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VADAPALANI

DNS
DEVELOPER NETWORK SPACE

HACKELITE 2026

HAWKINS

TEAM NAME:**VEC Titans**

PROBLEM STATEMENT:**Self -learning Glacial lake Stress- Testing &Intervention System**

PROBLEM STATEMENT

Glacial Lake Outburst Floods (GLOFs)

- Rising global temperatures are accelerating glacier and snow melt
- Meltwater accumulates in glacial lakes, rapidly increasing water volume
- These lakes are held back by unstable natural dams made of ice and loose debris
- Even small triggers such as heavy rainfall, seismic vibrations, or ice avalanches can cause sudden dam failure
- Glacial Lake Outburst Floods occur without warning, releasing massive volumes of water downstream
- Existing monitoring systems are passive, reactive, and threshold-based
- They fail to predict how, where, and when a dam will fail
- As a result, evacuation and mitigation efforts often begin too late

The absence of predictive, failure-aware monitoring systems makes GLOFs one of the deadliest and least controllable climate-driven disasters.

PROPOSED SOLUTION

The system integrates:

- IoT sensors for continuous ground-level monitoring Autonomous drones for high-resolution aerial inspection
- A Living Digital Twin that mirrors real-time lake and dam conditions Instead of waiting for danger thresholds
- The system: Actively stress-tests the digital twin Predicts probable failure modes, breach locations, and time-to-failure Using impact modeling, the system
- Identifies high-risk downstream zones Sends targeted SMS alerts to authorities and affected communities
- The framework also provides early intervention recommendations where feasible

A system that learns how a glacial lake will fail — before it actually does.

KEY FEATURES

- Real-Time Lake Monitoring

Continuous monitoring using sensors to track water level, pressure, and glacier movement.

- Living Digital Twin Simulation

Virtual model that predicts future lake behavior using live data.

- Failure-First Prediction Engine

Simulates possible dam collapse scenarios before disaster occurs.

- Autonomous Drone Surveillance

Detects cracks, erosion, and ice thinning in inaccessible regions.

- Targeted Early Warning System

Sends alerts only to communities at risk, enabling timely evacuation.

ARCHITECHTURE

GLOF Monitoring & Response Workflow

Phase 1: Detection (The Edge)

1. Continuous Sensing: Ultrasonic and pressure sensors detect a rapid rise in water level or a seismic "thump" from ice calving.
2. Edge Validation: The local Gateway checks the data. If the "Risk Threshold" (e.g., water rising > 5cm/min) is breached, it moves to Phase 2.
3. Data Uplink: The telemetry is sent via Satellite (Starlink/Iridium) to the Cloud Command Center.

Phase 2: Verification (The Drone)

1. Autonomous Launch: The Cloud sends a command back to the Drone Hangar at the lake site.
2. Visual Confirmation: The drone flies a pre-programmed path over the moraine dam.
3. AI Edge Analysis: Onboard AI processes the video feed in real-time to identify "Seepage" or "New Cracks." It sends high-res images back to the Digital Twin.

Phase 3: Simulation (The Digital Twin)

- Data Fusion: The Living Digital Twin combines the live sensor data, the 3D drone maps, and current weather forecasts.
- Failure-First Execution: The engine runs a Hydrodynamic Breach Simulation.
- Calculation: It determines the volume of water (V) and predicts the discharge rate (Q) if the dam fails.
- Inundation Mapping: The system generates a "Flood Polygon"—a map showing exactly which downstream areas will be underwater and at what time (T).
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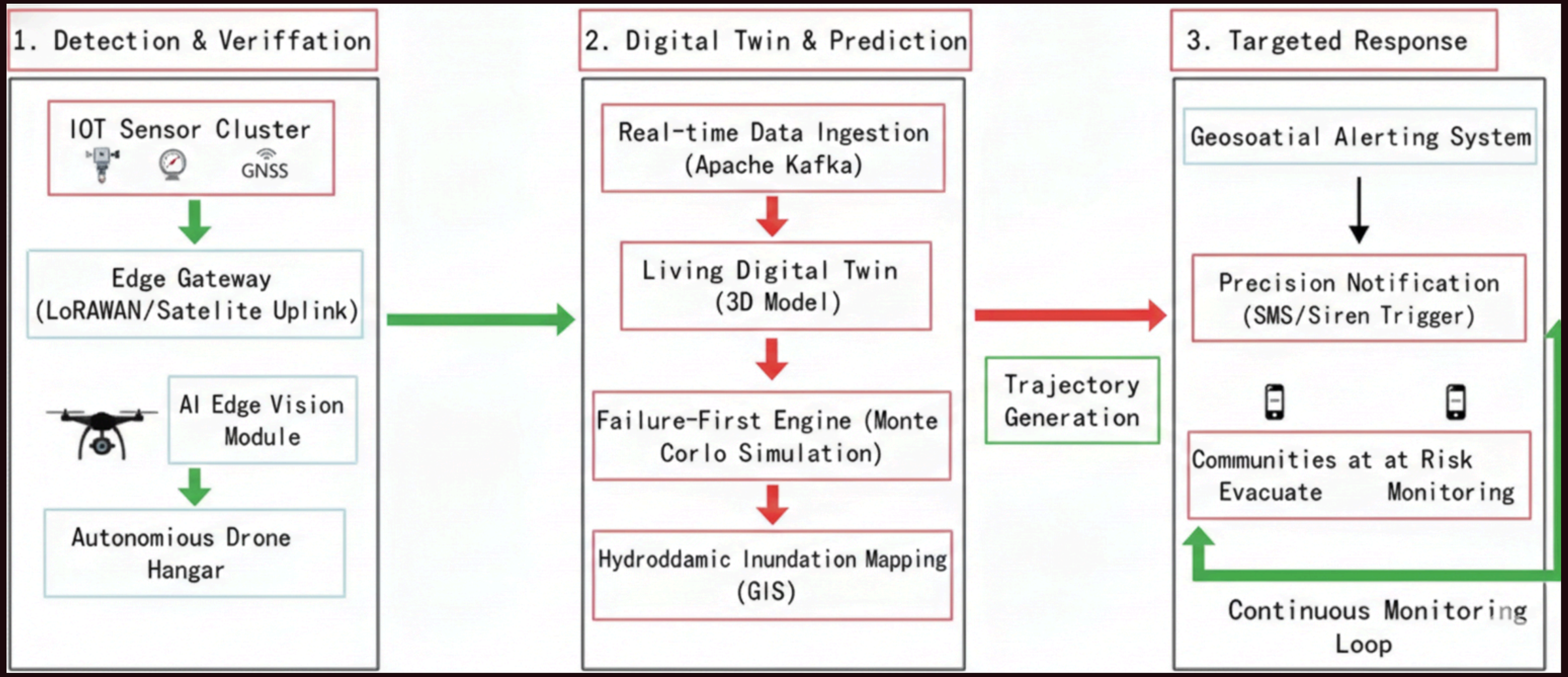
Phase 4: Targeted Response (The Warning)

- Geofencing: The system overlays the flood polygon onto a map of local villages.
- Precision Alerting: * Communities at Risk: Receive a "Flash Flood Warning" via SMS and local sirens.
- Safe Communities: Receive a "Monitoring Situation" update or no alert to prevent panic/fatigue.
- Continuous Loop: The system stays in "High Alert" mode, updating the evacuation window every 60 seconds until the threat subsides.


1. Detection & Veriffation
IOT Sensor Cluster
GNSS
Edge Gateway
(LoRAWAN/Satelite Uplink)
AI Edge Vision
Module
Autonomious Drone
Hangar
2. Digital Twin & Prediction
Real-time Data Ingestion
(Apache Kafka)
Living Digital Twin
(3D Model)
Failure-First Engine (Monte
Corlo Simulation)
Hydroddamic Inundation Mapping
(GIS)
Trajectory
Generation
3. Targeted Response
Geosoatial Alerting System
Precision Notification
(SMS/Siren Trigger)
Communities at at Risk
Evacuate
Monitoring
Continuous Monitoring
Loop

IMPACTS AND BENIFITS

Current Impact of GLOF Disasters

- **Over 15 million people worldwide live in areas exposed to potential glacial lake outburst floods.**
- **Hundreds to thousands of lives have been lost in past events due to sudden flooding.**
- **Infrastructure damage often exceeds billions of dollars per disaster.**
- **Entire villages, roads, and hydropower stations are destroyed within hours.**
- **Communities often get less than 1 hour warning.**

Benefits of Our Proposed System

- Can provide early warning hours or days in advance
- Helps evacuate thousands of people safely
- Reduces loss of life significantly
- Protects villages, roads, and power infrastructure
- Prevents economic losses worth billions
- Enables authorities to act before disaster strikes
- Supports long-term climate disaster preparedness

FUTURE SCOPE

1. Expansion to Global Glacier Regions

System can be deployed across Himalayas, Andes, Alps, and Arctic regions where glacial lakes are rapidly expanding.

2. Advanced AI Prediction Models

Future versions can use machine learning to improve prediction accuracy using historical disaster data.

3. Satellite Data Integration

Direct integration with real-time satellite monitoring for large-scale glacier observation.

4. Public Mobile Warning Applications

Mobile apps can provide live risk maps, evacuation routes, and alerts to citizens.

5. Automated Disaster Response Systems

Future systems could automatically trigger evacuation protocols and emergency services.

6. Multi-Disaster Monitoring Expansion

System can also monitor:

- Flash floods
- Dam failures
- Avalanche risks

7. Climate Change Research Support

Collected data can help scientists study glacier melting and climate impacts.

MONETISATION

Government Deployment Contracts

Governments pay for installation and maintenance of monitoring systems in high-risk glacier regions.

Revenue comes from:

- System setup fees
- Annual monitoring contracts
- Maintenance services

Disaster Monitoring as a Service (DMaaS)

Provide subscription-based monitoring to authorities.

Clients pay yearly fees for:

- Risk monitoring
- Early warning alerts
- Dashboard accessInfrastructure Protection Services
- Hydropower plants and infrastructure companies pay for monitoring services to protect assets.

International Climate & Disaster Funding

- Funding from:
- UN climate programs

TEAM DESCRIPTION

Team Name: Vec Titans

Team Members

•Team Lead-Amruta J

• Member 2 –Aishwarya R-IoT & Sensors

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