International Journal of Current Trends in Engineering and Technology
www.ijctet.org, ISSN: 2395-3152
Volume: 11, Issue: 02 (March-April, 2025)

A Survey of Artificial Intelligence-Driven Flood Risk Assessment and Forecasting with Remote Sensing Data

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Abstract:- Floods are among the most devastating natural disasters, causing significant damage to lives, property, and infrastructure. Traditional flood prediction methods, such as hydrological models and statistical approaches, often struggle with real-time data complexity and environmental variability. Recent advancements in artificial intelligence (AI) and machine learning (ML) have revolutionised flood risk assessment and forecasting by leveraging remote sensing data, IoT networks, and satellite imagery. This survey comprehensively reviews AI-driven flood prediction techniques, highlighting the efficacy of models like Random Forests, Support Vector Machines, and deep learning architectures such as Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). The study also explores ensemble methods, hybrid models, and metaheuristic optimisations to enhance prediction accuracy. Challenges such as data scarcity, computational constraints, and model interpretability are discussed, along with emerging solutions like quantum machine learning and semi-subjective analytic frameworks. The review underscores the transformative potential of AI in flood management, particularly in regions like India, where climate variability and rapid urbanisation exacerbate flood risks. By synthesising the latest research, this paper provides insights into future directions for improving flood forecasting systems and mitigating disaster impacts.

Keywords:- Flood Prediction, Machine Learning, Remote Sensing, Artificial Intelligence, Disaster Management, Real-Time Forecasting

INTRODUCTION

Floods are among the most catastrophic natural disasters, doing considerable harm to lives, property, and infrastructure. In nations such as India, where climate fluctuations and periodic monsoons lead to frequent flooding, precise and prompt forecasting is crucial for efficient disaster management as well as mitigation. Throughout the years, multiple approaches to flood forecasting have emerged, including both conventional statistical and hydrological models, as well as advanced computer techniques. Each of these methodologies has enhanced the understanding of flood behaviour, yet several inadequately address the escalating complexity of modern environmental data as well as the fluid dynamics of flood events [1].

Traditional flood prediction techniques, including rainfall-runoff models as well as physically based simulations, depend significantly on historical data as well as expert knowledge. Although these models provide a basis for flood risk evaluation, they often encounter significant uncertainty, restricted flexibility, and challenges in managing huge quantities of real-time data. These constraints have prompted researchers to seek more effective and flexible alternatives [2].

In recent years, the use of machine learning in flood-forecasting systems has accelerated considerably. Machine learning methodologies provide a data-centric framework that can discern intricate patterns from extensive and varied datasets without necessitating explicit coding. Algorithms such as “Decision Trees”, Random Forest, “Support Vector Machines” and Artificial Neural Networks have shown significant efficacy in hydrological modelling and flood prediction.

This chapter provides a comprehensive review of the current literature on flood prediction techniques, emphasising both conventional and machine learning methodologies. The objective is to discern the strengths and flaws of previous studies, solve current research gaps, and justify the use of machine learning in this field. The review establishes the research framework for this thesis and directs the choice of appropriate methods and tools for enhancing flood detection as well as forecasting [3].

LITERATURE SURVEY

In addition to harming lifelines and infrastructure, urban flooding puts pedestrians and cars in danger. To better understand how much flooding a place may suffer at a given moment, it is crucial to provide cities and local authorities with more quick flood detection capabilities and tools. As a consequence, flood control orders are promptly published, enabling locals and motorists to avoid flooded regions in advance. In order to create and train "machine-learning models" for flood detection in the City of San Diego, CA, USA, this study integrates information from remotely sensed satellite images with ground observed data obtained from police department road closure reports. In order to detect flooded pixels in images and assess the effectiveness of these machine learning models, flooding information is taken from Sentinel 1 satellite imagery and fed into a variety of unsupervised and supervised machine learning models, such as Random Forest (RF), Support Vector Machine (SVM), as well as Maximum Likelihood Classifier (MLC).

Additionally, a novel unsupervised machine-learning framework for urban flood detection is created using the Otsu algorithm, fuzzy rules, and iso-clustering techniques. It is based on the change detection (CD) methodology. According to the results of the performance assessment of the RF, SVM, MLC, and CD models, each model has precision measures of 0.53, 0.85, 0.75, and 0.81; recall values of 0.9, 0.85, 0.85, and 0.9; an F1-score of 0.67, 0.85, 0.79, and 0.85; and accuracy measures of 0.69, 0.87, 0.83, and 0.87. In summary, for improved quick flood mapping, the novel unsupervised flood picture classification and detection approach provides superior performance with the least amount of data and computing time. Other cities that are susceptible to urban flooding may find this methodical approach helpful in identifying nuisance floods via the use of satellite imagery and lowering the risk of flooding in urban infrastructure development and transportation design [4].

Table 1 Technological Innovations in Flood Prediction Systems

Ref	Technology	Description
[7]	Remote Sensing and Satellite Data	Real-time imagery for tracking rainfall, river overflow, and land changes.
[8]	Geographic Information Systems (GIS)	Integrates spatial and hydrological data to model flood-prone zones and evacuation routes.
[9]	IoT and Sensor Networks	It provides real-time water level and rainfall data, which is crucial for early warning systems.
[10]	Cloud Computing	Enables big data processing and remote collaboration on flood forecasting models.
[11]	UAVs and Drones	Offers rapid aerial imagery of flood zones for real-time assessment and damage evaluation.
[12]	Mobile-Based Early Warning Systems	Delivers alerts and evacuation instructions via SMS and mobile apps to targeted regions.

The frequent occurrence of emergency circumstances is a significant problem for humanity. The whole planet has gone through many natural and artificial mishaps throughout the years. According to a recent analysis, floods have impacted more people than any other kind of disaster in the twenty-first century. They accounted for 43% of all disaster occurrences, making Africa the second most susceptible region behind Asia. One of the main duties of the leadership in any nation, particularly in flood-prone regions, is to manage the danger of flooding with the goal of protecting the environment and ensuring the security and well-being of the populace. Applications of predictive analytics and machine learning may enhance risk management. Therefore, because flood risk cannot be eliminated, it is crucial to develop a scientific approach to its mitigation. The study suggests a machine learning-based approach for detecting and predicting pluvial floods. To evaluate how well the machine learning method performs on pluvial flood conditioning variables, the suggested model will use a classification based on fuzzy rules [5].

One of the most damaging natural calamities, floods, need to be managed carefully and promptly. Effective monitoring and evaluation of flood effects are made possible by remote sensing, which makes use of a variety of satellite imaging data. In this regard, machine learning and deep learning techniques, which are efficient and scalable, may greatly improve the precision of flood management and detection via the analysis of remote sensing data, thereby playing a vital role in reducing the hazards associated with flooding. Machine learning algorithms, such as Random Forest (RF) as well as "Histogram-based Gradient Boosting Decision Tree", were used in this study to detect floods using Sentinel-1 SAR data. Two metaheuristic algorithms, Harris Hawks Optimisation (HHO) and Ant Colony Optimisation (ACO), were also used for hyperparameter optimisation.

Additionally, a pre-trained VGG-16 Neural Network was used as the deep feature extractor to increase the models' overall performance and their capacity to identify flooded pixels. The performance of the four ensemble flood detection models—RF-HHO, RF-ACO, HGBDT-HHO, and HGBDT-ACO—was then assessed and contrasted using statistical measures. All four ensemble flood detection models performed quite well throughout the validation and testing stages, according to the data that were collected. During the validation and testing phases, these models' overall accuracy topped 95% and 97%, respectively. The best-performing model in this investigation, however, was the HGBDT-ACO model, which detected flood pixels with the greatest accuracy and the lowest error rate. In general, HGBDT models performed better than RF models since they needed a lot less time to train and produced equivalent outcomes. As a result, they were more effective and had superior computational complexity [6].

A natural disaster known as flooding occurs when a water body's capacity rises significantly over its natural bounds, causing an overflow and submerging the dry ground. The most frequent causes of floods are excessive precipitation and runoff, which submerge nearby land areas in water and cause significant damage to infrastructure, including buildings, bridges, and power supplies, as well as impairing transportation and causing economic hardship for the populace. Numerous steps have been taken over the years to anticipate flood alerts, including the use of sensor technology and active parameter monitoring. This resulted in the development of numerous data sets that can be used in the future. With the advent of data analytics techniques, which were ushered in by the revival of machine learning and the idea of intelligent machines, the datasets can be used directly to enable algorithms to learn from the gathered data and, using that information, generate a preset equation as a model to aid in forecasting future events. To develop a weak prediction model based on a Decision Tree, we suggest a Flood Detection mechanism that uses the Gradient Boost Algorithm to classify the data sets as well as perform regression on them to yield the best results from the datasets we will use to train it. The results may now be utilised to show the relevant authorities who can take preventative measures to address the issue. This method was created to be more appropriate for such purposes, offering very accurate predictions. It also makes use of a number of other technologies, such as remote sensing and sensor technology, to provide the precise datasets needed to train the model [13].

Flooding is defined as water overflowing onto typically dry ground or an increase in water that significantly affects human life. It is also considered one of the most common natural phenomena, causing serious financial crises for properties and goods in addition to having an impact on human lives. However, residents would benefit from avoiding such floods so that they have enough time to leave regions where flooding may occur before the actual floods occur. Many academics have put forward many answers to the problem of floods, including creating prediction models and constructing suitable infrastructure. However, from an economic standpoint, all suggested remedies are ineffective in Somalia. In order to detect water levels and measure floods with potential humanitarian consequences before they happen, the main goal of this research is to design a new robust model that is a real-time flood detection system based on machine-learning algorithms, namely Random-Forest, Naive-Bayes, and J48. The experimental outcomes of this suggested approach will address the fourth issue and investigate how a hybrid model based on Arduino and GSM modems may be used to mimic a unique technique of water level detection. According to the investigation, the Random Forest algorithm fared better than other machine learning techniques in terms of classification accuracy, with a 98.7% accuracy rate compared to 88.4% and 84.2% for J48 and Naive Bayes, respectively. By offering a fresh approach to flood prevention in the realm of artificial intelligence and data mining, the suggested technique advances the field of research [14].

The end outcome of climate change is floods, a complicated phenomenon that occurs worldwide. Even while certain gauging stations are used to forecast when floods will occur, their accuracy is not very high. Floods that happen unexpectedly are harming not just people's lives but also important infrastructure. Our project's goal is to use deep learning to create a dependable, real-time flood monitoring as well as detection system. Wireless sensor networking technology is suggested in this research as a dependable, low-power, wide-area communication method for flood detection. In addition, we use convolutional neural networks to find live things that were impacted by the flood [15].

One of nature's most devastating disasters, floods seriously and irreparably harm infrastructure, agriculture, human life, and the socioeconomic system. Numerous research has been carried out on flood forecasting systems and flood disaster management. It is difficult to make precise real-time predictions about when floods will start and develop. Combining data with computationally intensive flood propagation models is required to predict water levels as well as velocities across a wide region. By predicting floods using several machine learning models, this research attempts to lessen the significant dangers of this natural calamity while also making policy recommendations. To get an accurate prediction, this study will use Binary Logistic Regression, K-nearest neighbour (KNN), Support Vector Classifier (SVC), and Decision Tree Classifier. In order to determine whether the model provides more accuracy, a comparison study will be carried out using the results [16].

Floods are among the most devastating natural disasters, causing irreparable and significant damage to infrastructure, crops, human lives, and the socioeconomic system. Numerous research on flood forecasting systems and flood disaster management have been carried out. It is difficult to make precise predictions about the start and course of floods in real-time. Computationally intensive flood propagation models must be combined with data to predict water levels as well as velocities across a wide region. In addition to reducing the great dangers of this natural calamity, this study offers policy recommendations by predicting floods using several machine learning algorithms. To make an accurate prediction, this study will use a Decision Tree Classifier, Support Vector Classifier (SVC), K-nearest neighbour (KNN), and Binary Logistic Regression. The results will be compared in order to determine which model provides the highest level of accuracy [17].

Table 2 Challenges in Accurate Flood Prediction

Ref.	Challenge	Description
[5]	Data Scarcity in Remote Areas	Many regions lack sufficient historical or real-time hydrological data, making model training difficult.
[6]	Climate Variability	Unpredictable shifts in weather patterns reduce the reliability of traditional and data-driven models.
[1]	Model Overfitting and Bias	ML models may overfit training data, leading to poor generalisation and unreliable forecasts.
[3]	Integration of Diverse Datasets	Combining satellite, sensor, weather, and historical data requires high compatibility and preprocessing.
[5]	Lack of Real-Time Infrastructure	Limited access to IoT devices and real-time data pipelines hampers immediate response and forecasting.
[9]	Computational Constraints	Advanced ML models demand significant computational resources for training, deployment, and real-time use.

The most damaging and catastrophic event that can wipe out everything on land is flooding. The impacted regions will see more flooding as a result of these storms. Research is being done on flood prediction models to lower risk, think strategically, save lives, and lessen flood-related property damage. The forecasting process has been enhanced by AI approaches during the last two years, leading to increased execution and consistency in financial planning. These activities may, first and foremost, consider the sentiments of all participants. For flood warnings, flood mitigation, or flood prediction, artificial intelligence models are essential. Because machine learning systems need a lot of computing power for small amounts of data, they have been widely used. We think that representative vectors with the highest scores can be obtained by gathering a minimal quantity of data. The chosen tree's superior accuracy and highest score made it successful. Decision trees, logistic regression, and other machine-learning methods are employed in this flood prediction for comparison and assessment. Compared to other algorithms, logistic regression may provide findings that are more accurate while also being very efficient and improving. Floods may inflict lasting destruction and a tremendous deal of pain for people, making them perhaps the most devastating occurrence on the planet. Because of the abrupt failure of their hard labour, which makes their hearts sad, farmers are often the most distressed people in the world. It is crucial to develop an exposure model that incorporates safety in order to monitor water level and velocity across a wide region. These models may be used in a variety of ways to enhance the forecast. Furthermore, these models accurately forecast the occurrence of floods in a given year, but they don't go into great depth about the solutions that are required [18].

Floods, an unavoidable natural force, attack without mercy and mercy. Every country tries to take sufficient measures to protect itself against this disaster. Every year, floods destroy many nations, causing incalculable damages in a variety of areas, including the environment, human life, and finances. Unfortunately, no matter how hard one tries, these losses cannot be recovered. Flash floods are the most dangerous of the several kinds of flood because they have the devastating power of a flood combined with incredible speed. When heavy rainfall exceeds the soil's capacity to absorb water, flash floods like this happen. They also happen when water fills dry creeks or streams or when enough water builds up to break riverbanks, causing quick surges. Within minutes after triggering events, flash floods may occur, leaving little time for public warning as well as safety. Machine learning is one aspect of artificial intelligence that significantly advances predictive systems by providing improved performance and affordable solutions. To lessen the damage caused by flooding, predictions must be made quickly and accurately. The ability of machine learning algorithms to evaluate vast amounts of data and identify minute trends has made them popular for flood prediction in recent years. This study provides an overview of machine learning-based flood prediction technology, including the many algorithms used, the technology's advantages and disadvantages, upcoming problems, and possible improvements [19].

Flooding, a complicated phenomenon that happens all across the world, is the ultimate result of climate change. While certain gauging stations are employed to predict the probability of floods, their accuracy is low. Unexpected floods are destroying vital infrastructure in addition to taking lives. The objective of our study is to develop a system for precise and real-time flood detection and monitoring using deep learning. "Wireless sensor networking technology" is used in this study's reliable, low-power, wide-area communication approach for flood detection. We also search for any live organisms affected by the flood using a convolutional neural network [20].

Applications for machine learning (soft) techniques are many and span many fields, including hydrology. These techniques were first used in hydrology in the 1990s and have subsequently been widely used. Hydrologists use linear or non-linear Muskingum (NLM) techniques or numerical solutions of the St. Venant (SV) flow equations or their simplified versions to forecast flood hydrographs, which are crucial. However, soft computing techniques are also used. In order to forecast flood hydrographs, this research examines the use of artificial neural networks (ANN), genetic algorithms (GA), ant colony optimisation (ACO), and particle swarm optimisation (PSO). The ANN is trained using flow field data collected on an outfitted stretch of the Tiber River in central Italy. The GA, ACO, and PSO techniques are then used to determine the ideal values for the parameters of the rating curve method (RCM). The approaches accurately forecast real hydrographs, with an average inaccuracy in peak discharge as well as time to peak of 4% & 1%, respectively.

Additionally, the same techniques are used to optimise the Non-linear Muskingum Model (NMM) parameters for flood routing in an artificial channel. The flood hydrographs produced by the NMM and those derived from the St. Venant equations' numerical solutions are contrasted. The findings show that the "machine learning models "(ANN, GA, ACO, & PSO) are effective instruments that may be used to forecast flood hydrographs. They have no serious issues with parameter estimates, consume less data, and are easily measured [21].

Natural disaster preparation has advanced significantly with the University of Technology Malaysia's "Early Flash Flood Detection System Using Machine Learning Algorithms" study. The main goal is to enhance public safety by reducing the impact of flash floods by giving precise and timely flood warnings. To accurately predict flash floods, the system employs strong machine-learning algorithms and regularly evaluates important environmental factors. The agile approach was used to build the project, which included rapid iterations, stakeholder interaction, and the creation of the "minimum viable product" (MVP). Key technologies that increase user engagement and development productivity include Visual Studio Code, Flutter, Dart, TensorFlow, and Firebase. "The Software Requirement Specification (SRS), Software Design Document (SDD), as well as Software Test Document (STD)" regulated the planning, design, implementation, testing, and review stages of the system's design process. This project highlights the importance of interdisciplinary cooperation and the transformative potential of incorporating state-of-the-art technology into disaster management. Communities will become safer and more robust as a result of the successful use of this technology, which will also show innovation in disaster management and environmental monitoring. The appendices of the study provide thorough methods, design choices, and testing processes [22].

One of the most devastating natural disasters that may impact people, communities, and lives is flooding. Flood prediction is always a difficult undertaking because of the complexity of the data available. The traditional approach to disaster management depends on radar results and satellite imagery. Processing takes a very long time. An alternative viewpoint on this hydrological issue was made possible via machine learning. Modern implementation and prediction are the result of recent advancements in ICT (information and communication technology) and machine learning (ML). Finding the best machine learning model to detect floods is the main goal of this study, which compares the classifiers of logistic regression, decision trees, and naive Bayes, as well as encourages vector machines. Metrics like accuracy, precision, recall, F1-score, and RMSE are used to assess machine learning techniques. Datasets with one, three, and four features are used to test all of the techniques. The quantitative analysis shows that the decision tree method expands exponentially with the number of features analysed and is best suited for flood prediction [23].

With a focus on daily flood events along Germany's Wupper River in 2023, this study explores the potential of quantum machine learning to enhance flood forecasting. Our method combines "classical machine learning techniques" with QML techniques; this hybrid model makes use of quantum properties like superposition and entanglement to improve accuracy and efficiency. This research represents a step towards using quantum technologies for climate change adaptation. We emphasise collaboration as well as continuous innovation to implement this model within real-world flood management, ultimately enhancing global resilience against floods. The results of a comparison between classical and QML models based on training time accuracy and scalability show that QML models provide competitive training times as well as improved prediction accuracy [24].

Among the most destructive natural disasters, floods and landslides do extensive harm to people, property, and vital infrastructure all over the globe. In order to lessen the effects of catastrophic calamities, accurate and timely forecast is essential. However, since environmental elements are complex and variable, typical prediction approaches often fail. New approaches to successfully addressing these issues have been made possible by emerging developments in machine learning (ML), which use sophisticated algorithms to handle environmental complexity. With an emphasis on methodology, datasets, strengths, and limits, this study offers a thorough analysis of cutting-edge machine learning algorithms for flood and landslip prediction. Techniques: The two primary parts of the technique are the extensive review and article selection. A comprehensive search spanning papers from 2011 to 2023 was carried out in databases including IEEE Xplore, Scopus, and Google Scholar. A selection of publications was examined according to their significant contributions, performance measures, datasets used, and machine learning methodologies. Findings: Machine learning algorithms have shown to be very accurate in predicting landslides and floods. Methods like ensemble approaches and "convolutional neural networks" (CNNs) have been used extensively. Hybrid models and transfer learning improve model robustness while cutting down on training time. However, there are still issues like computing demands, a lack of real-time data, and data scarcity [25].

One of the most damaging natural disasters, floods are very difficult to model. Research on improving flood prediction models has been helping to reduce risk, recommend policies, minimise the number of fatalities from floods, and lessen the damage to property. Over the last 20 years, machine learning (ML) techniques have greatly advanced prediction systems that provide improved performance and more affordable solutions by simulating the intricate mathematical expressions of the physical processes of floods. ML's popularity among hydrologists has skyrocketed due to its many advantages and possibilities. In order to find more precise and effective prediction models, researchers have been adding new machine-learning techniques and hybridising old ones. The primary contribution is showcasing the most advanced machine learning models for flood prediction and providing information on the best models. In order to provide a comprehensive overview of the many ML algorithms used in the area, special attention has been paid to the literature where ML models are benchmarked via a qualitative study of robustness, accuracy, efficacy, and speed. Within the context of a thorough assessment and debate, the performance comparison of ML models provides a thorough grasp of the various approaches. Consequently, the study presents the most promising forecasting techniques for both short-term and long-term floods.

Additionally, the main developments in raising the calibre of flood prediction models are examined. The most successful tactics for enhancing ML techniques are said to include hybridisation, data decomposition, algorithm ensemble, and model optimisation. Both climate scientists and hydrologists may use this survey as a reference to help them choose the best machine-learning technique based on the results of the prediction task [26].

The most well-known and deadly calamities of our century are floods. The lack of an effective flood forecasting system has resulted in significant losses to infrastructure and human life. This has reaffirmed how crucial it is to have a flood prediction system in place. The goal of this study is to create the best flood-determining model possible. Residents and the government will get all the essential help and support they need thanks to AI calculations and a robust, effective, and accurate flood expectation framework. As a result, the Decision Tree Model is being developed. This approach uses a range of accuracy to actualise different computations on datasets. The program uses artificial intelligence (AI) to forecast floods and uses an Android application to notify local and governmental agencies. Gradient Boost, Random Forest, and Decision Tree are the three machine learning algorithms that are being compared. By handling more complex data and a sophisticated algorithm, this model aims to increase the prediction rate [27].

Given the ongoing urbanisation and climate change, urban flood-risk mapping is a crucial tool for flooding prevention. Unfortunately, many poor nations do not have access to enough precise data to create accurate risk maps using current techniques. Better techniques are also required to assist managers and decision-makers in integrating current data with more supple semi-subjective data, such as citizen observations of vulnerable and flood-prone regions in light of existing settlements. As a result, we provide a novel method for structuring the issue framework that incorporates both subjective and objective evaluations: the "semi-subjective Analytic Hierarchy Process "(AHP). Using this method, decision-makers judgments are assessed for consistency, pairwise comparisons are conducted to select a solution, and both criteria and sub-criteria are considered to evaluate potential options. Classification and regression tree models are then used to produce an urban flood-risk map based on the vulnerabilities and hazards of various metropolitan regions. The map may be used as a starting point for developing flood-risk mitigation strategies as well as for assigning warning & forecasting systems. The results demonstrate the effectiveness of machine-learning techniques in urban flood zoning. The Iranian city of Rasht is used to demonstrate that the most important factors influencing flood dangers are proximity to rivers, "urban drainage" density, and its proximity to susceptible regions. In a similar vein, the most significant variables influencing urban flood susceptibility include population density, land use, housing quality, family income, distance to cultural heritage, as well as distance to hospitals and medical facilities. The current study's integrated approach for both objective & semi-subjective data yields reliable findings that may be attained without the need for expensive field surveys and intricate modelling. The suggested approach is particularly useful in places where managers and decision-makers lack sufficient data to characterise and illustrate flood dangers [28].

CONCLUSION

The literature review offers an in-depth review of the current research on flood prediction, including both traditional and modern techniques. Traditional flood forecasting techniques, including empirical statistical models as well as "physically based hydrological simulations", have been used for an extended period to comprehend flood behaviour. Rainfall-runoff models, as well as hydraulic models, have been the basis for several early forecasting methods. Nonetheless, these models often encounter difficulties with complex, "non-linear environmental relationships", as well as their efficacy is significantly dependent on the accessibility and precision of historical data. They also exhibit flexibility in adapting to changing climatic & geographical conditions.

The study emphasises the development of machine learning as a revolutionary tool in "flood prediction systems". Diverse machine learning models, such as Decision Trees, Random Forests (RF), Support Vector Machines, as well as Artificial Neural Networks, have shown significant potential in enhancing the accuracy and flexibility of flood event predictions. These models can elucidate intricate relationships among several variables and are very proficient in managing extensive and varied datasets. Recent advancements in deep learning, including Convolutional Neural Networks (CNNs) as well as Recurrent Neural Networks (RNNs), provide enhanced capabilities for real-time flood detection as well as forecasting. Ensemble approaches that integrate many models have been investigated to improve robustness and prediction efficiency.

In the Indian context, the literature highlights specific problems, including significant rainfall unpredictability, fast urbanisation, insufficient drainage infrastructure, and the essential need for precise flood warnings. Machine learning models have been progressively used in Indian case studies, demonstrating their capacity to provide timely and localised forecasts, crucial for disaster management and planning.

Notwithstanding significant developments, modern research continues to encounter challenges concerning data quality, model interpretability, and real-time implementation. Rectifying these deficiencies is essential for creating more dependable and effective flood forecasting systems that can save lives and reduce economic damage.

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