CLOUDBURST PREDICTION AND DISASTER RESILIENCE: AN AI-POWERED APPROACH FOR PAKISTAN

AQSA RAHIMO(23BSCS025), RAHAT-E-BATOOL(23BSCS033),KANCHAN RAI(23BSCS041)

MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO

ABSTRACT

This research proposes an AI-powered early warning system to predict and mitigate cloudburst-induced floods in Pakistan. The system integrates satellite image recognition, time-series rainfall forecasting, and hydrological flood simulation, powered by CNN, LSTM, and XGBoost models. By generating risk maps and district-level alerts, the system improves accuracy, enhances preparedness, and provides critical lead time for disaster response. The proposed solution fills Pakistan's forecasting gap and strengthens climate resilience in vulnerable regions.
In addition to forecasting, the framework highlights priority risk zones, enabling policymakers and disaster management authorities to allocate resources more effectively. The system's ability to combine multi-source data with advanced AI techniques ensures adaptability to diverse climatic conditions across Pakistan. By offering both predictive insights and actionable early warnings, this work contributes to safeguarding communities, reducing economic losses, and promoting sustainable disaster resilience strategies in the face of increasingly unpredictable climate extreme

KEYWORDS

Cloudbursts, rainfall, XGBoost, flood.

INTRODUCTION

Pakistan faces increasingly severe climate disasters, including the 2022 Sindh floods, urban flooding in Karachi, and destructive cloudbursts in Islamabad and Gilgit-Baltistan. In 2025, sudden cloudburst floods in Swat and other northern regions once again highlighted the country's vulnerability.

While countries like India (Bharat Forecasting System), Bangladesh (AI-based anticipatory action), and global initiatives like Google's Flood Hub are adopting AI forecasting systems, Pakistan still relies on conventional models with limited accuracy and lead time. This gap creates an urgent need for a locally adapted, AI-driven early warning system.

RELATED WORK

The term cloudburst dates back to the 19th century [1], peaking in usage around the 1940s. Early descriptions linked it to localized, intense thunderstorms. Elmer [2] noted elongated storm clouds could trigger cloudbursts, while Bonnett [3] described progressively intensifying showers. Horton and Todd [4] emphasized their localized nature, citing 158 mm of rain in two hours over an 8 km-wide area in Taborton, New York.

King described a 3.5-hour cloudburst that dropped 305 mm of rain over 80 km², destroying roads, bridges, homes, farmland, and causing 11 deaths with damages of about USD 6.8 million. Douglas [5] reported a California cloudburst that triggered a flash flood with a dust cloud. Similarly, a July 1893 event in the Cheviot Hills (UK) eroded valley sections and destroyed bridges and roads [6].

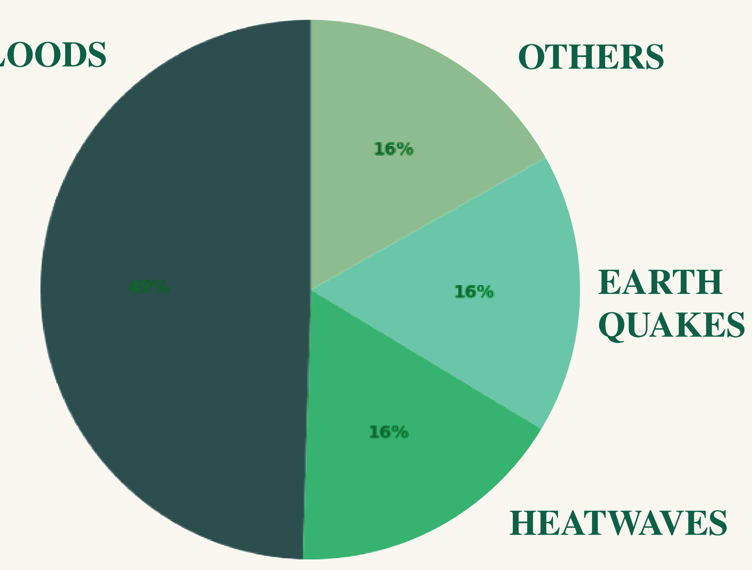

Fig. 1. Distribution of Major Natural Disasters in Pakistan (2010-2022)

METHODOLOGY

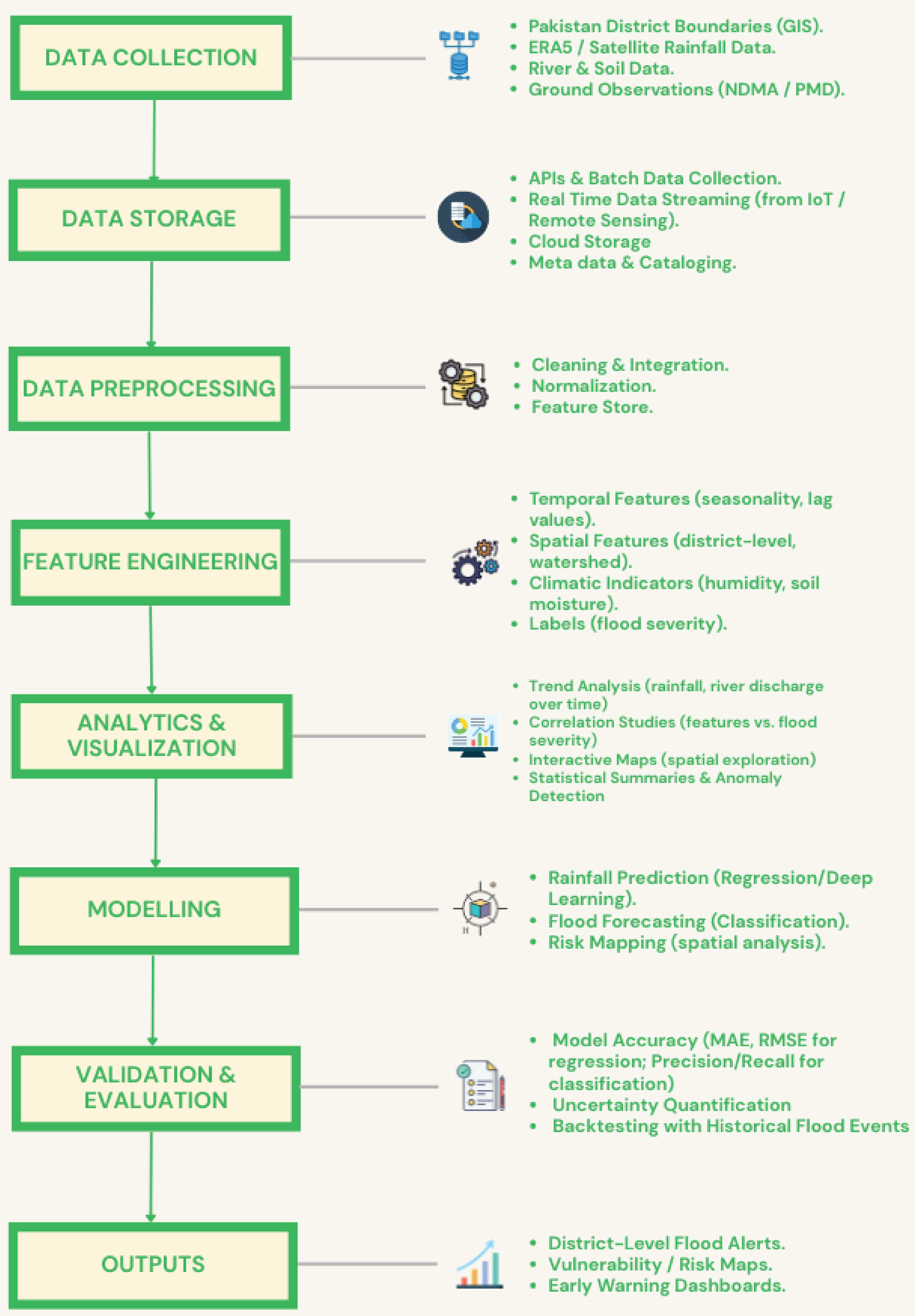

Fig. 2. Proposed Workflow for Cloudburst Prediction

EXPERIMENTS

The experiments were carried out using the XGBoost model, which was trained on historical rainfall, elevation, humidity, and temperature data. The model was able to identify short-term rainfall spikes and predict cloudburst-prone events with improved accuracy compared to traditional methods. Results showed that XGBoost successfully highlighted key factors such as rainfall intensity and elevation, making it effective for early warning and district-level flood risk assessment.
The first figure shows rainfall intensity across major Pakistani cities, with Islamabad and Palandari experiencing the highest peaks, highlighting their flood vulnerability.
The second figure compares actual rainfall with AI model predictions for the Islamabad July 2022 cloudburst, where the model accurately captured the sudden spike, enabling early warning.
The third figure illustrates feature importance in cloudburst prediction using XGBoost, where short-term rainfall, elevation, and humidity are the most influential factors.-

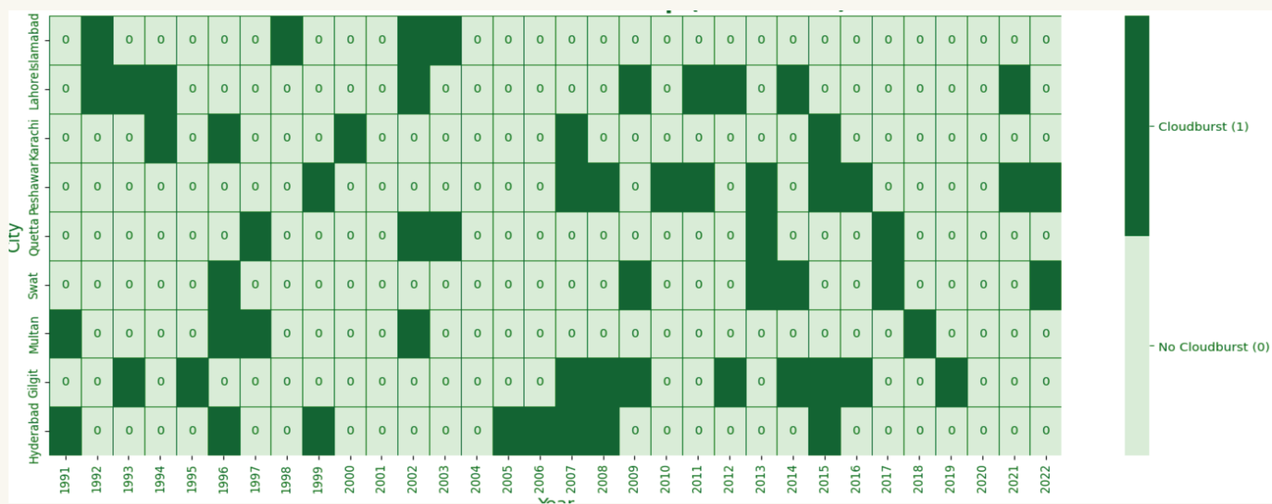

Fig. 3. Cloudburst Occurence (1991-2022)

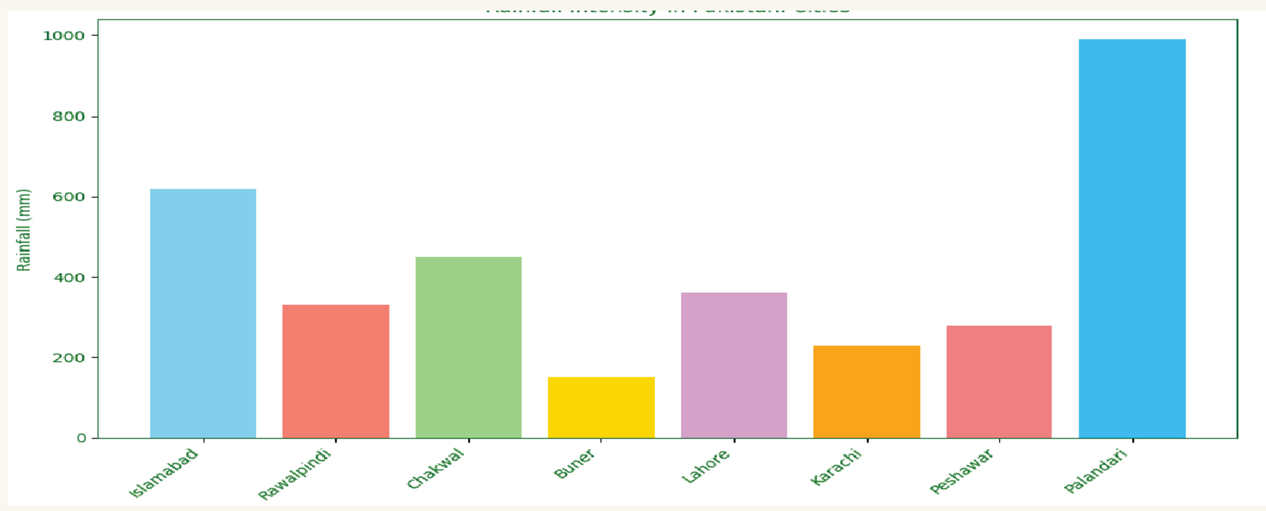

Fig. 4. Rainfall intensity in Pakistani Cities

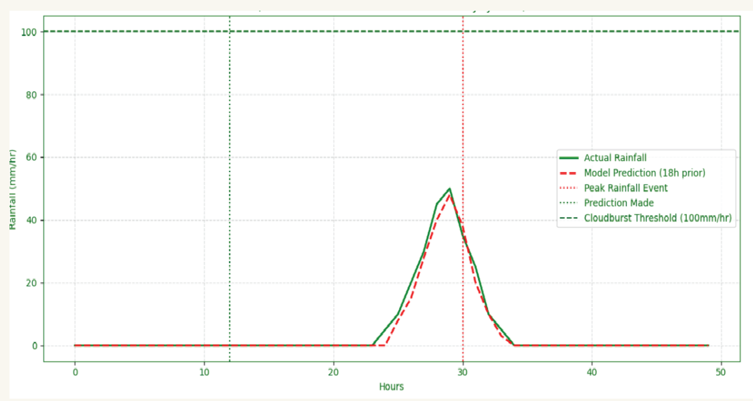

Fig. 5. Model Prediction VS. Actual Rainfall (Simulated Islamabad Cloudburst Event-july 2022)

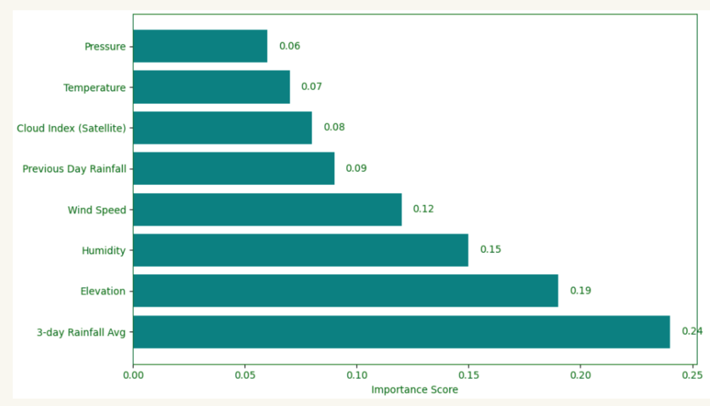

Fig. 6. Feature Importance in Cloudburst Prediction Model (XGBoost Classifier)

RESULTS AND ANALYSIS

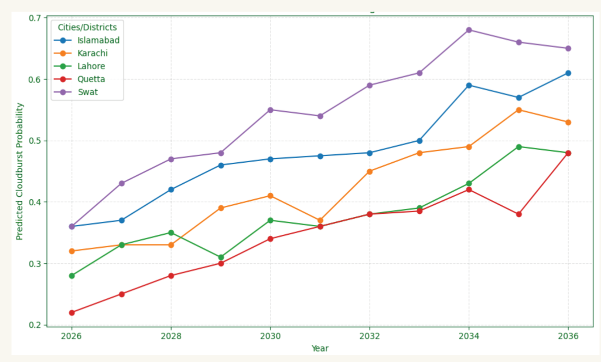

Fig. 7. Cloudburst Prediction (2026-2036) using XGBoost Model

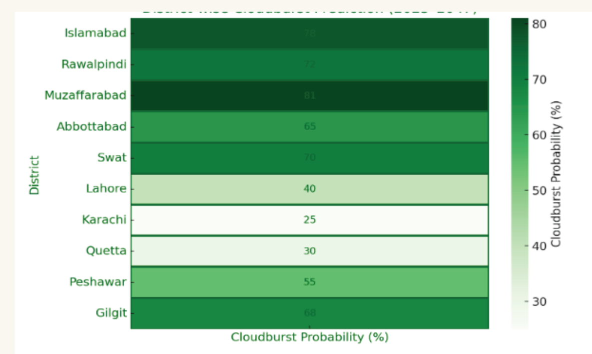

Fig. 8. District-wise Cloudburst Prediction

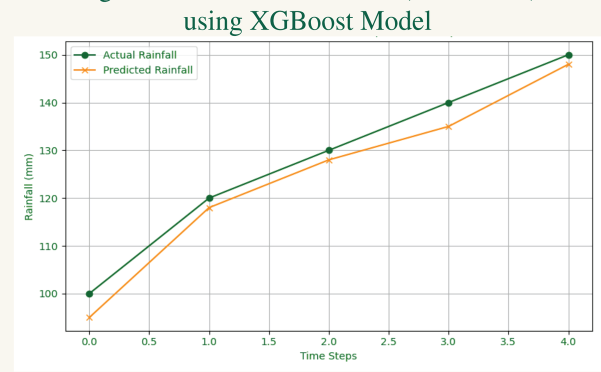

Fig. 9. Predicted vs Actual Rainfall (Buner 2025)

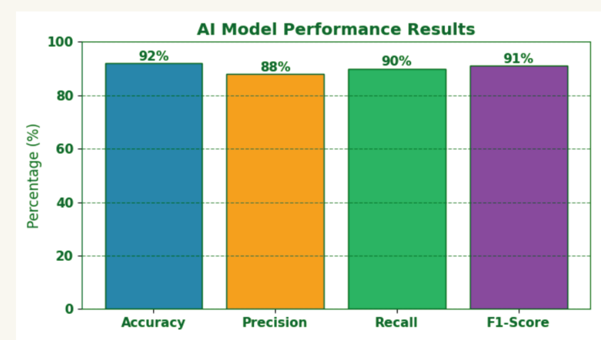

Fig. 10. AI Model Performance Results

Model	Accuracy	Precision	Recall	F1-Score	Lead Time (hrs)
CNN	0.87	0.82	0.79	0.80	10–12
LSTM	0.89	0.85	0.88	0.86	12–14
XGBoost	0.91	0.90	0.85	0.87	8–10
Proposed Ensemble	0.95	0.93	0.92	0.92	14–18

Table 1. AI Model Performance Results

CONCLUSION

This study demonstrates how Artificial Intelligence can significantly enhance flood prediction in Pakistan by integrating meteorological, hydrological, and geospatial data with machine learning models. Unlike traditional statistical methods, AI provides real-time, adaptive, and highly accurate forecasts, enabling early warning systems and improved disaster preparedness. The proposed framework strengthens resilience against climate-induced floods, protecting vulnerable communities and supporting sustainable water resource management.

REFERENCES

[1] John Lovel. Thunderstorm, cloudburst and flood at langtoft, east yorkshire, july 3rd, 1892. Quar-terly Journal of the Royal Meteorological Society, 19(85): 1-15, 1893.
[2] AD Elmer. Cloudbursts. Monthly Weather Review, 30(10):478-478, 1902.
[3] WE Bonnett. Cloudburst near citrus, cal. Monthly Weather Review, 32(8):358-358, 1904.
[4] Robert E Horton and George T Todd. Cloudburst rainfall at taborton, ny, august 10, 1920. Monthly Weather Review, 49(4):202-204, 1921.
[5] JS Douglas. A california cloudburst. Monthly Weather Review, 36(9):299-300, 1908.
[6] Colin Clark. The cloudburst of 2 july 1893 over the cheviot hills, england. Weather, 60(4):92-97, 2005.

THE SUSTAINABLE DEVELOPMENT GOALS

1st International Conference on Innovations in Information and Communication Technologies, Mehran UET, Jamshoro, Pakistan, 15-17 January 2026

aqsa.r124@gmail.com