Korea's AI Strategy for Complex Disaster Prevention and Management

New Strategies for the Prevention and Management of Complex Disasters using AI

Prof. Hong-Gyoo Sohn
Yonsei University, Seoul, Republic of Korea

IDRLF 2026 | Session 1 | Monday, 7 September 2026 | 11:10–12:40

One message: trusted AI begins before the model

AI becomes useful only when data, analytics and governance form one evidence chain

Four main stage of Korea’s strategy

1. Observe
Satellite · drone · CCTV · hydrology

2. Structure
CRS · time · quality · metadata

3. Predict ion and Analysis
GNN · KG · RAG · AI agents

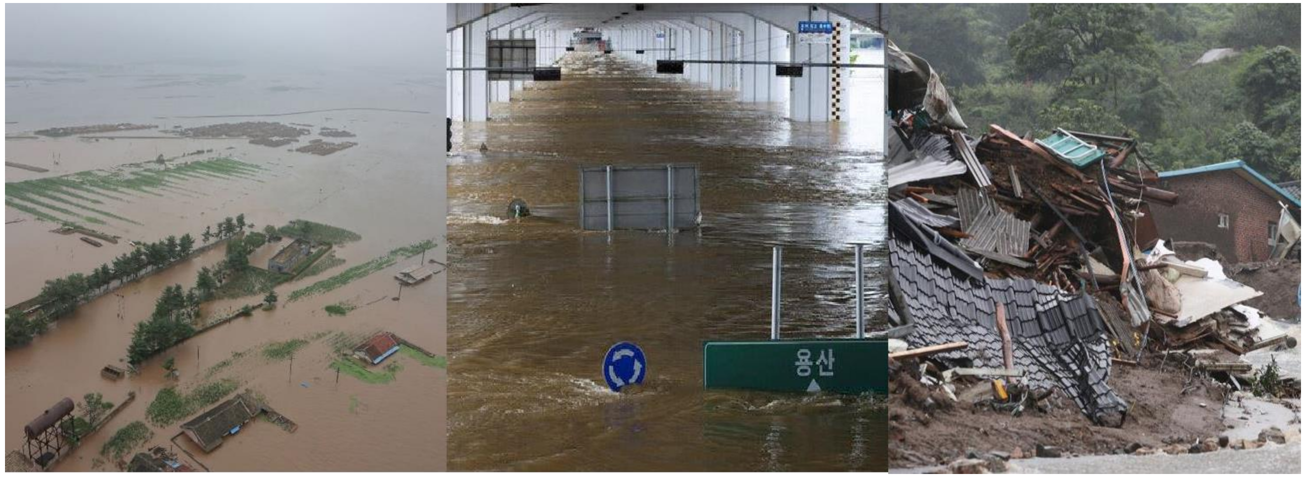
4. Governance
Human review · provenance · ethics

Korea’s multi-source flood-risk context

Korea has a very complex disaster environment

- **A single rainfall episode can trigger urban flooding, river overflow, slope failures and infrastructure disruption.**

- **All kinds of flooding causes severe damage every year**

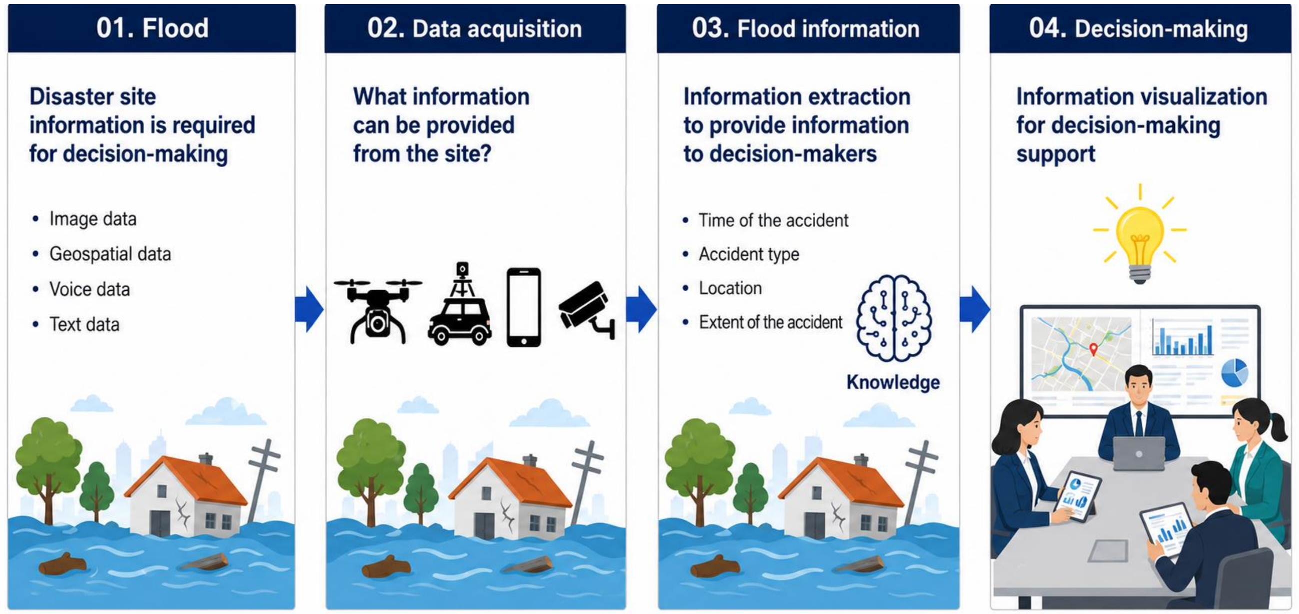


- The response question is no longer only "where is the water?"
- Need to understand how rainfall, terrain, drainage systems, roads, bridges, buildings, and vulnerable communities interact with one another.
- Korea is also highly mountainous, and local disaster data are often distributed across different organizations.
- This makes it especially important for AI to combine incomplete observations into one coherent operating picture

Complex disaster AI = multi-hazard sensing + spatial context + uncertainty-aware decisions

Disaster AI must transform observations into decision intelligence

The most important role of disaster AI is to turn field observations into information that supports decisions.



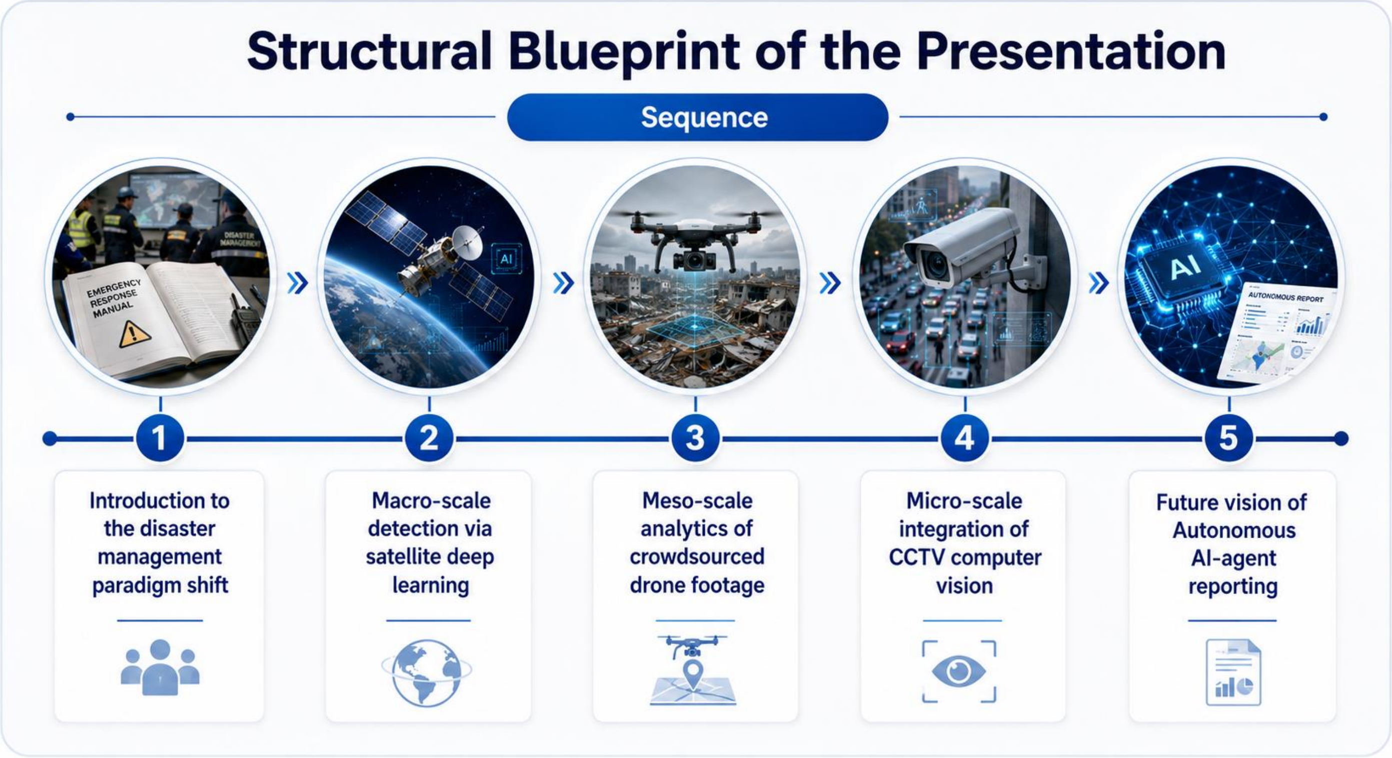
From field data acquisition to decision support

- Field observations answer what happened, where, when, and how severe.
- AI has a major advantage because it can process this information quickly and over large areas.
- We need geospatial analysis and physics-based or analytical models to validate and interpret the results.
- We need one connected process from data acquisition, to information extraction, to knowledge, and finally to decision support

Data acquisition → information extraction → knowledge → decision support

AI approach: multi-scale sensing + analytical validation + AI agents

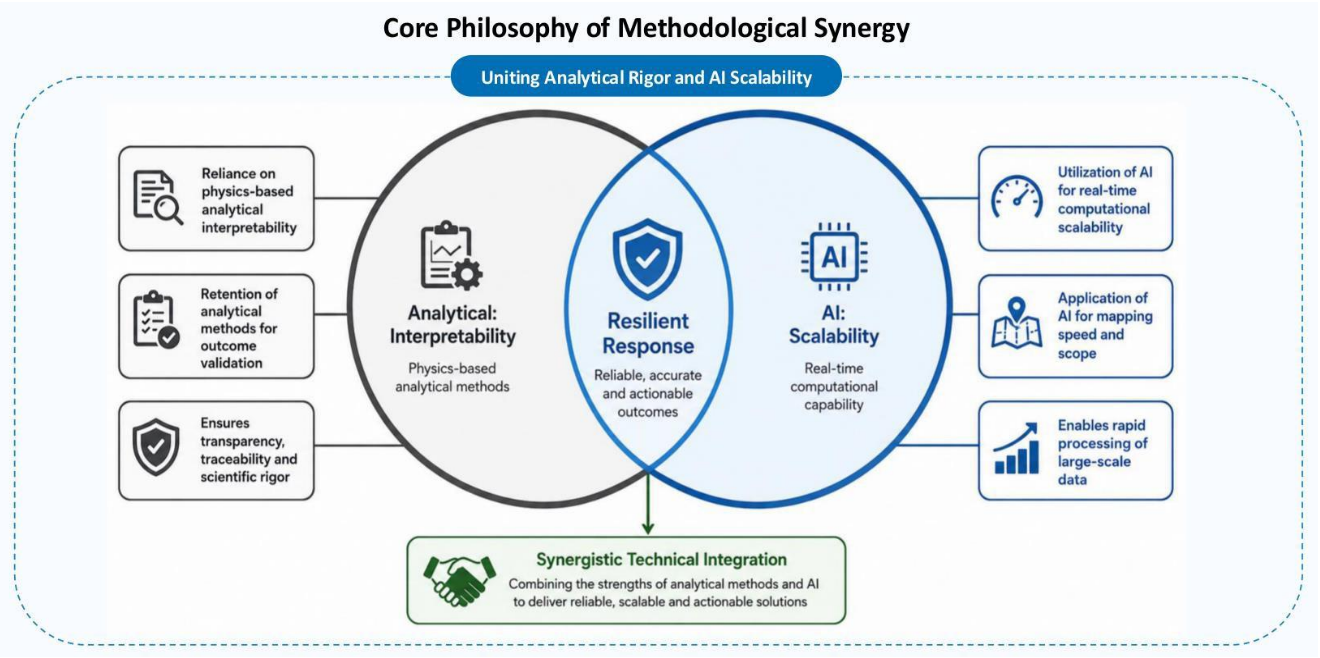
- **Each layer answers a different question and has a different uncertainty structure.**



- **Wide-area** risk understanding: satellite SAR and geospatial analytics
- **Local evidence**: drones, CCTV and 3D spatial interpretation
- Data foundation: AI-readable → AI-understandable → AI-ready
- Prediction layer: apply prediction models, Knowledge Graphs, RAG, and AI agents
- Cooperation layer: moving toward connecting these systems with international disaster-data platforms

AI scalability must be bounded by analytical rigor

- **In disasters, speed without trust can be dangerous; trust without speed can be irrelevant.**



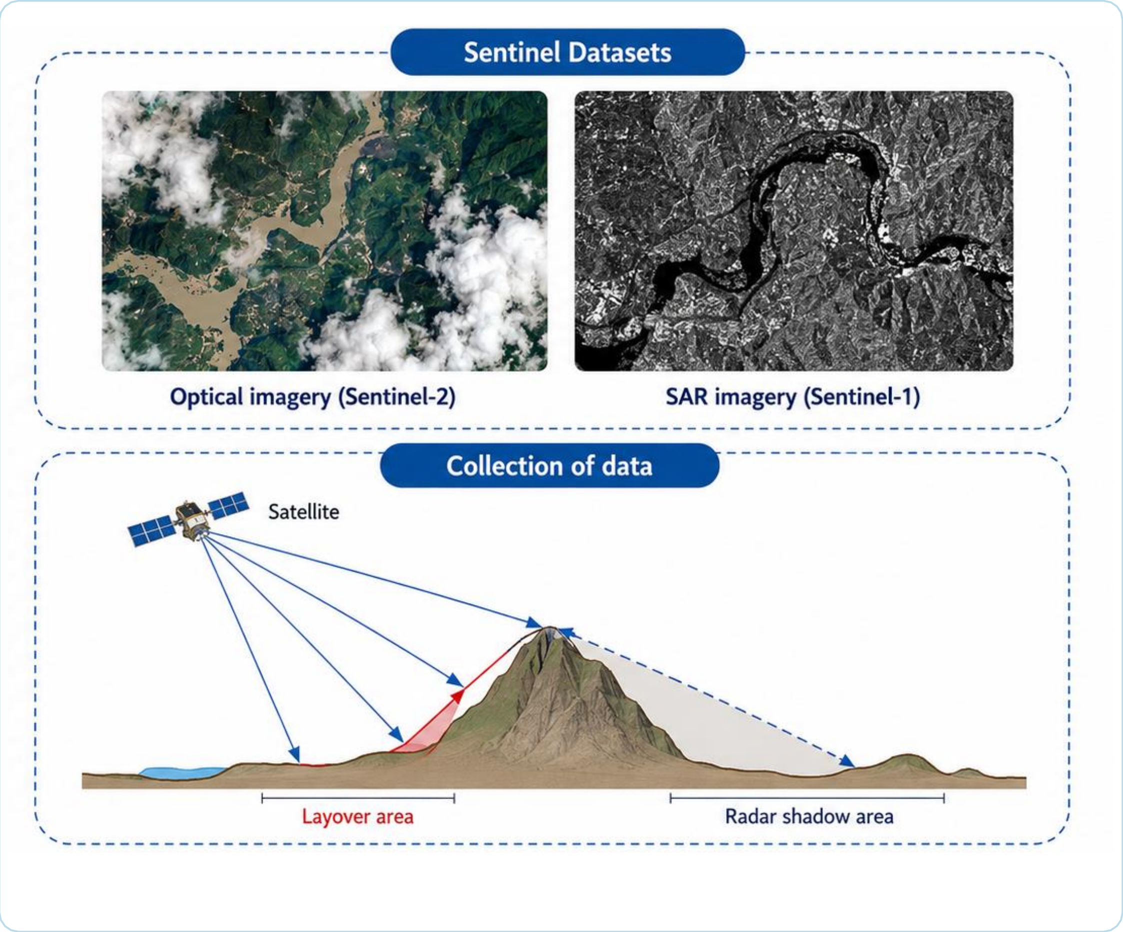
- Use AI for fast information extraction, large-scale analysis, and summarization.
- Use geospatial and physics-based methods for validation and interpretation.
- Keep humans accountable for release, warning and resource decisions.

AI is a decision partner, not an uncontrolled decision-maker

The 5th IDRLF International Disaster Resilience Leaders Forum Incheon 2026

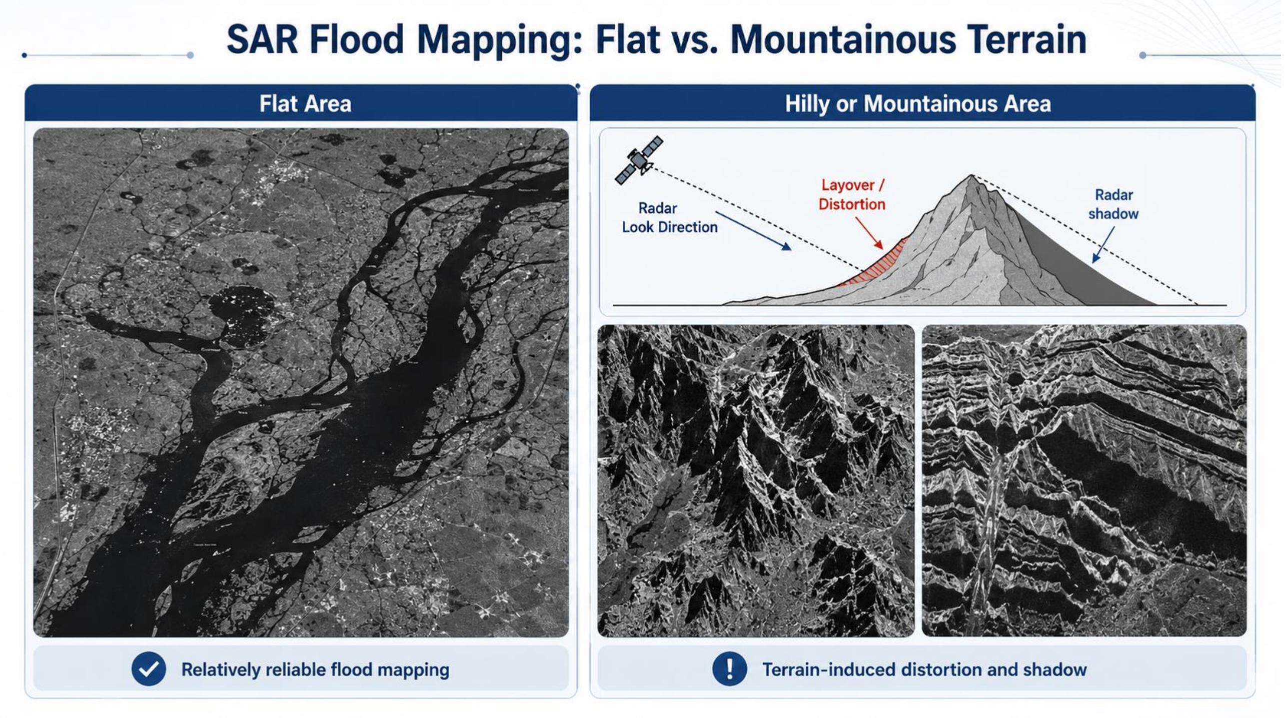
01 Risk Understanding

Satellite AI and geospatial analytics for wide-area flood detection



Satellite AI in Korea: SAR is essential during heavy rainfall

- Optical imagery is often blocked by clouds; SAR can observe the surface regardless of weather and illumination.



- **Korea is very mountainous.**
- **SAR-specific geometric effects, such as layover and shadow, can be misclassified as flooded areas.**

- Korean approach needs to combine SAR imagery with DEMs, drainage information, terrain information, and AI.

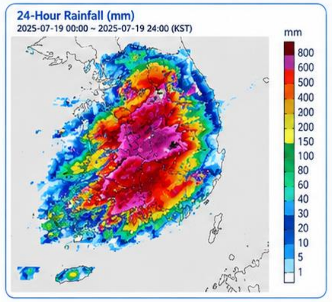
Example: 2025 heavy rainfall in Gyeongnam as a test case

Purpose is not simply to classify flooded areas accurately.

Overview

Event background

- Between 16 and 20 July 2025, South Korea experienced severe heavy rainfall that caused widespread flood and landslide damage.
- In Gyeongnam province, intense rainfall affected mountainous and river-adjacent areas.



News headlines

Key data

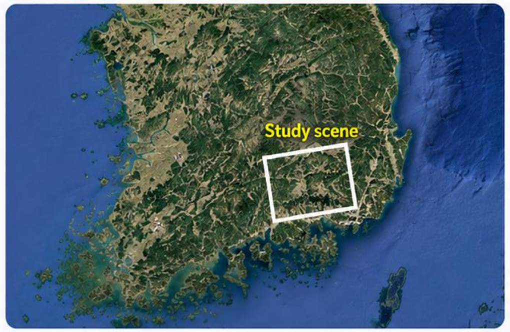
Category	Values		Source
Total damage	KRW 1.0843 trillion		MOIS Press Release (Aug. 2025)
Recovery budget	KRW 2.7235 trillion		MOIS Press Release (Aug. 2025)
Daily rainfall on 19 July 2025	Hapcheon	280.1 mm	KMA Weather Nuri, Regional Detailed Observation (AWS), accessed on July 19, 2025
	Uiryeong	214.6 mm	
	Jinju	191.5 mm	

Sentinel Platform

Input data

- Sentinel-1 SAR scene acquired during the active heavy rainfall period was used as the primary input for flood mapping.
- The original SLC (Single Look Complex) data were geocoded to CSLC-S1 (Coregistered Single-Look Complex) format using several ancillary datasets.

Sentinel-1 scene – Study Area



Scene metadata

Item	Description
Sensor / Platform	Sentinel-1A (C-band SAR)
Acquisition Mode	Interferometric Wide (IW)
Polarization	VV (Co Polarization) / VH (Cross Polarization)
Orbit Direction	Ascending
Acquisition Time	19 July 2025, 18:23 KST
Path / Frame	54 / 111

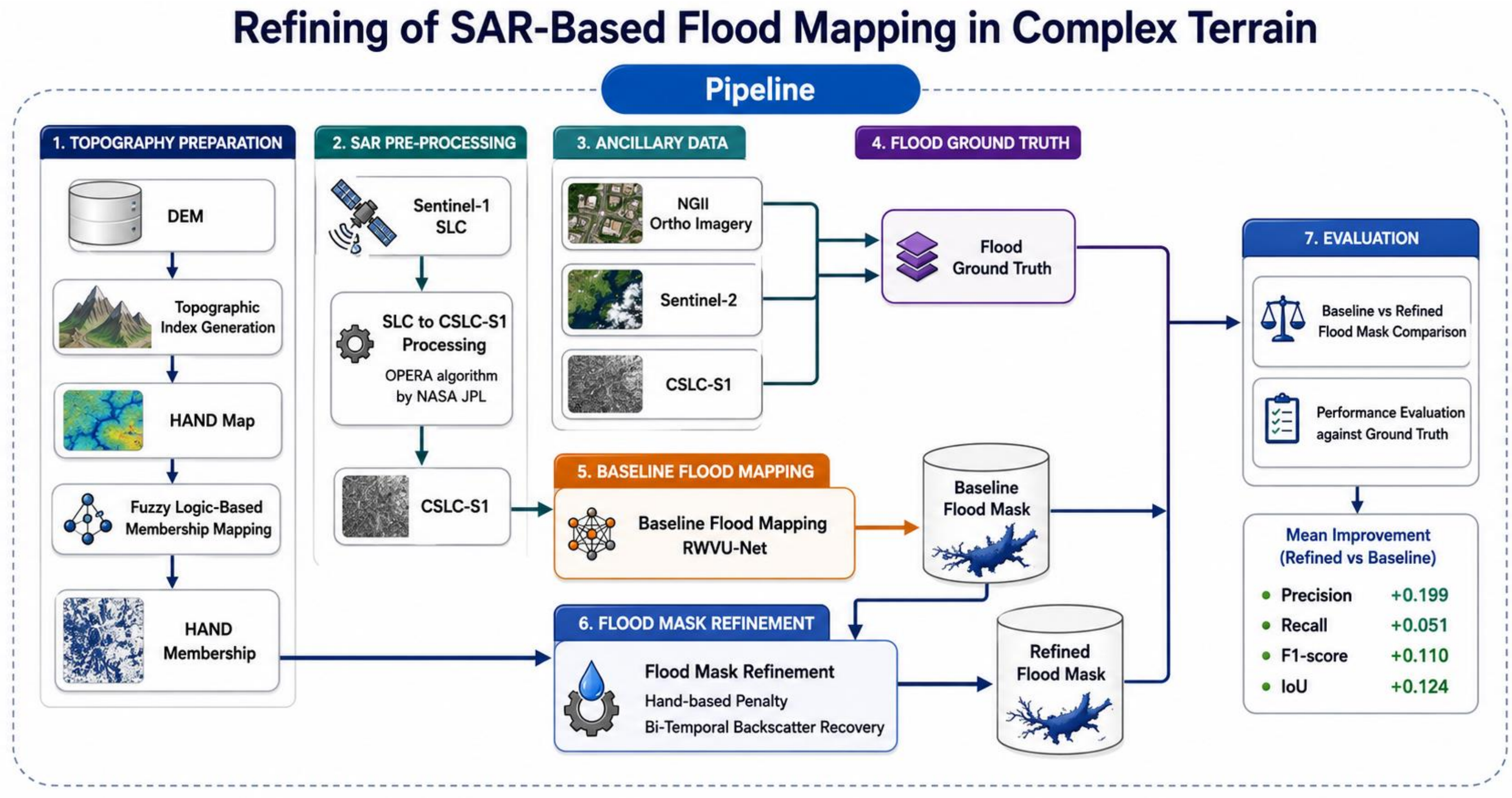
Ancillary Inputs for Geocoding

Item	Description
SAR Scene	Sentinel-1 IW SLC
Orbit File	Precise orbit ephemeris (AUX_POEORB)
DEM	Copernicus GLO-30 DEM
Ionospheric Data	TEC (Total Electron Content) map for ionospheric correction
Burst Database	Spatial database for burst processing
Config File	YAML processing configuration

The goal is to turn an AI flood map into information that can be used in a real operational situation board.

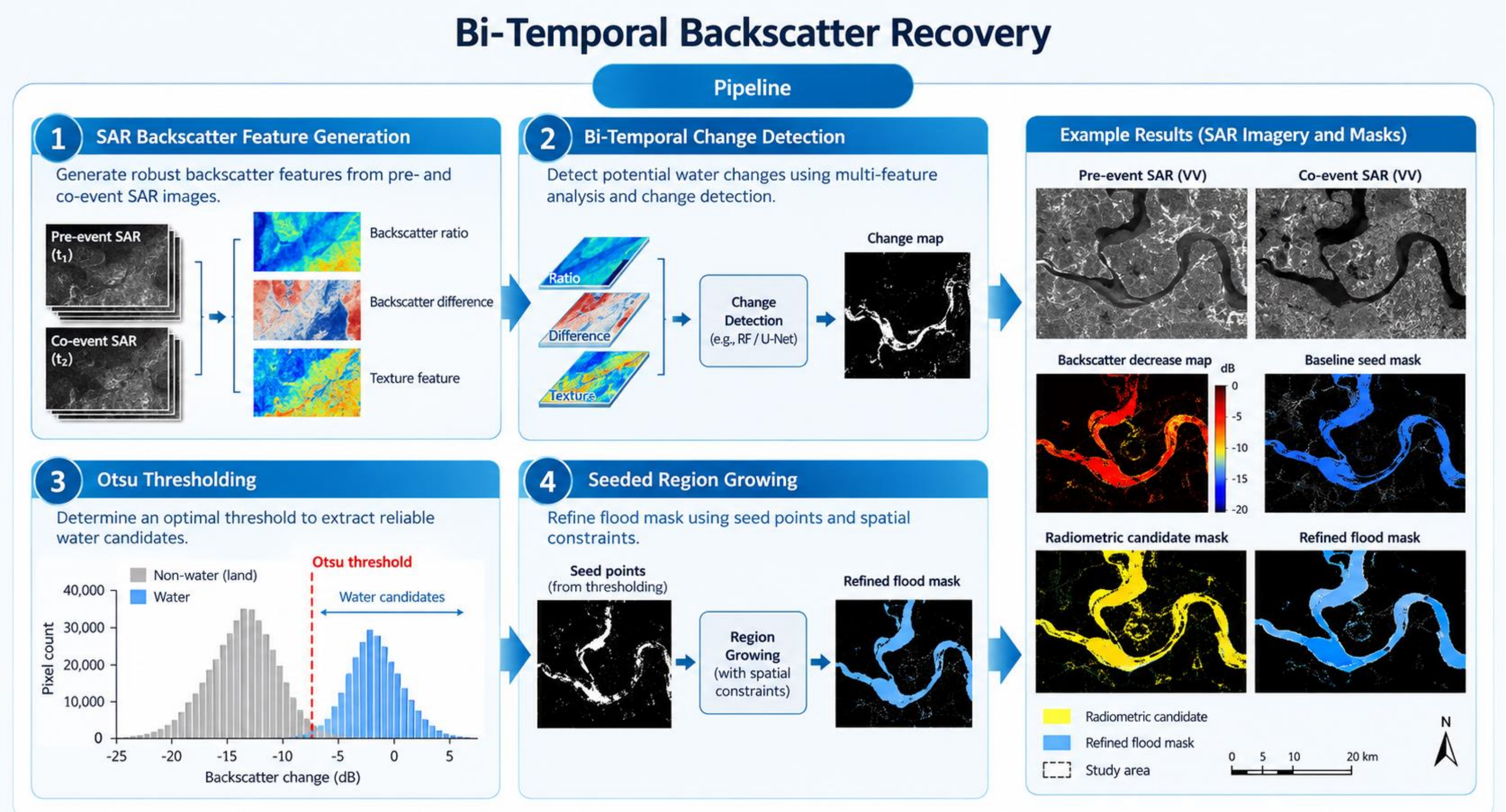
Terrain-aware SAR flood mapping reduces operational false alarms

Our workflow combines AI-derived masks with HAND and bi-temporal backscatter recovery.



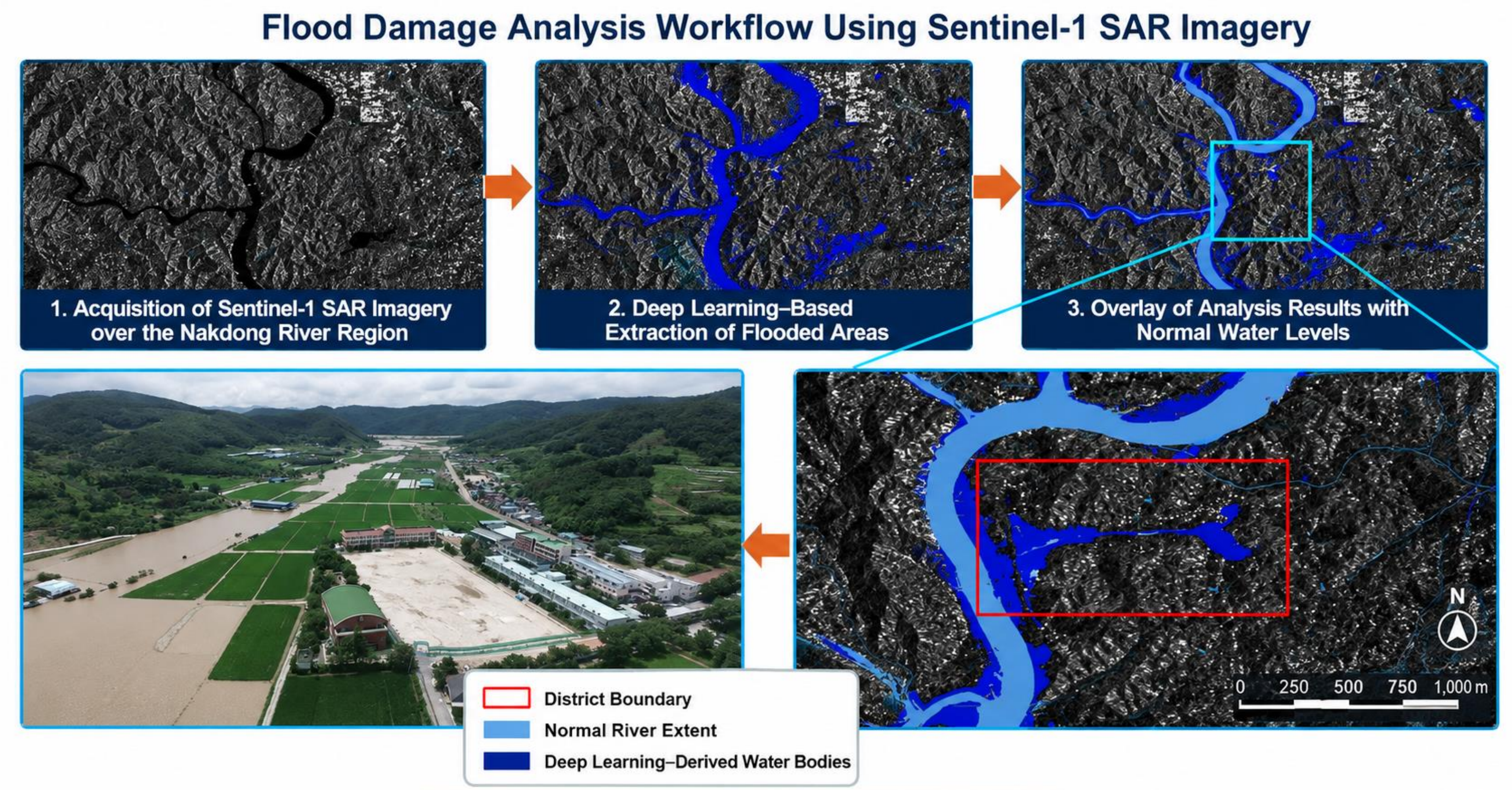
Terrain-aware SAR flood mapping reduces operational false alarms

Our workflow combines AI-derived masks with HAND and bi-temporal backscatter recovery.



Key idea is not to replace AI, but to improve its reliability by adding spatial and physical constraints to the AI result.

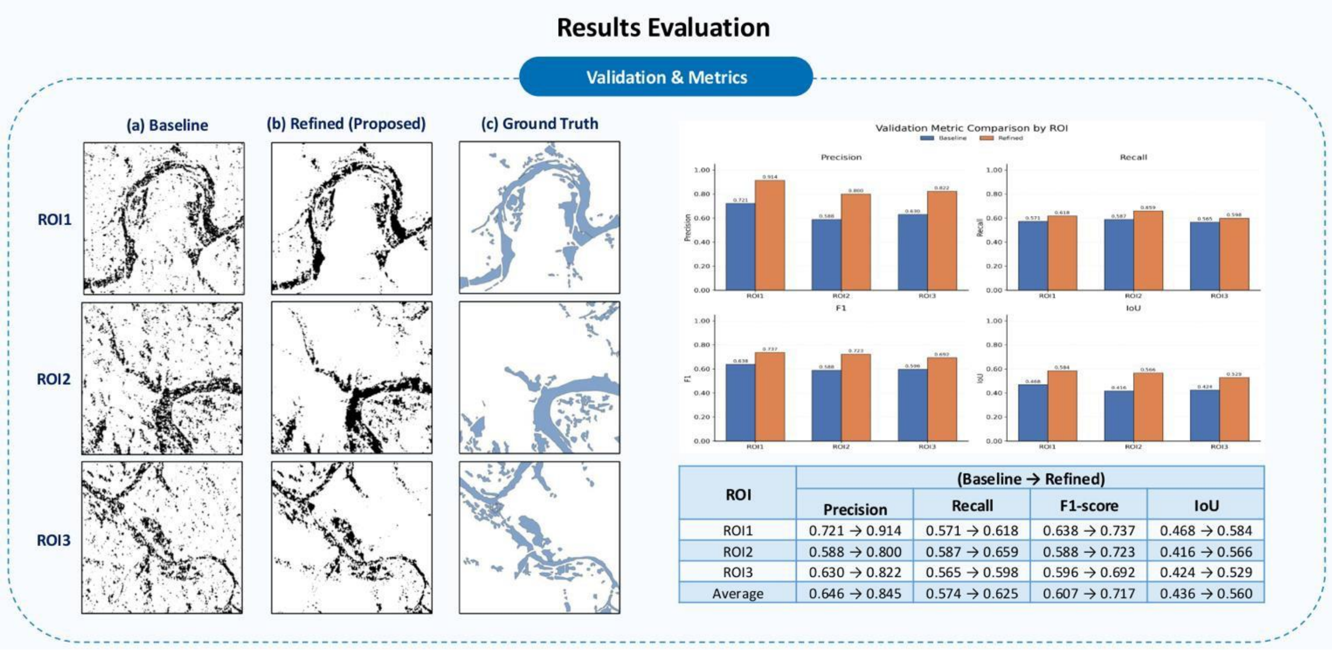
Deep learning can accelerate extraction of inundated areas



AI makes it very useful during the early stage of situation assessment.

Result: AI flood masks become more useful by terrain logic

- **The most important issue is not only how much the numerical accuracy improves.**
- **A more practical question is how much we can reduce false alarms that may confuse field operations**



ROI	(Baseline → Refined)			
	Precision	Recall	F1-score	IoU
ROI1	0.721 → 0.914	0.571 → 0.618	0.638 → 0.737	0.468 → 0.584
ROI2	0.588 → 0.800	0.587 → 0.659	0.588 → 0.723	0.416 → 0.566
ROI3	0.630 → 0.822	0.565 → 0.598	0.596 → 0.692	0.424 → 0.529
Average	0.646 → 0.845	0.574 → 0.625	0.607 → 0.717	0.436 → 0.560

- Using terrain information, we can reduce scattered false detections in mountainous areas while preserving the major flooded areas along river corridors.
- This helps field teams decide where to inspect first.

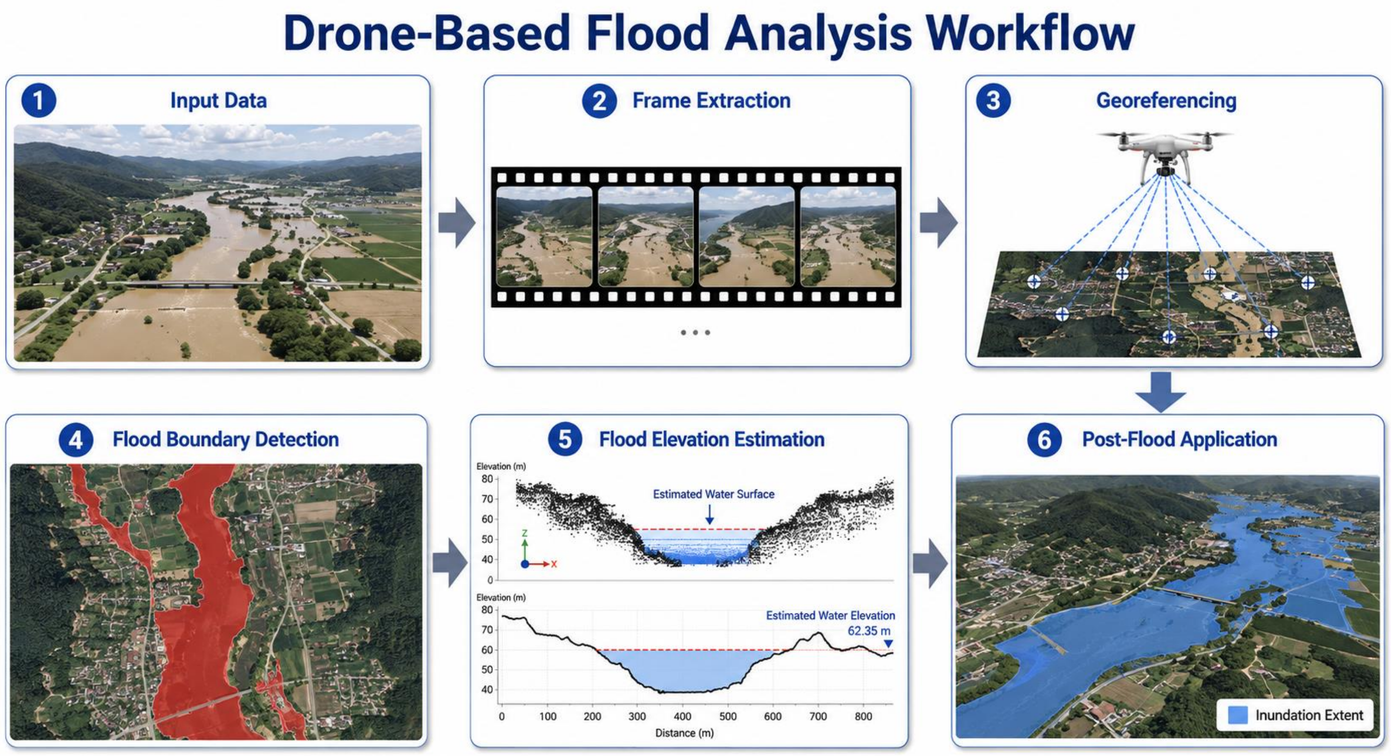
AI + terrain logic → fewer false alarms → faster decisions

02 Early Warning & Local Evidence

Drones, CCTV and 3D geospatial intelligence for more detailed local information.

Meso-scale AI: drones footage fill observation gaps

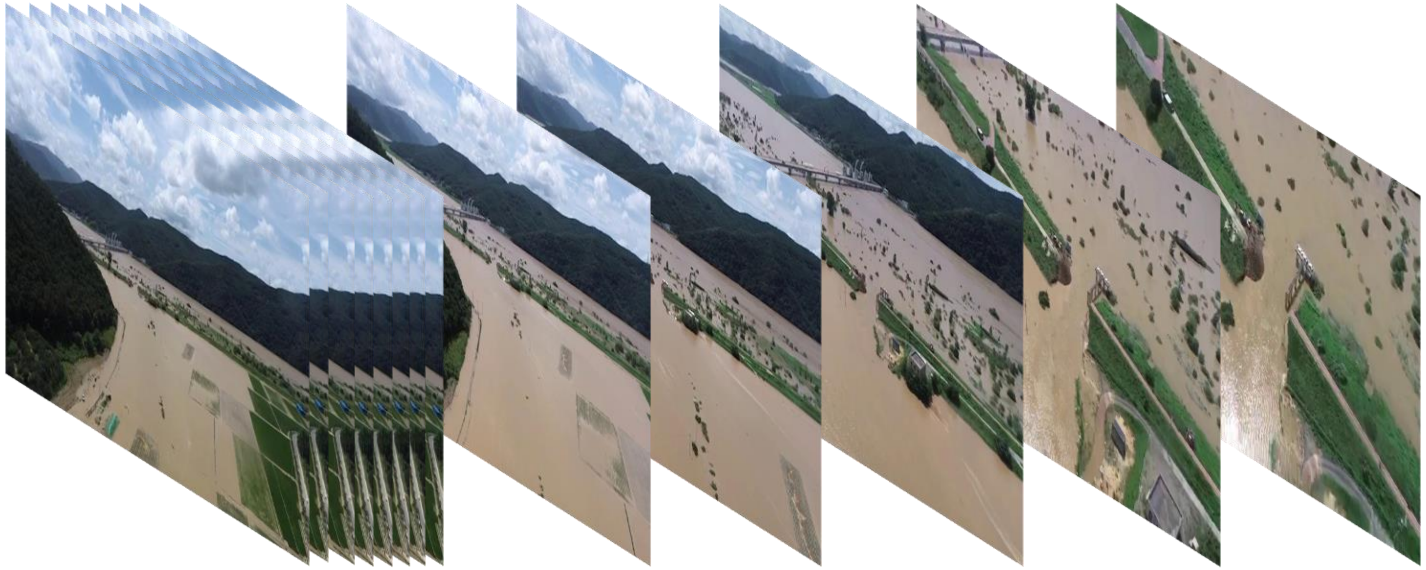
Local imagery helps responders see places that fixed sensors or satellites cannot capture at sufficient detail .



- Smart frame selection removes redundant or low-value footage.
- Object and boundary detection help locate damaged roads, flooded zones and blocked access points.
- Georeferencing turns visual evidence into mappable operational information.

Optimized through smart key-frame selection from video data

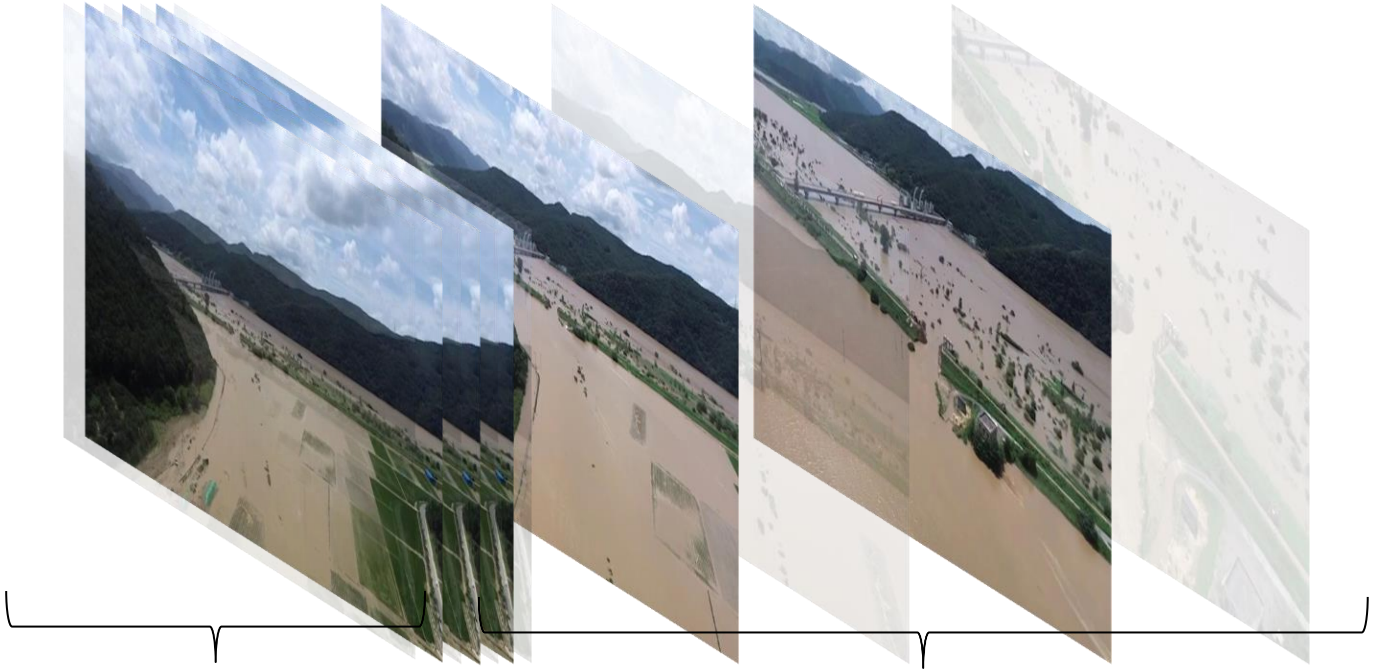
Importance of frame selection



Optimized through smart key-frame selection from video data

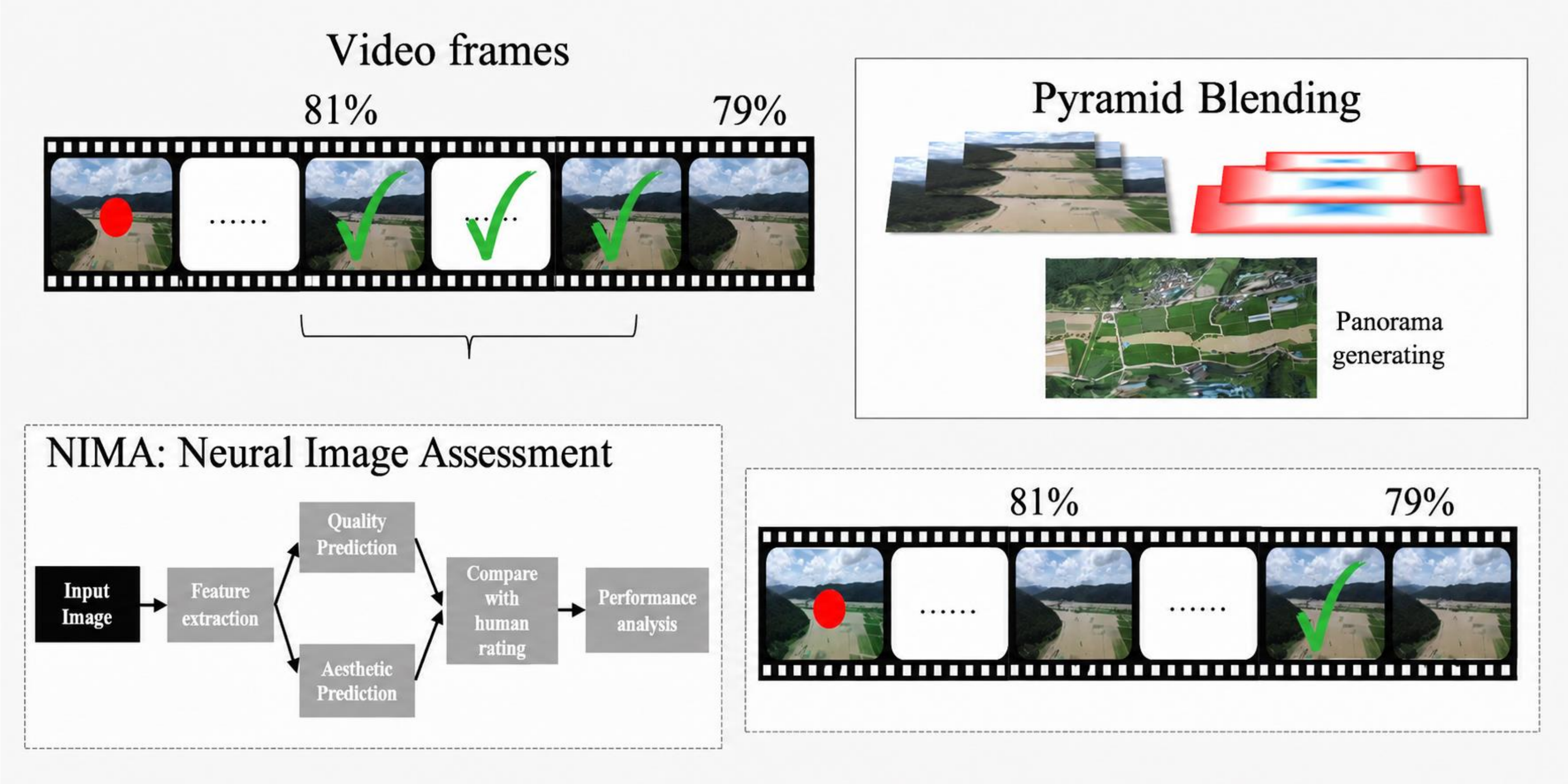
Importance of frame selection

Fixed interval frame selection



Optimized through smart key-frame selection from video data

Schematic workflow for frame selection pipeline

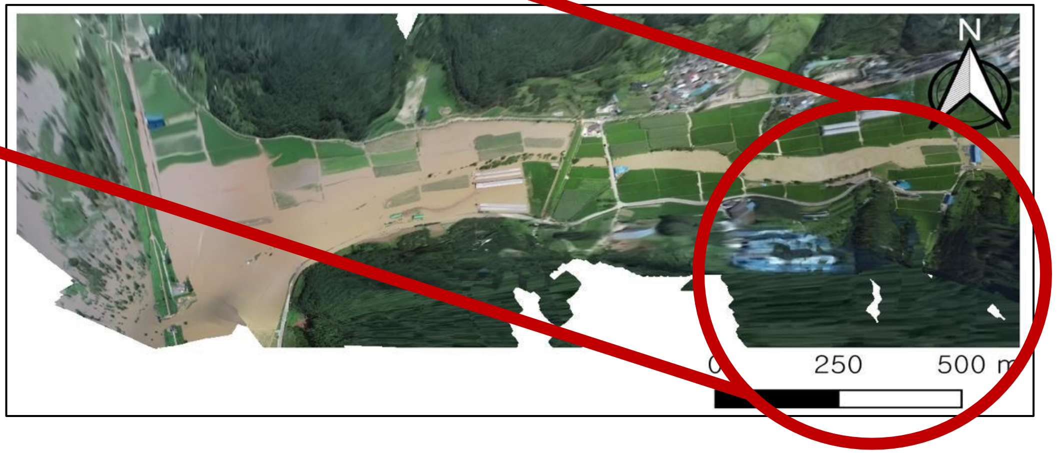


Optimized through smart key frame selection from video data

Schematic workflow for frame selection pipeline

Orthoimage improvement

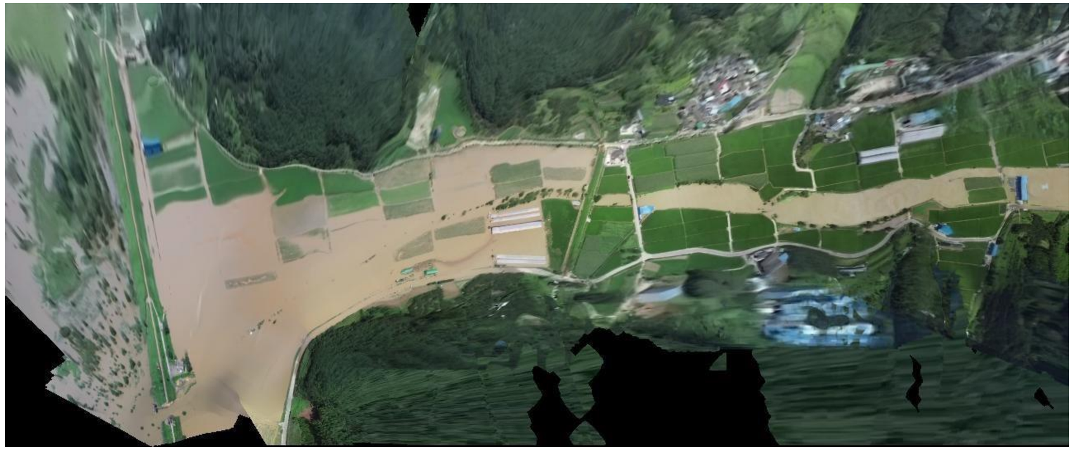
Orthoimage from fixed frame interval



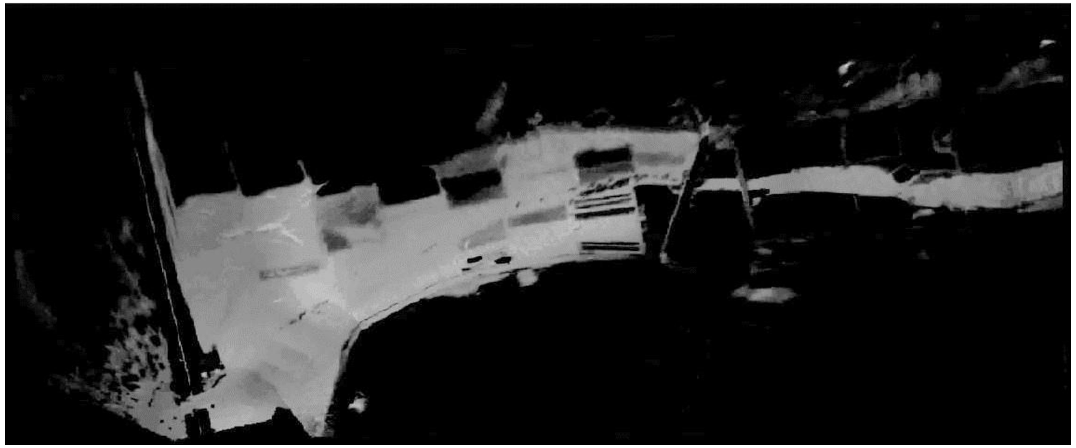
Orthoimage by optimum frames

Optimized through smart key frame selection from video data

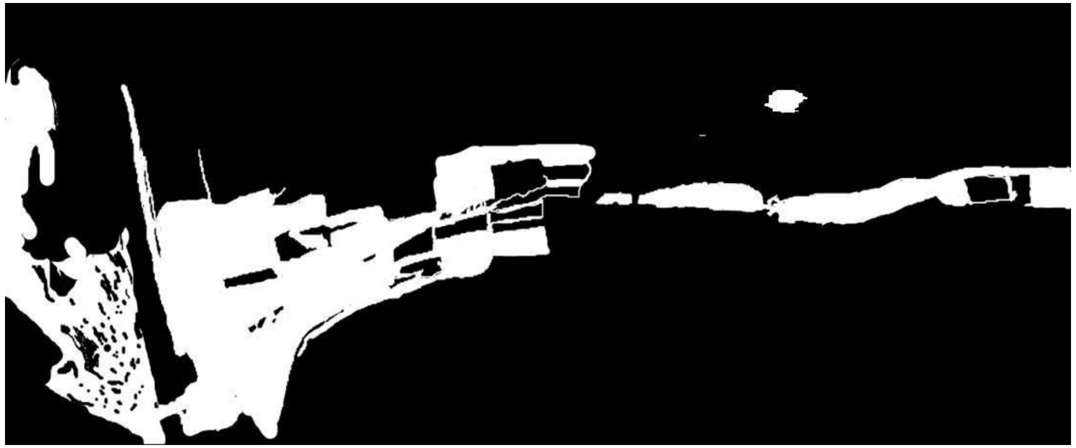
Flood Extend Detection



Orthoimage



FWI (The accuracy is 79.4%)



Ground Truth (Manual)

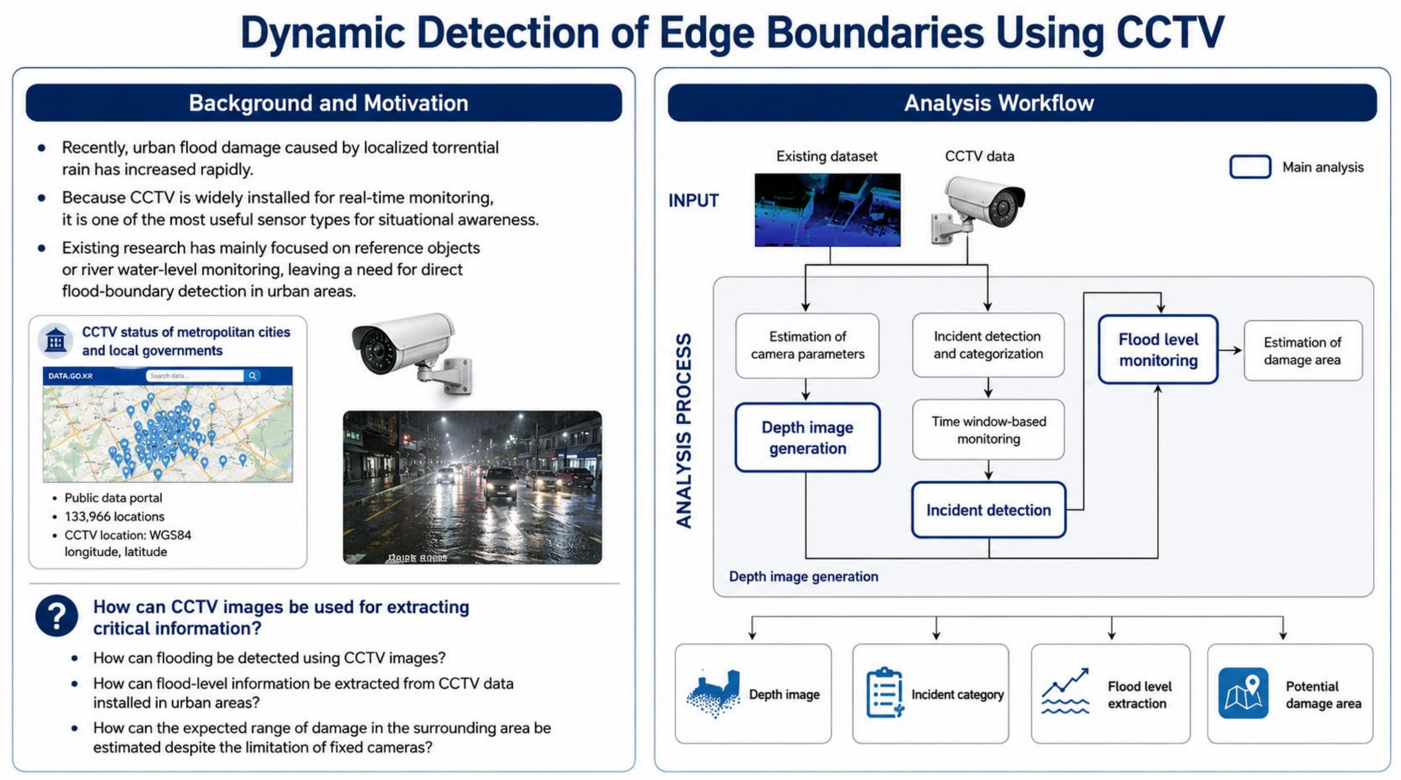
U2−Net (The accuracy is 91.81%)

Optimized through smart key frame selection from video data

3D Visualization of Flood

Micro-scale AI: CCTV detects local flood boundaries

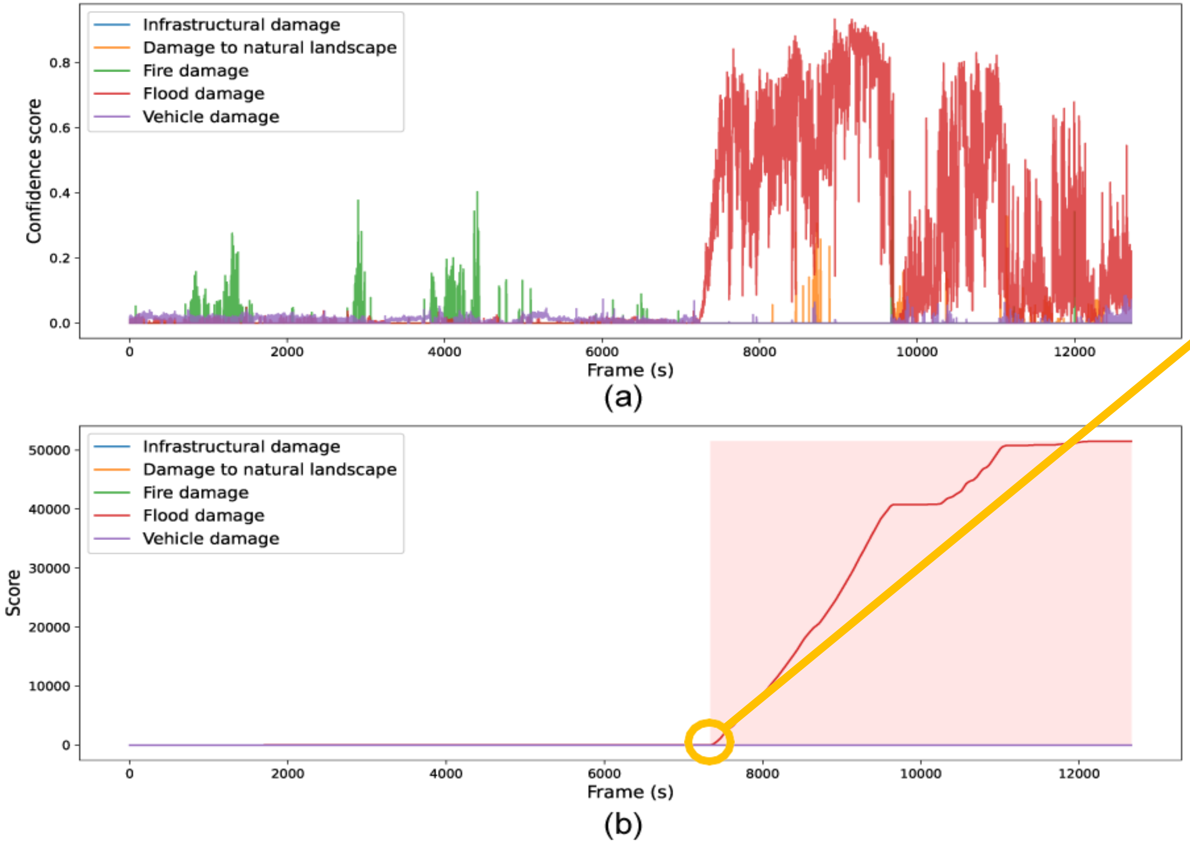
Fixed cameras provide continuous monitoring at critical urban nodes, underpasses and roads.

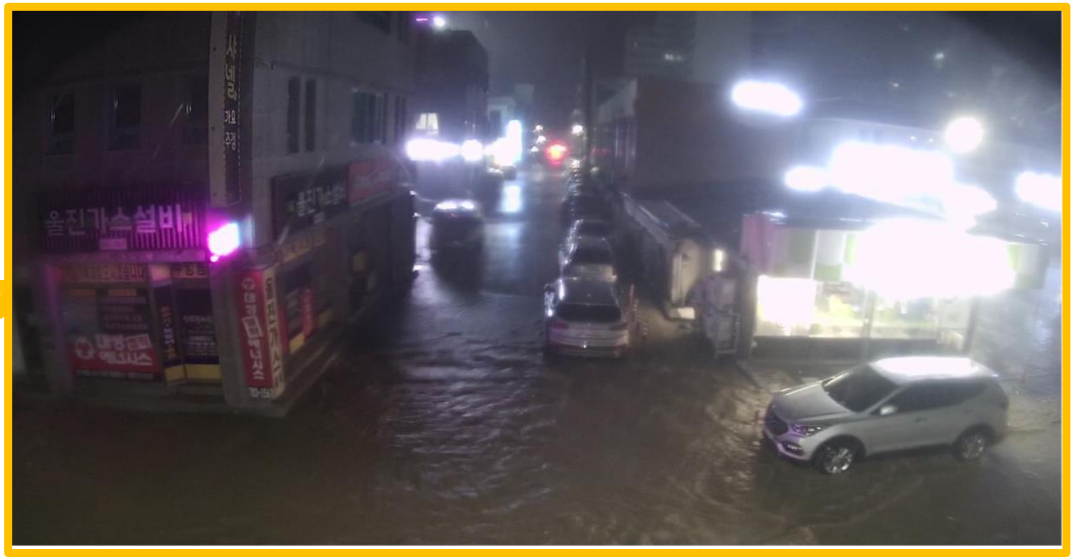


CCTV AI turns ordinary surveillance infrastructure into a real-time disaster sensor network.

Micro-scale AI: CCTV detects local flood boundaries

Dynamic AI Flood Incidence Detection Using CCTV Video Data

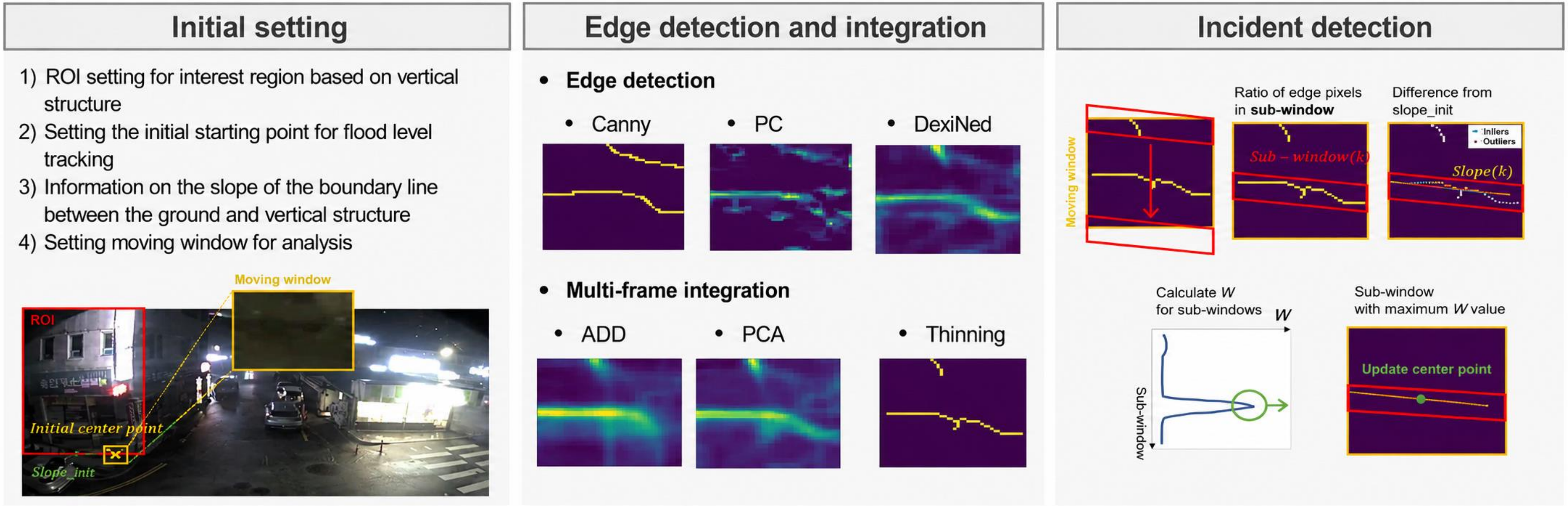




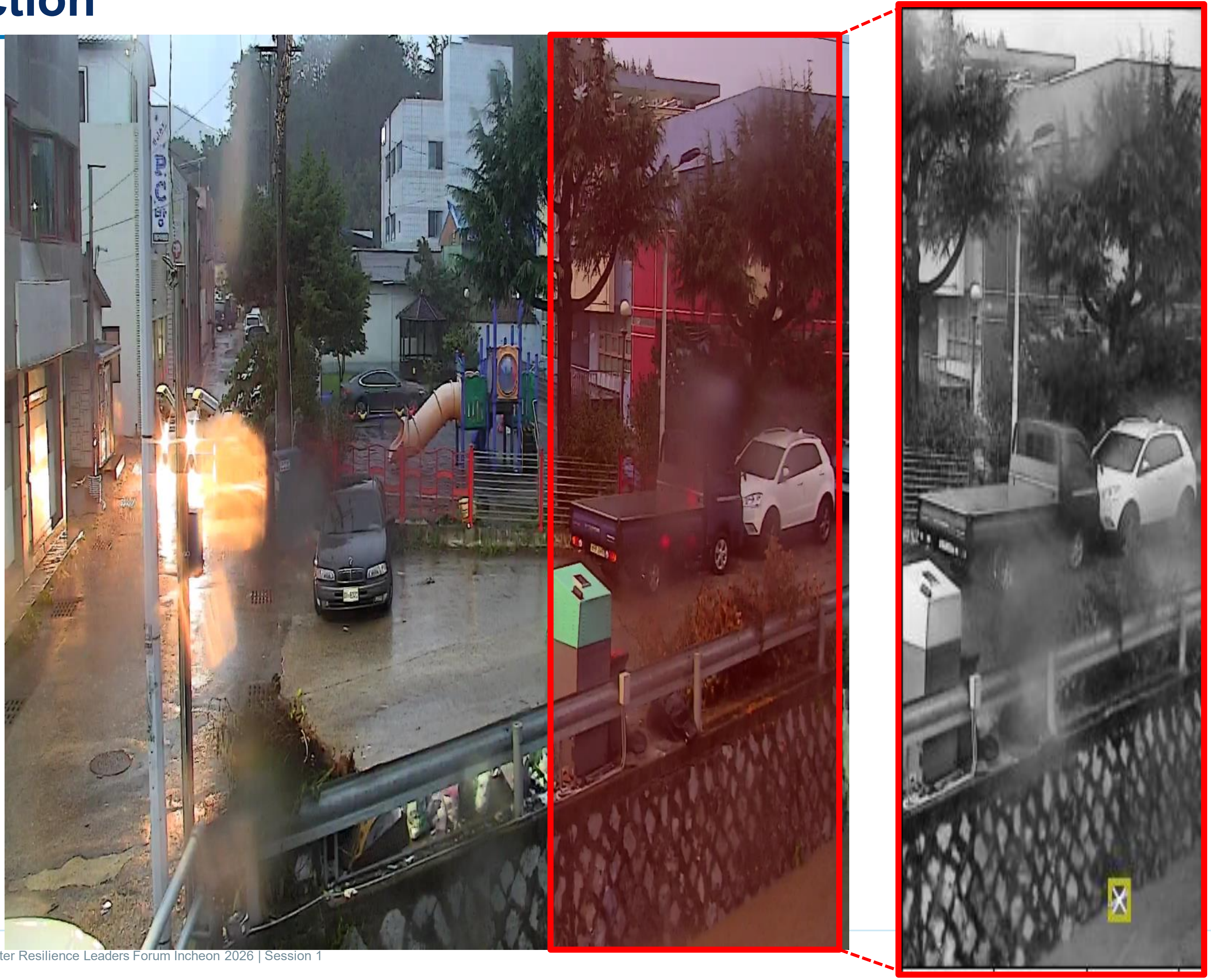
Flood incidence detection at the same time with flood boundaries

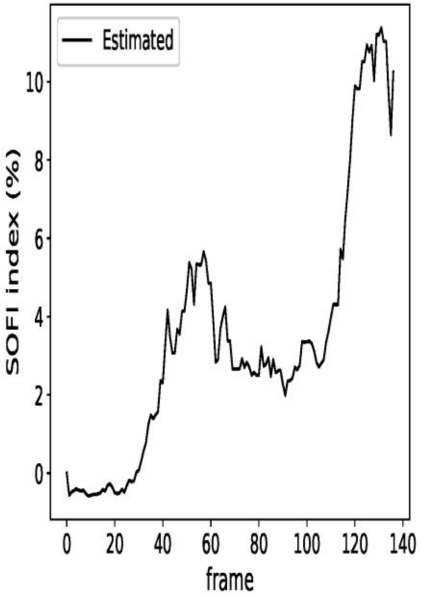
Micro-scale AI: CCTV detects local flood boundaries

IMAGE-BASED LOCALIZATION



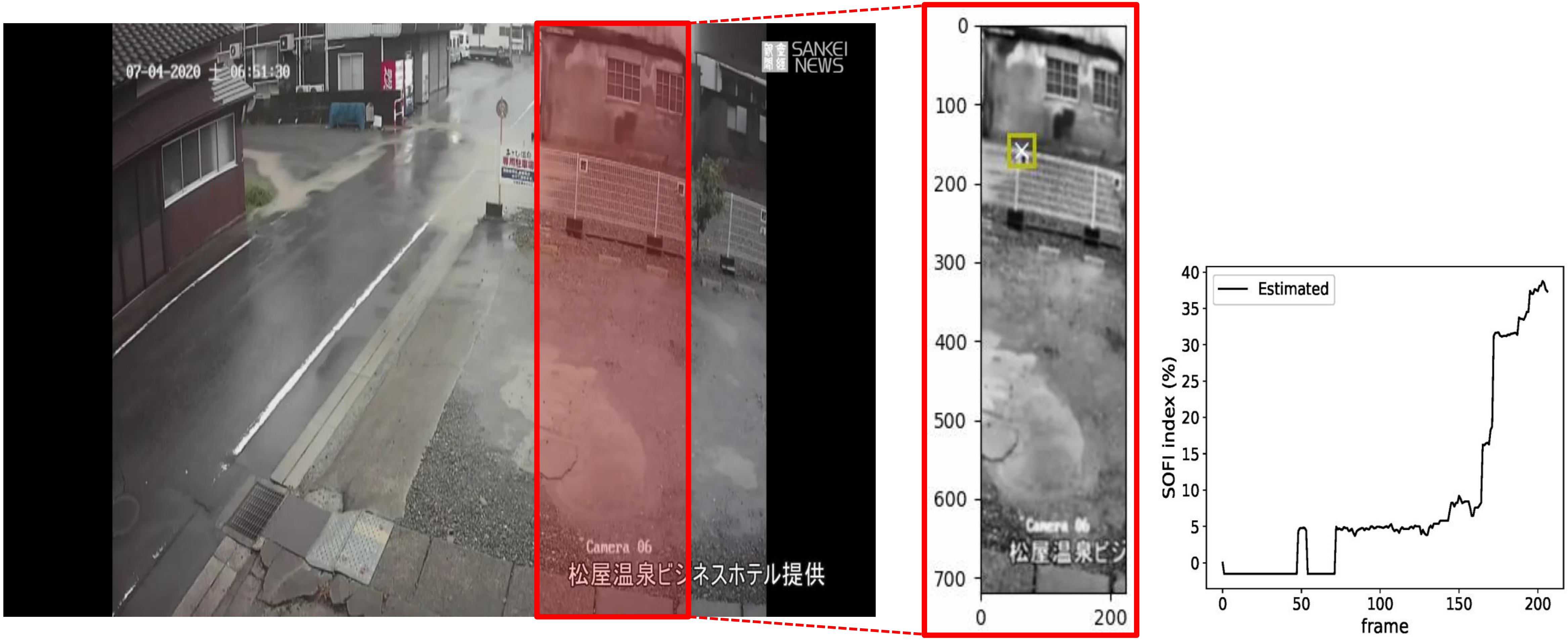
From video pixels to flood intelligence: segmentation and 3D projection





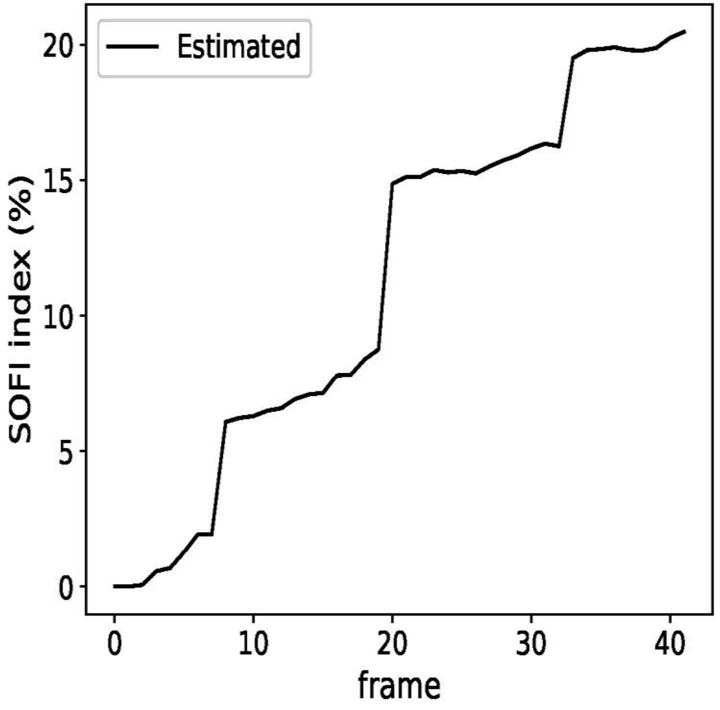
From video pixels to flood intelligence: segmentation and 3D projection

https://www.youtube.com/watch?v=8hO6WZVwlks

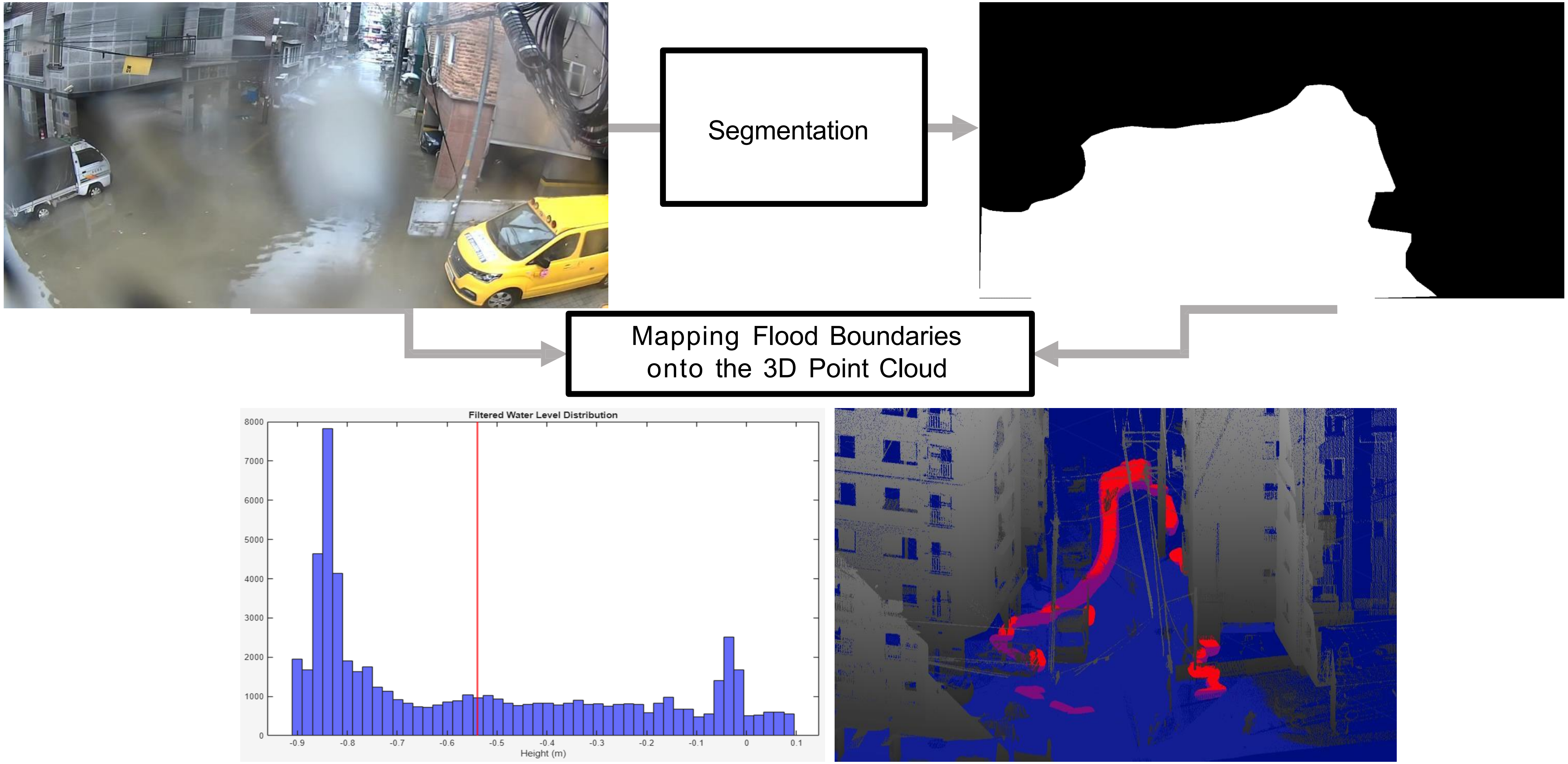


From video pixels to flood intelligence: segmentation and 3D projection

https://www.youtube.com/watch?v=Y40mG4DMiv0

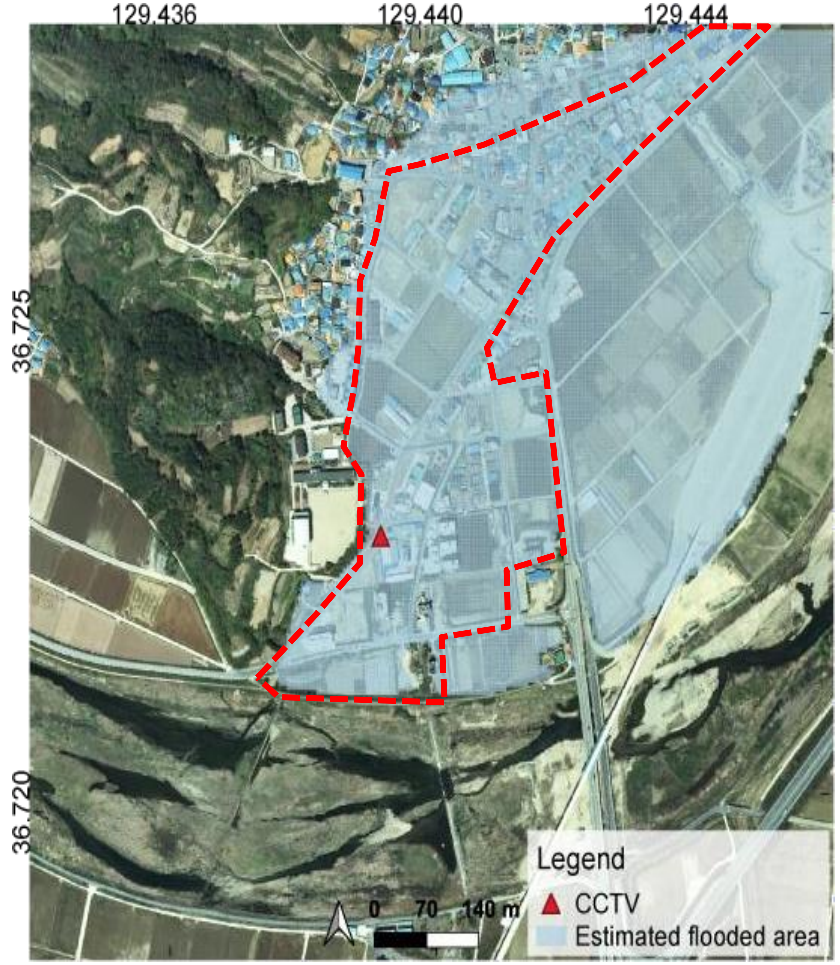


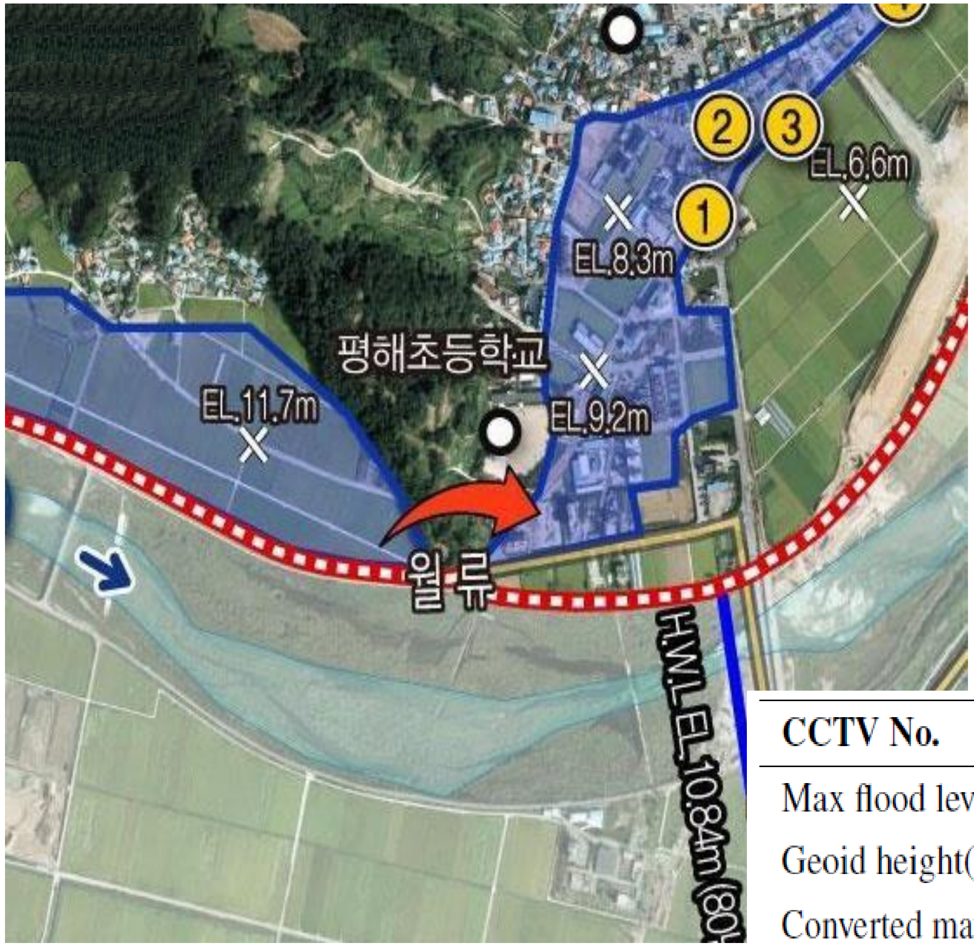
From video pixels to flood intelligence: segmentation and 3D projection



From video pixels to flood intelligence: segmentation and 3D projection

Flood Boundary Estimation Using Local High Accurate Digital Elevation Model.

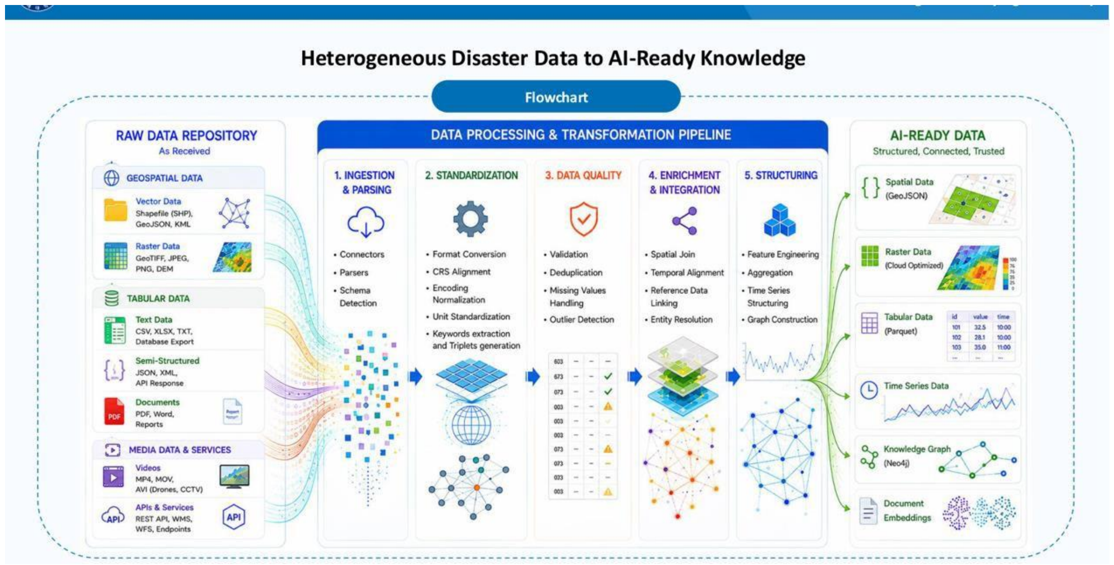




CCTV No.	CCTV #1
Max flood level (m)	39.66
Geoid height(m)	29.12
Converted max flood level to orthometric height (m)	10.54

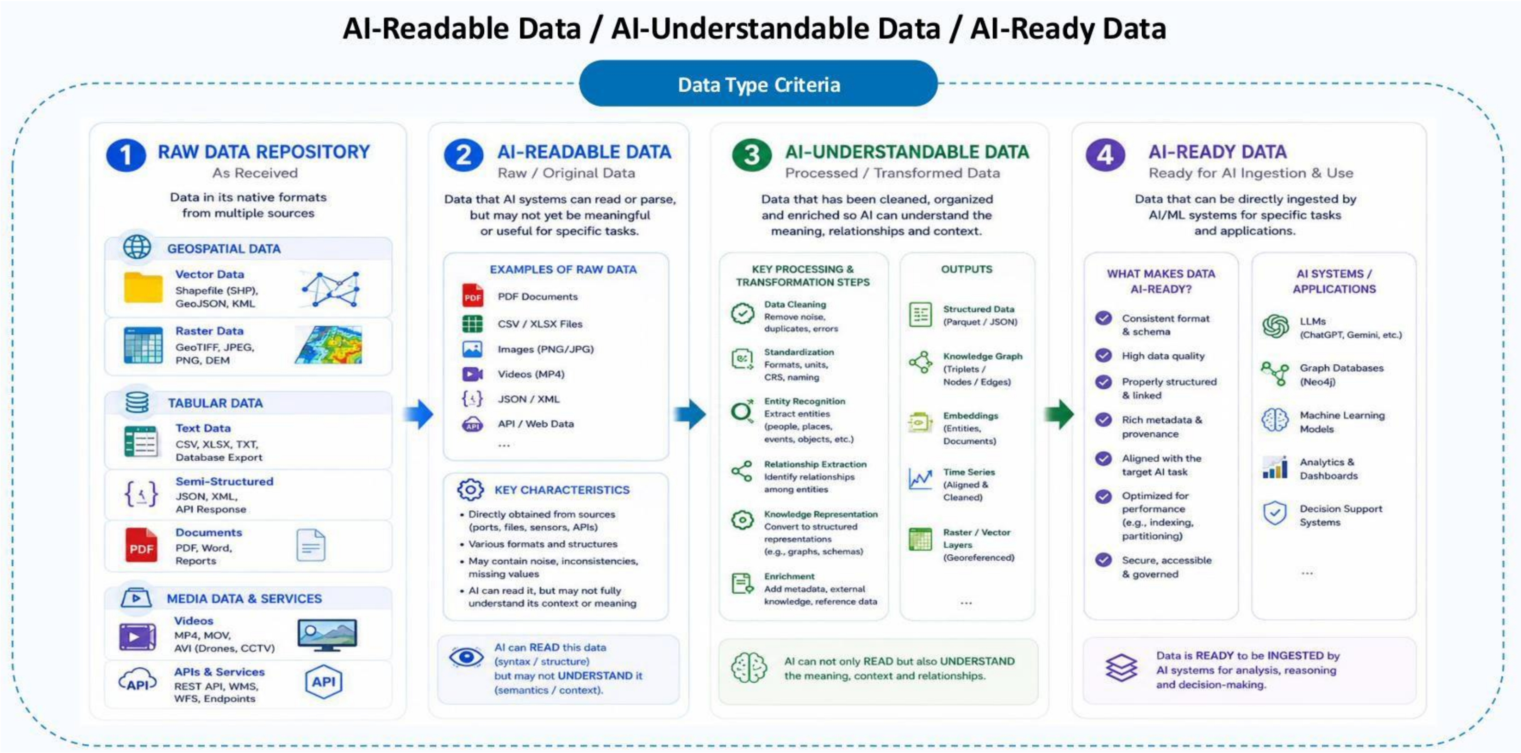
03 AI-Ready Disaster Data

Korea's foundation for trusted AI:
standardization, linking,
quality and knowledge graphs



The hidden infrastructure: AI-ready disaster data

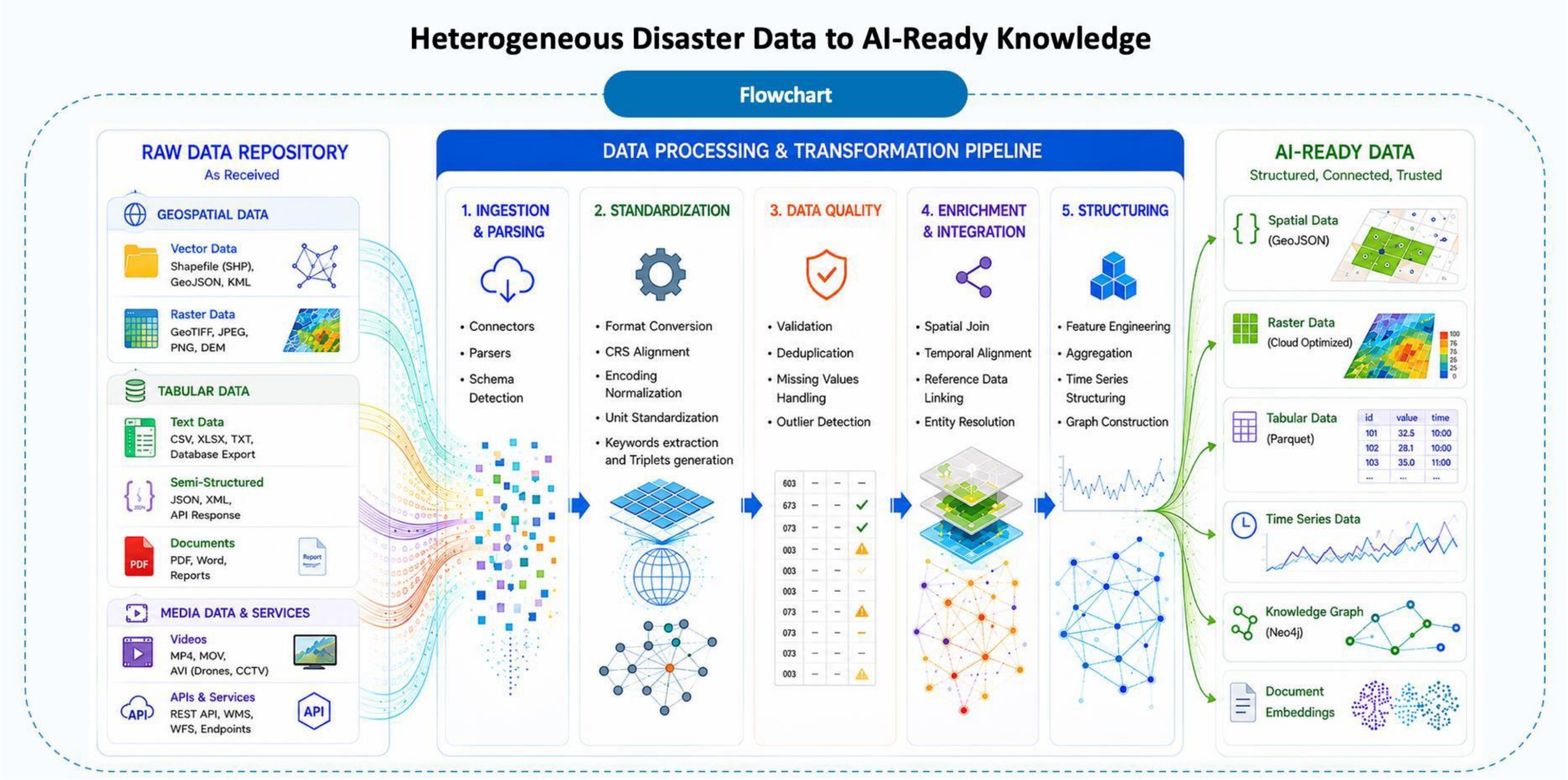
Korea’s central lesson is that AI performance depends on standardization before modeling.



- AI-readable: the system can open or parse the file.
- AI-understandable: entities, context and relationships are extracted.
- AI-ready: data are structured, connected, trusted and directly usable for a specific task.
- For disaster decisions, “readable” is not enough.

Data pipeline: ingestion → standardization → quality → enrichment → structure

This pipeline makes local disaster data reusable for prediction, reasoning and reporting.

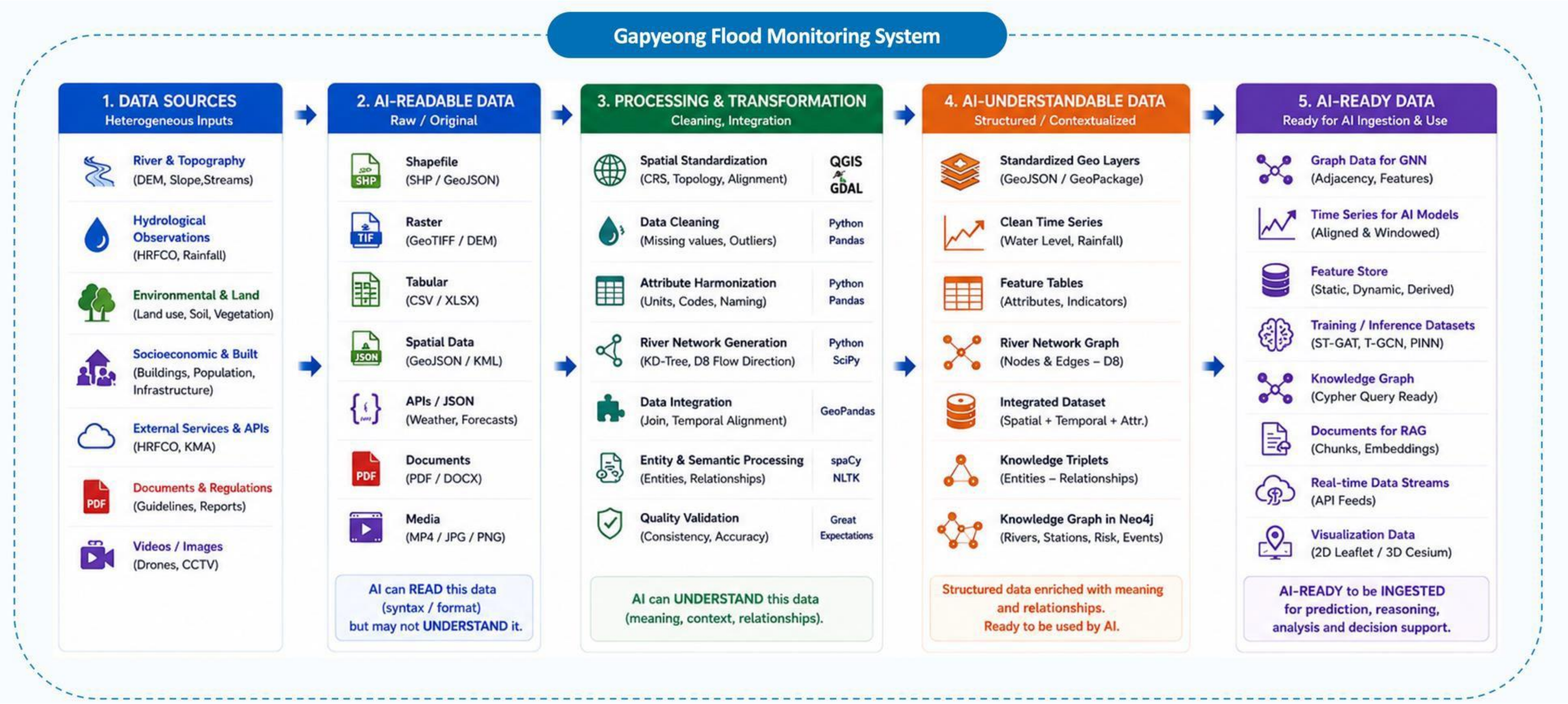


Non-negotiable steps

- CRS, units, formats and timestamps must be harmonized.
- Missing values, duplicates and outliers must be checked.
- Spatial joins, temporal alignment and entity resolution connect data sources.
- Final outputs include feature stores, graphs, embeddings and time series.

Gapyeong pilot: converting local disaster data into AI-ready resources

The pilot shows how Korean local-government datasets can support AI prediction and reasoning.

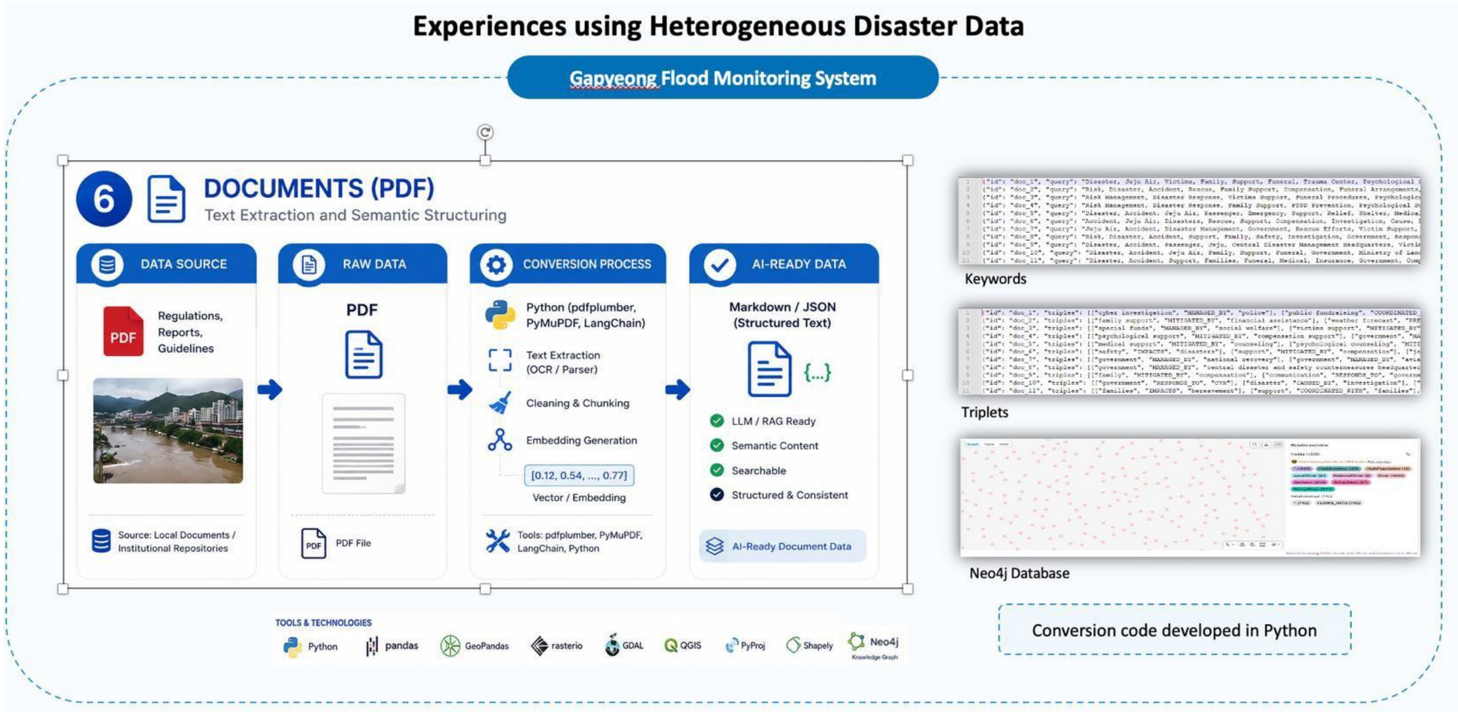


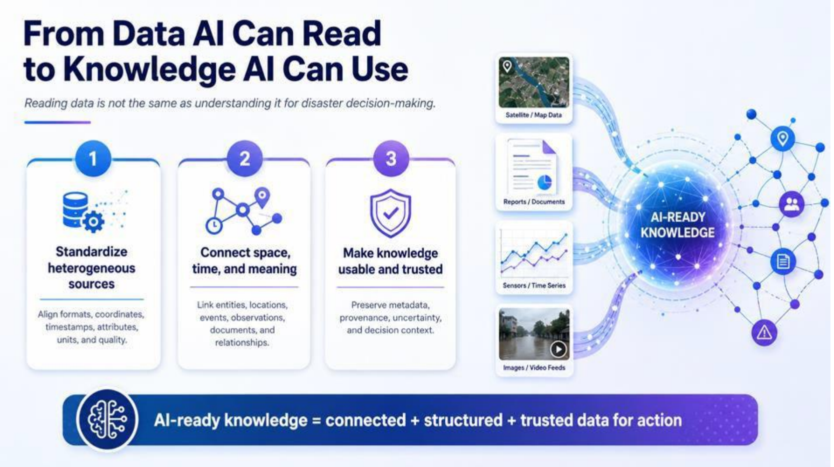
- River networks, catchments and stations → graph data.
- DEM, slope, land cover and imagery → optimized raster layers.
- Water level, rainfall and flow → aligned time series.
- Population, buildings and land use → exposure and vulnerability attributes.
- Documents and reports → chunks, embeddings and knowledge graph nodes.

Knowledge graphs and RAG connect events, places, observations and documents

From readable data to usable knowledge

AI agents need structured evidence, not disconnected files.



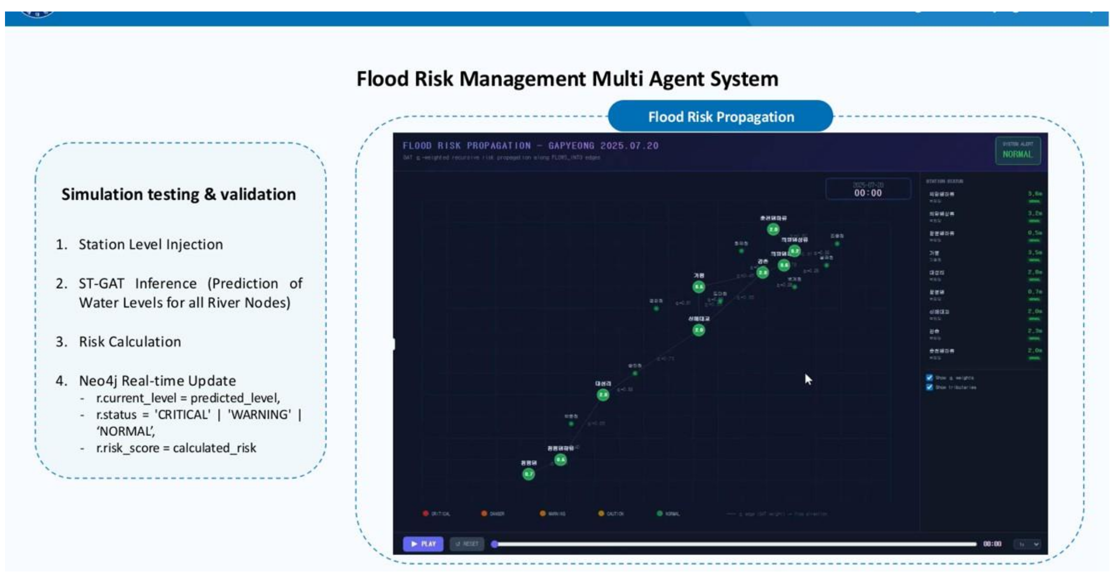


Why this is important

- Links hazard events with locations, observations, assets and reports.
- Supports question answering with source-grounded evidence.
- Makes AI explanations more traceable for decision-makers.
- Creates a bridge to international identifiers and taxonomies.

04 Prediction, Reasoning & Agents

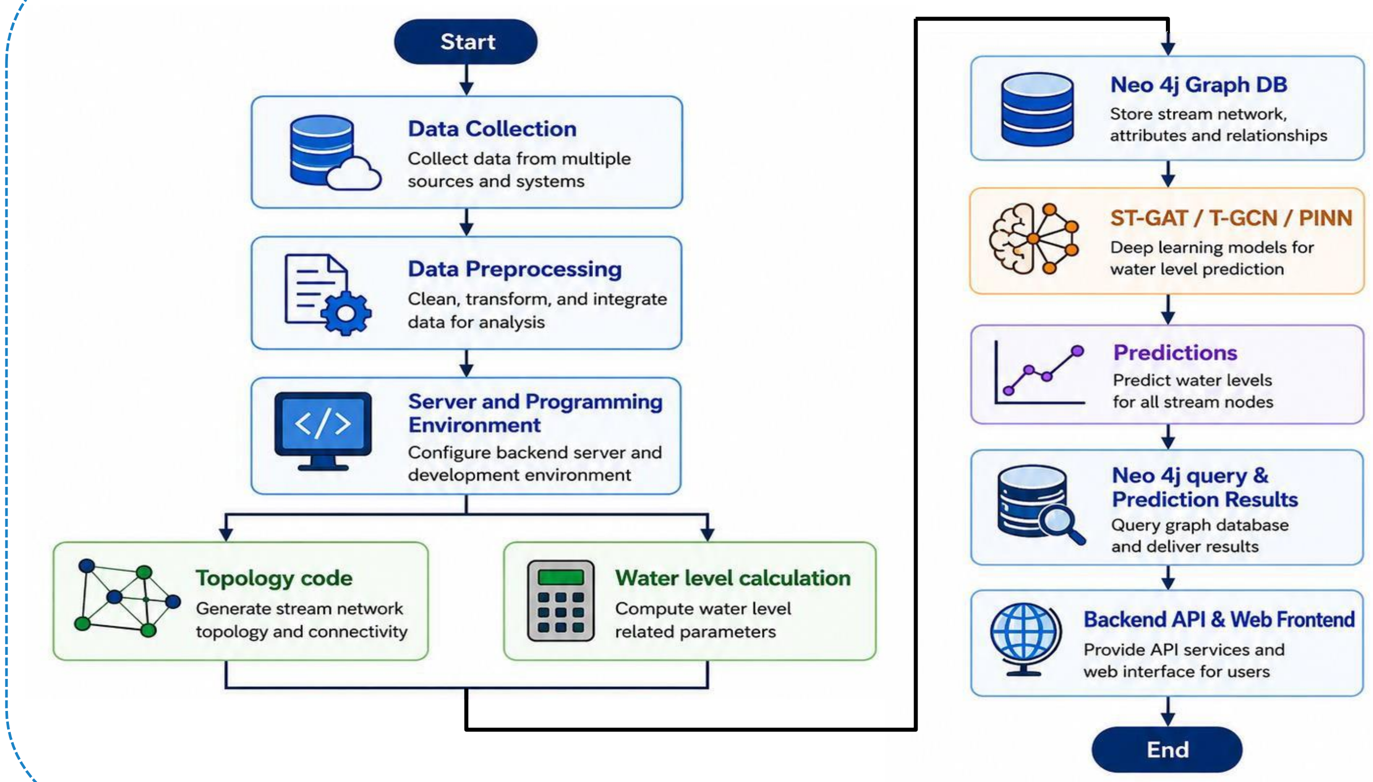
Combining GNNs, knowledge graphs, RAG and human review for decision support



Prediction layer: river networks can support spatiotemporal AI models

Graph-aware models can learn how water-level signals propagate through connected stream networks.

Flowchart



Description:

- Multiple spatial and hydrological datasets are integrated into a unified river network database.
- The information is stored in Neo4j and used to train graph-based water-level prediction models.
- Results are then delivered through web-based 2D and 3D visualization systems.

In Korea, small-stream and local flood risk require prediction at the network scale, not only at individual gauges.

Flood Risk Management Multi Agent System

Simulation testing & validation

1. Station Level Injection
2. ST-GAT Inference (Prediction of Water Levels for all River Nodes)
3. Risk Calculation
4. Neo4j Real-time Update
   - r.current_level = predicted_level,
   - r.status = 'CRITICAL' | 'WARNING' | 'NORMAL',
   - r.risk_score = calculated_risk

Flood Risk Propagation

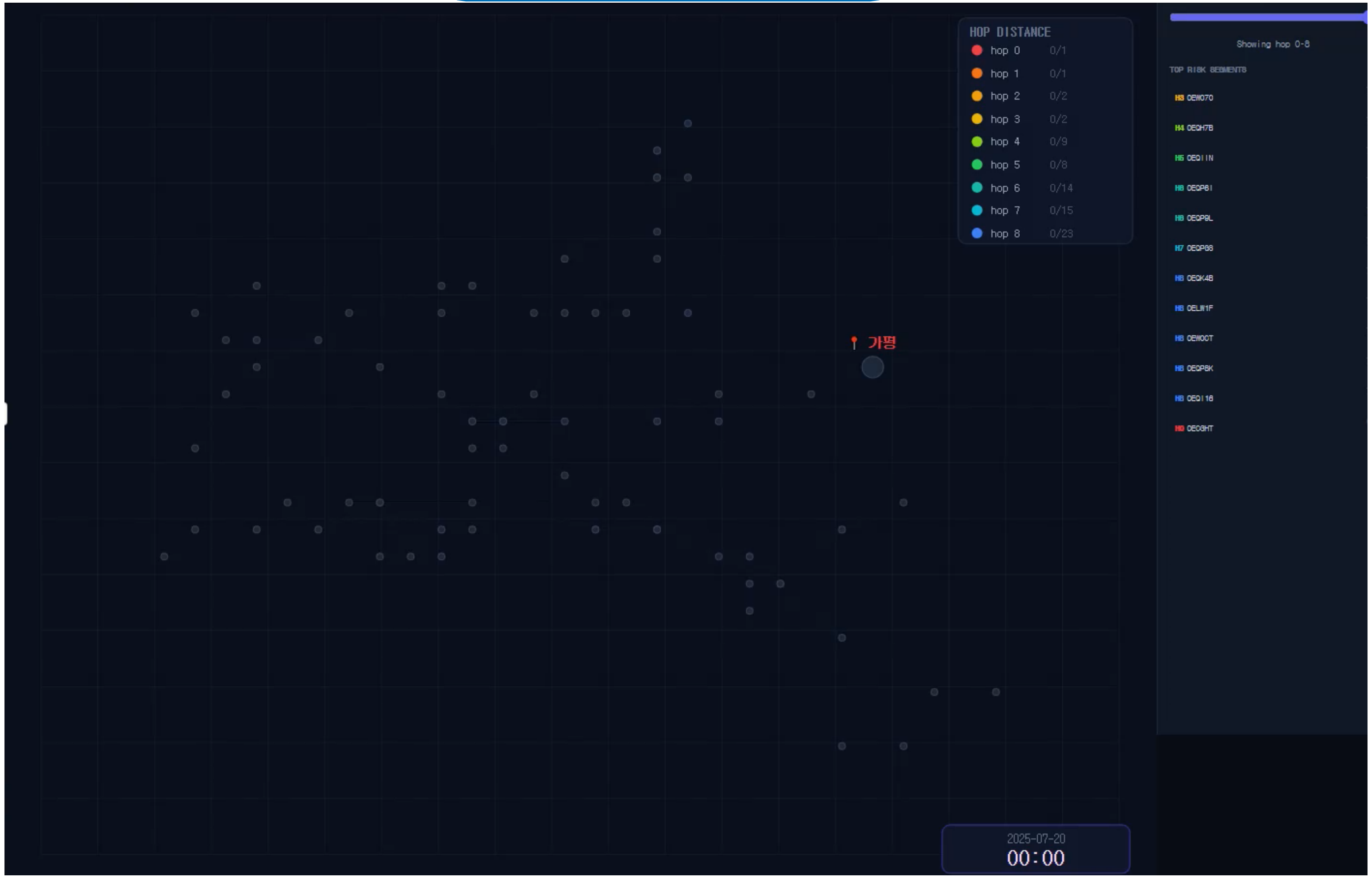
Flood Risk Management Multi Agent System

The 5th IDRLF
International Disaster Resilience Leaders Forum Incheon 2026

Simulation testing & validation

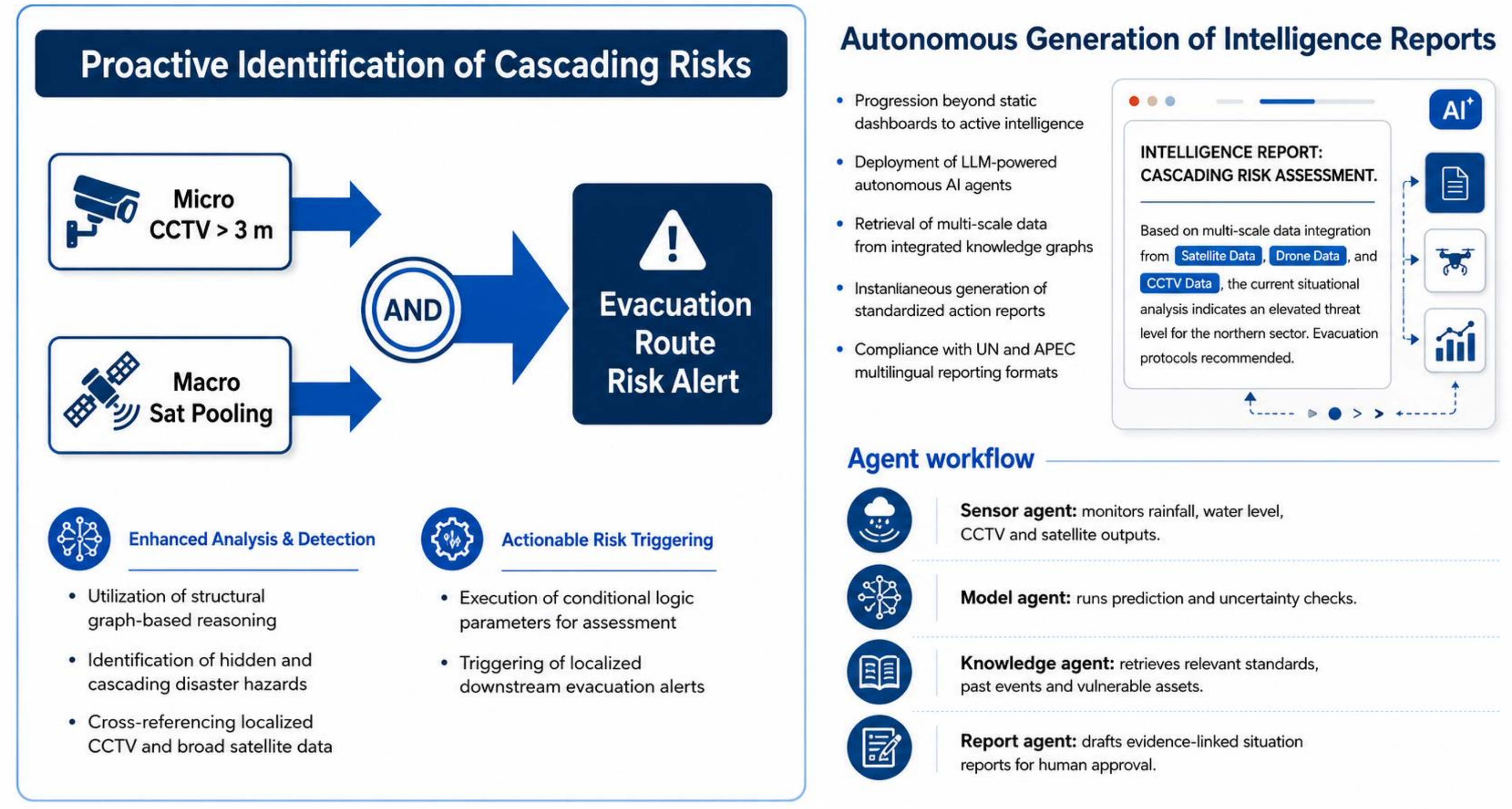
1. Station Level Injection
2. ST-GAT Inference (Prediction of Water Levels for all River Nodes)
3. Generation of connectivity and influence
4. Ratio = predicted_level / baseline_level
   - if ratio >= 2.5: CRITICAL (Risk 95+, red)
   - if ratio >= 1.5: WARNING (Risk 60+, orange)
   - else: NORMAL (Risk 15, green)

Flood Risk Propagation



AI agents should orchestrate evidence, not replace responsibility

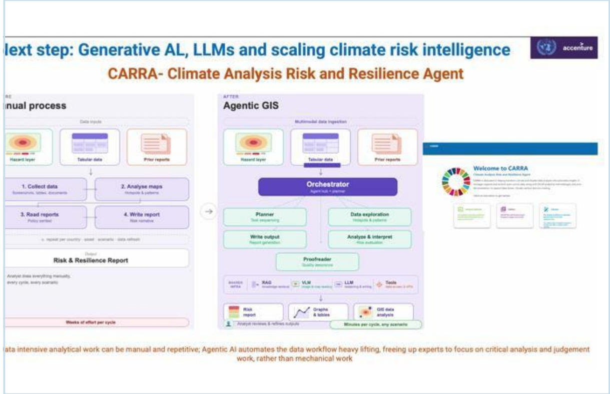
The best role for agents is to connect data, models, knowledge and reporting under human review



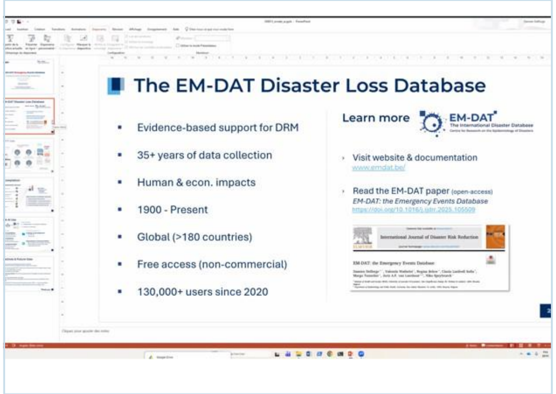
Responsible use and cooperation: Korea can connect with global disaster-data systems

The 5th IDRLF International Disaster Resilience Leaders Forum Incheon 2026

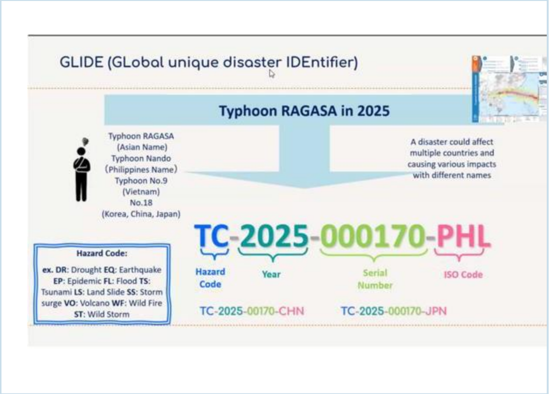
The next strategy is to connect Korea’s technical pipeline with regional and global disaster-data systems.



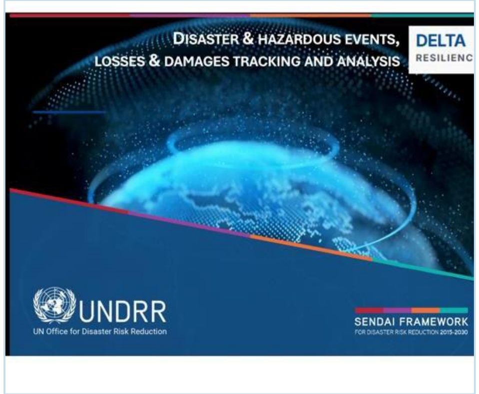
ESCAP CARRA / agentic GIS



EM-DAT disaster loss data



GLIDE identifier



UNDRR DELTA

Cooperation priorities

- Map domestic hazard categories to international reference taxonomies.
- Use identifiers such as GLIDE to link cross-border and multi-country events.
- Connect AI-ready data through APIs, metadata and provenance records.
- Build human-in-the-loop quality control into shared workflows.
- Pilot Korea–partner-country flood and landslide workflows with regional platforms.

Closing: three practical strategies

for AI-enabled complex disaster prevention and management

1. Build AI-ready knowledge Standardize data before modeling

2. Validate AI with analytics Combine model speed with geospatial rigor

3. Scale through cooperation Link Korea's pipelines with EM-DAT, GLIDE, DELTAand ESCAP

Take-home message

Trusted AI for complex disasters begins with AI-ready knowledge, is strengthened by analytical validation, and scales through responsible regional cooperation.