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## Statewide Flood Risk Monitoring and Early Alert Framework for Tamil Nadu Using Reservoir Scans, Multi-Year Satellite Archives, and Dual-Path Messaging

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### Abstract

Flood hazard management across Tamil Nadu demands broader spatial coverage, faster evidence fusion, plus dependable public messaging. This paper presents a statewide flood risk monitoring and early alert framework that scans reservoir status across Tamil Nadu, evaluates weather signals for any district, reviews multi-year satellite image archives from 2023-2026, and delivers decision support through multimodal agent reasoning. The implementation follows a Python pipeline that couples Twilio messaging, SerpApi web retrieval, Gemini agents, LangChain orchestration, and PIL-based image handling with dashboard-level analytics. A district request triggers weather acquisition, statewide reservoir scraping, district-level reservoir filtering, multi-year image retrieval, risk summarization, and message generation. High-risk cases trigger alert SMS delivery; low-risk cases trigger routine forecast messages that carry general weather status rather than alarm language. Figure-guided

discussion highlights the transition from a narrow, partially manual flow toward a broader reservoir-linked architecture with archive-backed visual review. The resulting framework offers scalable monitoring, timely communication, and stronger operational value for local administrators, emergency teams, and residents across flood-prone districts of Tamil Nadu.

**Keywords** *Tamil Nadu; flood risk monitoring; reservoir scanning; satellite archive analytics; multimodal agents; Twilio alerts*

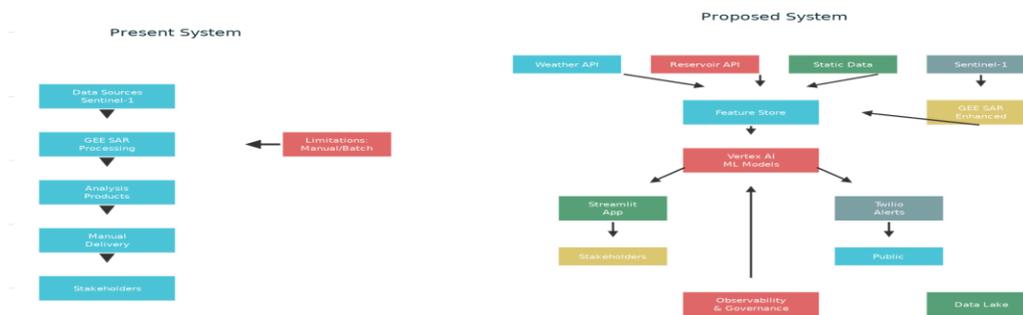
### 1 Introduction

Flood damage across coastal and river-linked districts of Tamil Nadu often follows a compound pattern shaped by rainfall bursts, reservoir storage pressure, drainage stress, land-cover change, and public warning delays. Practical monitoring therefore demands a workflow that can gather heterogeneous evidence quickly, summarize district conditions clearly, and push messages without operational friction.

Many project reports describe flood monitoring through

Asian catchments, and later studies report improved

### SAR Flood Mapping: Present vs Proposed



a single data stream or a narrow location set. Such framing misses a core field reality: district administration teams need statewide context, yet local teams also need district-specific interpretation. A useful platform therefore needs broad reservoir visibility, district-level weather interpretation, multi-year image archives, plus fast communication logic.

The revised system addressed here follows that operational view. Reservoir status retrieval now covers Tamil Nadu as a whole; district selection now spans all supported districts; image review now covers dense archives from 2023 through 2026; and public communication now follows a dual route. High-risk cases receive flood alerts, whereas lower-risk cases receive routine forecast summaries. Fig. 1 and Fig. 2 support this shift from a narrow prototype toward a statewide, code-aligned monitoring workflow.

## 2 Literature Survey

Recent survey studies place remote sensing at the core of modern flood intelligence, especially when radar and optical products need rapid fusion across cloud-prone regions. Reviews by Amitrano et al. and Munawar et al. summarize strong value from SAR coverage, multispectral products, and pre-disaster prediction workflows, while Bukhari et al. discuss broader data-analytic pipelines that connect sensing,

Fig. 1 contrasts a present manual or batch-style flood mapping route with the proposed architecture.

learning, and alerting layers [1]-[3], [11], [12].

Recent Sentinel-1 studies report strong gains for flood extent extraction through radar backscatter analysis, Random Forest classification, and deep-learning mapping chains that support near-real-time response [4], [5].

Forecast-focused work also favors data fusion. Bagmati basin experiments using satellite precipitation plus machine learning highlight operational value for South

lead-time performance from hybrid or attention-based deep learning models [6]-[8].

Flood susceptibility mapping and communication layers now extend beyond detection alone. Recent studies connect GIS-based zoning, explainable learning, and decision dashboards so that technical outputs can support local planning, warning design, and community response [9], [10].

## 3 Gap Statement and Contribution

Earlier manuscript text described a useful concept, yet several operational updates remained outside that version. Reservoir interpretation covered only a limited narrative, image discussion centered on an older archive view, and notification logic emphasized flood alerts without fully describing routine forecast messaging during lower-risk periods.

The present revision contributes four code-aligned updates. First, statewide reservoir scanning now covers all available Tamil Nadu reservoir entries retrieved from the public TN agriculture portal. Second, district support now extends across the full registry assembled from coordinate and archive folders. Third, satellite review now spans dense image collections from 2023-2026, enabling one representative image per year plus remaining archive browsing. Fourth, message policy now follows two paths: an alert path for risk detection and a forecast path for non-risk conditions.

These updates matter for journal presentation because architectural breadth, decision logic, and public communication policy now match the implemented workflow much more closely. The revised narrative also reduces ambiguity around evidence flow, figure interpretation, and end-user value.

## 4 Proposed Statewide Workflow

The updated framework starts with statewide reservoir acquisition rather than a single-location request. Parallel weather collection follows district selection, while archive retrieval gathers representative

satellite images plus additional yearly samples. Search augmentation through SerpApi adds current public context, and Gemini agents transform multi-source evidence into a structured district report.

Fig. 1 Legacy-versus-proposed conceptual flow retained from the earlier manuscript; revised paper maps the proposed side to statewide reservoir scanning, district-wide screening, and dual-path messaging.

A district request triggers five coordinated stages. Stage 1 gathers geolocation-linked weather data and a three-day forecast. Stage 2 scrapes the Tamil Nadu reservoir table for the latest statewide values, then filters district-linked reservoirs through a normalized mapping layer. Stage 3 loads yearly image samples and full archive tiles from the satellite folder structure. Stage 4 queries public web signals related to flood conditions, safe places, and local context. Stage 5 composes a structured risk report that includes chance score, risk level, causal drivers, precautions, current-condition summary, and safe-place hints.

Communication logic then branches through a dual-message policy. When risk crosses alert criteria, the platform sends a Twilio SMS alert with flood chance, risk label, and compact precaution guidance. When

dashboard rendering, chart display, archive browsing, and operator interaction. Weather retrieval uses

WeatherAPI, statewide reservoir retrieval uses an HTML scraping layer over the Tamil Nadu agriculture portal, and public context retrieval uses SerpApi. Gemini agents support structured reasoning, whereas LangChain can coordinate prompt flow, tool chaining, and response assembly across modular services. PIL handles TIFF loading and display preparation for district image review.

The codebase organizes core logic through service-oriented classes. A district registry manages coordinates and folder discovery. A reservoir mapping module connects districts with named reservoirs. A weather service retrieves current conditions plus a three-day forecast. Reservoir services scrape statewide values, convert them into tabular form, filter district-linked entries, and build short historical series for chart display. Satellite services group TIFF images by year, select representative yearly views, and prepare imagery for multimodal reasoning. A risk analyzer then combines weather signals, reservoir context, SerpApi results, and safe-place hints into a structured JSON report. An alert service formats SMS payloads and submits them through Twilio. Fig. 3 preserves a sample

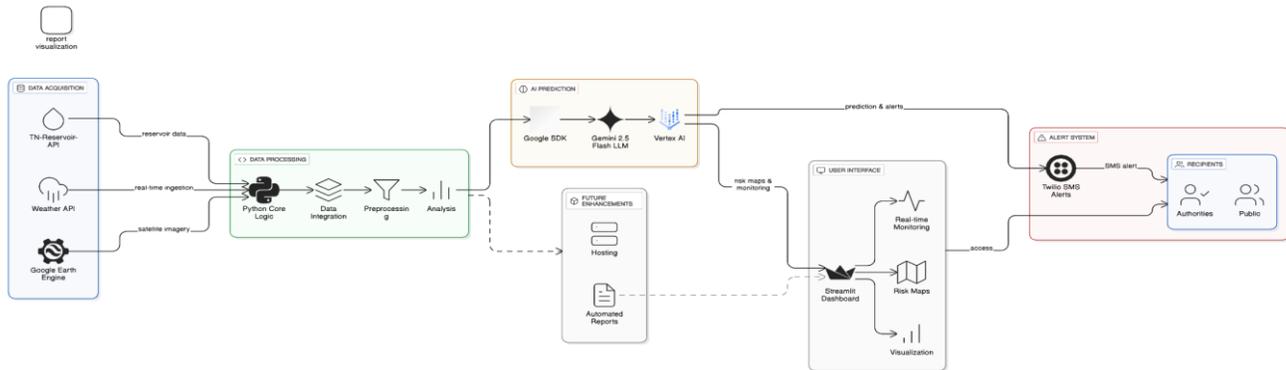


Fig. 2 Code-aligned architecture covering WeatherAPI intake, statewide TN reservoir scraping, Gemini reasoning, dashboard rendering, and Twilio distribution.

high-risk criteria remain unmet, the platform still sends an SMS, but that message carries general weather status and forecast detail rather than alarm wording. Such behavior strengthens public usefulness because silent dashboards often leave residents uncertain during borderline weather episodes.

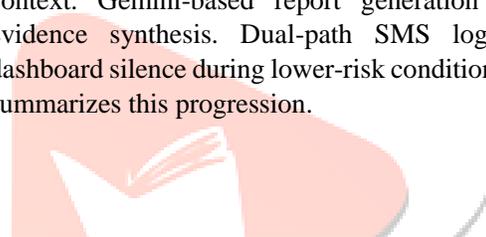
### 5 System Design and Implementation

Fig. 2 presents the implementation architecture. A Python Streamlit front end manages district selection,

archive panel from the earlier dashboard view. Although that screenshot shows a three-year sample, the revised workflow now handles denser archives from 2023 through 2026 and supports one representative image per year plus additional yearly browsing. This archive-oriented design helps operators compare settlement expansion, channel morphology, wetness signatures, or exposed floodplain pressure across multiple seasons.

Alert Status: Risk level is below the 95% threshold. No alert sent.

Satellite Imagery (Past 3 Years)



Condition: Overcast  
Precipitation (last hour): 0.0 mm  
3-Day Rain Forecast  
Monday, Oct 27: 17.2 mm, 100% chance  
Tuesday, Oct 28: 1.24 mm, 88% chance  
Wednesday, Oct 29: 0.0 mm, 0% chance

AI Risk Analysis

Flood Chance (Next 3 Days)

65%

Moderate Risk

Historical Parallels

No direct parallel.

Alert Status: Risk level is below the 95% threshold. No alert sent.

Satellite Imagery (Past 3 Years)

- Fetching high-resolution satellite images... This may take a moment.
- Running get\_gEE\_images(...)

Fig. 3 Sample archive panel from the earlier interface; current workflow now supports denser district archives across 2023-2026 while preserving the same visual review concept.

Fig. 4 displays the dashboard-level risk view generated from the structured analysis stage. That interface presents flood chance, risk label, historical parallels, alert status, and image-linked context. Operationally,

such a panel supports quick interpretation during screening, escalation, and public messaging.

Fig. 4 Dashboard view for AI-assisted district risk analysis and operational alert status.

6 Functional Outcomes and Discussion

Current material supports a functional evaluation rather than a benchmark study with labeled flood events. No calibrated accuracy claim therefore appears here. Instead, discussion centers on workflow capability, traceable data movement, and decision coverage visible from the code path and retained interface figures.

The updated framework delivers six practical gains over the earlier manuscript version. Statewide reservoir scanning offers broader hydrological context. Full district support removes narrow geographic framing. Multi-year archive handling strengthens temporal comparison. SerpApi retrieval adds current public context. Gemini-based report generation improves evidence synthesis. Dual-path SMS logic avoids dashboard silence during lower-risk conditions. Table 1 summarizes this progression.

**Table 1 Updated capability progression from earlier narrative to revised implementation.**

Capability	Earlier narrative	Revised implementation
Reservoir scope	Partial reservoir discussion	Statewide Tamil Nadu reservoir scan with district-linked filtering
District coverage	Narrow operational framing	Full supported district registry through coordinate and archive sources
Image handling	Older sample archive view	Dense 2023-2026 archive with yearly representative picks plus full browsing
Evidence fusion	Descriptive multi-source concept	Weather, statewide reservoirs, SerpApi context, image review, and agent reasoning
Public messaging	Flood alert emphasis	Alert SMS for risk cases plus forecast SMS for non-risk cases
Operator output	Narrative dashboard notion	Structured report, chart-ready reservoir context, and safe-place hints

From an operations perspective, the strongest upgrade lies across communication policy. Earlier alert-only logic could leave citizens and field staff without any outbound message during moderate or low-risk weather. The revised pipeline closes that gap by delivering a compact forecast SMS even when alert criteria stay unmet.

Archive depth also adds analytical value. Representative yearly selection supports fast visual screening, while expandable yearly galleries support deeper manual review when surface water spread, settlement growth, or channel obstruction demand closer attention. That capability complements numeric weather and reservoir traces rather than replacing them.

## 7 Limitations and Future Scope

Current prototype still carries three practical limits. First, risk scoring depends on rule-guided agent synthesis over weather, reservoir, web, and image context rather than supervised calibration against a labeled Tamil Nadu flood event corpus. Second, archive review currently relies on visual comparison plus multimodal summarization, not pixel-level flood segmentation. Third, message routing currently targets configured recipients rather than role-based district rosters.

Next-stage work could add historical event backtesting, district-specific threshold learning, automatic water-spread extraction from TIFF tiles, and contact-list

personalization for district authorities, relief teams, and residents. A tighter coupling between reservoir trajectories, rainfall nowcasting, and archive-derived land-change scores could further improve warning precision and operational trust.

## 8 Conclusion

The revised manuscript now matches the implemented statewide flood workflow far more closely. Reservoir scanning covers Tamil Nadu as a whole, district screening supports the full configured registry, archive review spans 2023-2026 collections, and messaging supports both risk alerts and routine forecast updates. Together, these changes move the system toward a stronger operational profile for district monitoring, public communication, and archive-backed situational review. Future work can add labeled event benchmarking, automated archive scoring, and stronger district-specific safe-route guidance.

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