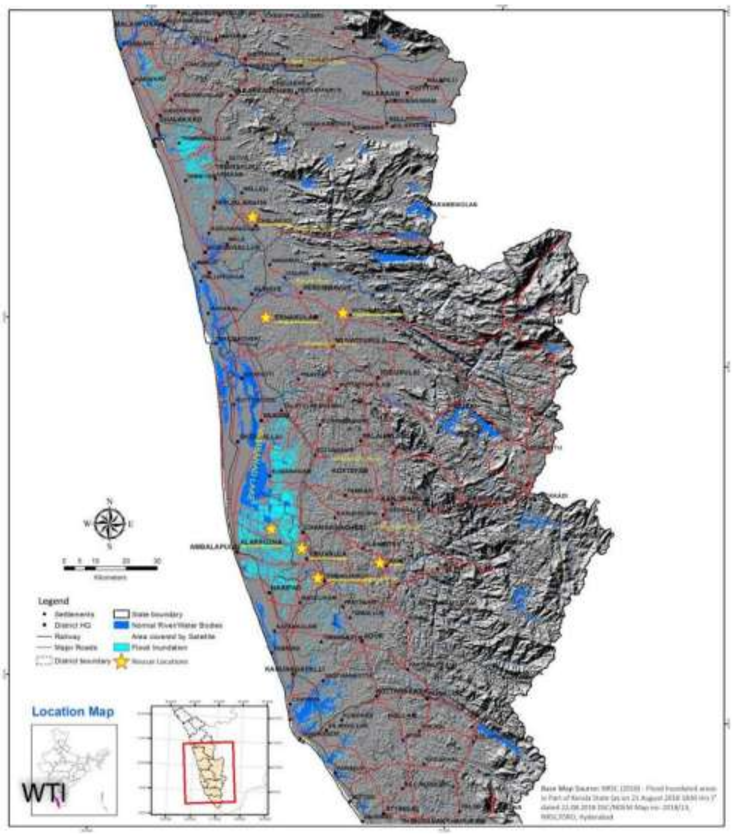


Impact of Kerala flood (2018) on Critical Infrastructural Systems



Flood inundated areas in part of kerala state

VII. LITERATURE REVIEW

1.Parameters used

The selection of flood-controlling factors depends on the physical and natural characteristics of the study area and data availability. In the studies examined, researchers used at most 21 parameters and at least 5 parameters for FSM , the first 20 parameters that are frequently used in 170 studies examined in this study are given [3].

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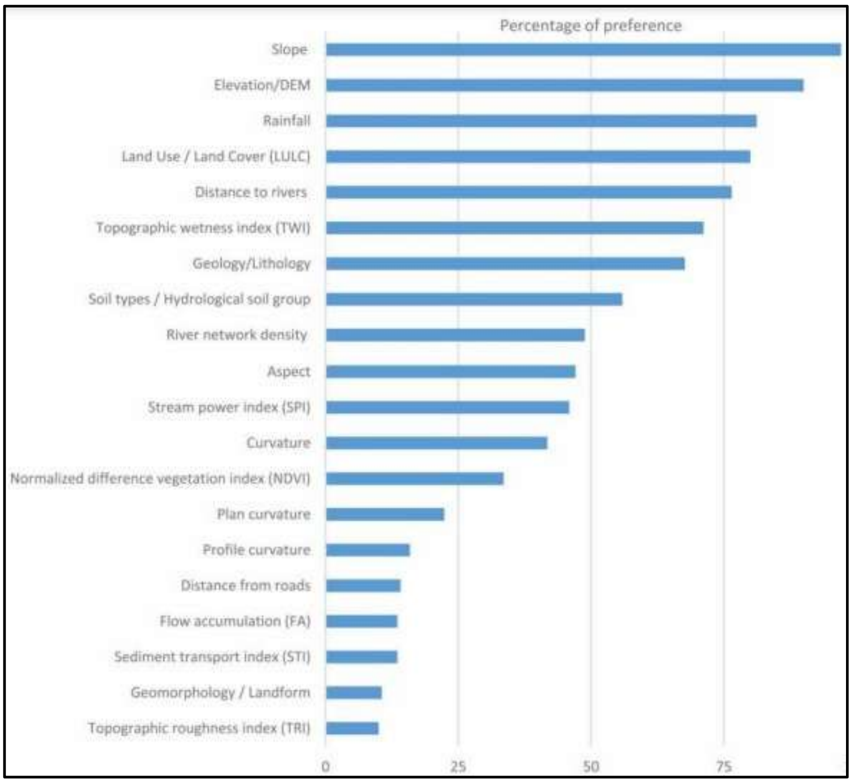
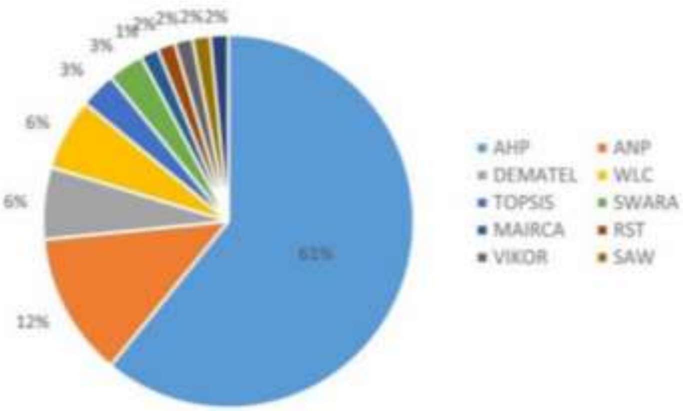


Parameters most used in the studies examined

2.Flood susceptibility model
a.Multi-criteria decision making

It is one of the methods that allow decision-makers to make the most appropriate decision according to the problem and factors.Out of 11 MCDM methods used in the examined studies,the AHP method was the most preferred, used in 61% of the studies .In the AHP method, which enables complex problems to be simplified by creating a hierarchical structure.The decision-maker's knowledge and experience are also included in the decision-making process[3].



MCDM methods used in flood susceptibility maps in the reviewed articles

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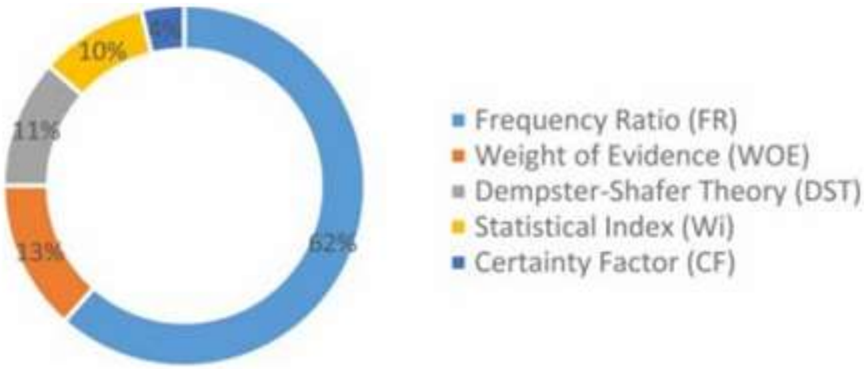
b.Statistical method

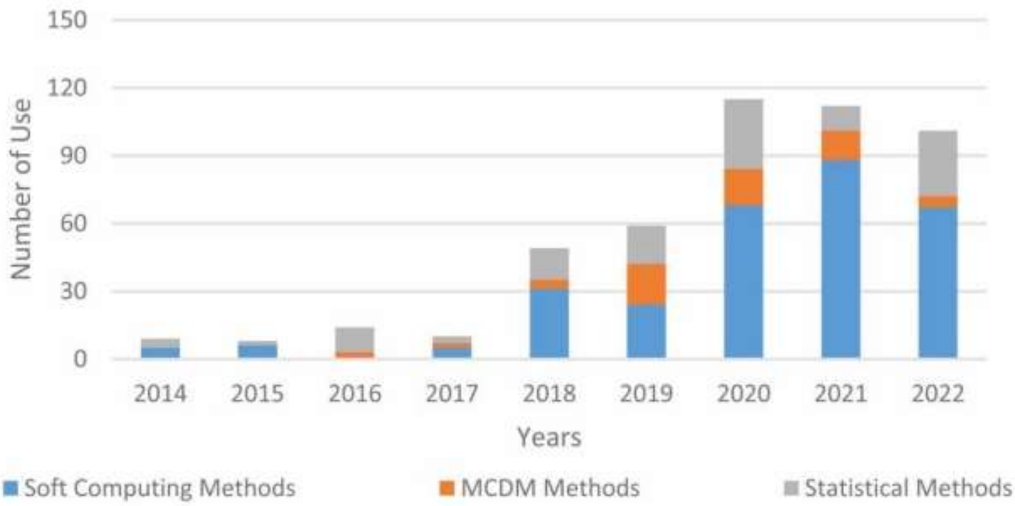
Statistical methods are indirect methods that are commonly used to evaluate the correlation between flood triggers and floods based on mathematical expressions[6].The frequency ratio (FR) method is one of the most widely used methods to measure the effect of each factor class on flood[7]. The FR method (62%), which is the most preferred statistical method among the statistical methods used in FSM.The FR method is an easy-to-apply method based on the correlation between the spatial distribution of floods and the factors that contribute to flood formation[8].



Statistical methods (BS) used in flood susceptibility maps in the reviewed articles

2.Soft computing method

Soft computing methods, which combine computation and intelligent methods, are increasingly used in landslide and flood susceptibility analyses. Suitable for a wide range of applications due to their adaptability to changing conditions and data patterns.Most commonly used model in kerala is boosting model.



The methods used in the 170 FSMs examined in this study, while Figure shows the frequency of their use over the years

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VIII. COMPARATIVE ANALYSIS OF FSM METHODS

FSM methods	Area of application	FCFs applied	No. of FCF applied	No. of FCF applied
MCDM	FSM	Slope, Elevation, TPI, TWI, NDVI,LULC Drainagedensity,Aspect ,Roughness ,Distance from road	10	(Kanani-Sadat et al. 2019)
Ml models	FSM	Slope, SPI, geology, TWI, curvature, DEM, rainfall, DFR, LU/LC, and soil type Elevation, SPI, slope, STI, lithology, slope aspect, TWI, curvature, NDVI, soil type, rainfall, , and land use	10-13	(Tehrany et al. 2014b) (Chen et al. 2019)
Statistical models	FSM	Lithology, DFR, soil texture, land use, slope angle, TWI, plan curvature, altitude, and NDVI,slope Aspect DFR, altitude, NDVI, slope, LU/LC, aspect, SPI, distance from fault, soil type, TWI, geology,distance from road, STI, rainfall, and curvature	10-15	(Rahmati et al. 2016a) (Shafapour Tehrany et al. 2017)

Shows comparative analysis of various FSM methods

IX. STRENGTH AND LIMITATIONS OF EACH METHOD

a.MCDM

Strengths	Limitations
• Ability to integrate spatial and nonspatial data within a decision-making process • Easy implementation within the GIS environment • Consistency in the expert's judgment that represents human reasoning • Allows all stakeholder to express their opinions, preferences,and alternatives • Less data input requirement • Simple computation process • Ability to assign varying significance of alternatives to scalarvalues (crisp, fuzzy, grey numbers) simultaneously • Easier characterization and structuring of the preferences • Suitable for regional studies	• With AHP, pairwise comparisons are based on very practical uncertaincriteria • Generally, subjective evaluation due to human reasoning which is sometimes found to bias • With AHP, large pairwise comparisons overwhelming participatingexperts leading to uncertainty in the judgment process and high consistency ratio • Loss of information due to the subjectivity of the method • Results can be influenced by dominant stakeholders and noise in theresponses • Reliance on a group of experts' or expert's opinion

b.Statistical model

Strengths	Limitations
• Improve predictive capability than other methods • Easy computation and implementationc. Applies a straightfoeward concept. • Bivariate methods can evaluate the relationship between adependent (flood) and independent (FCFs) • Multivariate methods do not necessarily require normallydistributed data and can easily implement continuous ordiscrete dataset • Ability to address uncertainty within the predicted flood and flooding region outputs. • Yields realistic estimates • Easy implementation within the GIS environment • Does not require a large capacity computing system to operateAbility to manage incomplete dataset • Reasonable operation cost.	• The inability of the multivariate method to analyze the relationshipbetween individual flood contributing factor and flood • Large numbers of FCFs will require a longer computation process andduration • Complex processing required to transform independent factor layers into evidential belief layers (with EBF) • Longer processing time for models such as EBF. • Statistical model such as FR is not capable of modeling complex flood terrains • Bivariate methods usually infer that flood is generated due to the combination same FCFs for an entire study area

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c.ML model

Strengths	Limitations
• High computing and automation level • Ease in the recognition of trends and structures within flood dataset • Ability to incorporate multi-variety and highly complex flooddatasetd. • High prediction efficiency • Ability to combine other models (ensemble) for better output • High computation speed • Accurate learning • Efficient mapping into feature spaces. • Good generalization capabilities • Ability to incorporate large datasets • Easy implementation within the GIS environment Suitable for regional and large-scale study areas	• Large and long-duration data required for training and validation • Difficult to optimize • Complex network architectured. • Requires highly trained manpower to perform accurate predictionse. • Prone to input data uncertainty. • Requires high-capacity computer system to operate. Reliance on remote sensing datasets for ungauged areas

X. CONCLUSION

In conclusion, the study embarked on a comprehensive exploration of various models and methods employed for flood susceptibility assessment, with a specific focus on the unique geographical and environmental conditions of Kerala. The current flood situation in Kerala served as a backdrop, emphasizing the urgency and relevance of understanding and mitigating flood risks in the region. Through an extensive literature review and empirical analysis, we evaluated the strengths and limitations of different models.

REFERENCES

[1]. Rentschler, J., Salhab, M., & Jafino, B. A. (2022). Flood exposure and poverty in 188 countries. Nature Communications, 13(1), 3527. https://doi.org/10.1038/s41467-022-30727-4
[2]. Walia, A. and Nusrat, N. (2020). Kerala Floods 2018. National Institute of Disaster
[3]. Management, New Delhi, Pages 106.
[4]. Çağla Melisa Kaya, & Leyla Derin Cengiz. (2023). Parameters and methods used in flood susceptibility mapping: areview. Journal of Water and Climate Change, 14(6), 1935–1960.https://doi.org/10.2166/wcc.2023.035
[5]. Srija, P., Nithin, G., Chaithanya, V., Swaraj, M., & Sridevi, M. (2021). A Case Study on Kerala Floods. 26| International Journal of Current Engineering and Technology, Special Issue, 9. https://inpressco.com/wp-content/uploads/2021/08/Paper626-31.pdf
[6]. Post-Disaster Needs Assessment - Kerala | United Nations Development Programme. (n.d.).In www.undp.org.https://www.undp.org/publications/post-disaster-needsassessment-kerala
[7]. Wubalem, A., Getahun, B., Hailemariam, Y., Mesele, A., Tesfaw, G., Dawit, Z., & Goshe, E. (2022). Landslide Susceptibility Modeling Using the Index of Entropy and Frequency Ratio Method from Nefas-Mewcha to Weldiya Road Corridor, Northwestern Ethiopia. Geotechnical and Geological Engineering, 40(10), 5249–5278. https://doi.org/10.1007/s10706-022-02214-6
[8]. Jebur, M. N., Pradhan, B. & Tehrany, M. S. 2014 Optimization of landslide conditioning factors using very high-resolution airborne laser scanning (LiDAR) data at catchment scale. Remote Sensing of Environment 152, 150165.https://doi.org/10.1016/j.rse.2014.05.013
[9]. Tehrany, M. S., Lee, M. J., Pradhan, B., Jebur, M. N. & Lee, S. 2014b Flood susceptibility mapping using integrated bivariate and multivariate statistical models. Environmental Earth Sciences 72 (10), 4001–4015. https://doi.org/10.1007/s12665-014-3289-3.