# Satellite-Based Flood Monitoring and Early Warning Systems for Disaster Risk Reduction in Nepal


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# Objectives of the Study

i. Integrate EO satellite data for flood detection and forecasting

ii. Develop near-real-time monitoring workflows

iii. Support disaster risk reduction strategies

# Background

- Nepal is one of the most disaster-prone countries in South Asia, owing to its turbulent geological and meteorological position.
- Nepal have long been subject to recurring earthquakes, flooding, landslides, and a broad array of other hazard regimes (these hazards combine to produce complex, cascading disasters ).
- Introduces new risk factors and patterns of vulnerability which may amplify the impacts of cascading disasters.

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- Debris floods, like the 2021 Melamchi Disaster, are the result of cascading hazards.
- Predicting the likelihood and severity of debris floods and extreme flow events requires complex monitoring and assessment methods.

- Need for near-real-time flood monitoring and early warning

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- Five physiographic regions:(the Terai, Siwaliks, Middle Mountains, High Mountains, and Himal)
- Elevation ( 60m asl in the south to 8,848.6m asl in the north) within a short horizontal distance of less than 200 km.
- Nepal ranks 12th in the world in terms of the proportion of the population exposed to the threat of floods annually (24%) (UNDP 2004).

# Flood Hazards in Nepal

- Flash floods
- Riverine floods
- Glacial Lake Outburst Floods (GLOFs)
- Major basins affected: Koshi, Narayani, Karnali


- This event has been attributed to the rapid expansion and sudden drainage of a supraglacial lake system that formed atop the Purepu Glacier, approximately 35 kilometers upstream from the Nepal-China border at an elevation of about 5,150 meters above sea level.
- The flood occurred without warning at 3:15 a.m. Nepal time (5:30 a.m. Beijing time), and no alerts were issued in advance. As of one week later, eleven people were confirmed dead and 17 remain missing, including both Nepali and Chinese nationals.

Flood Aftermath, 2025, Nepal

31st May 2025

# Pre-monsoon (March – May, 2025) Precipitation Monitoring

Precipitation monitoring of 20 stations (Average): — Daily accumulated precipitation — Daily accumulated normal *mm → millimeter

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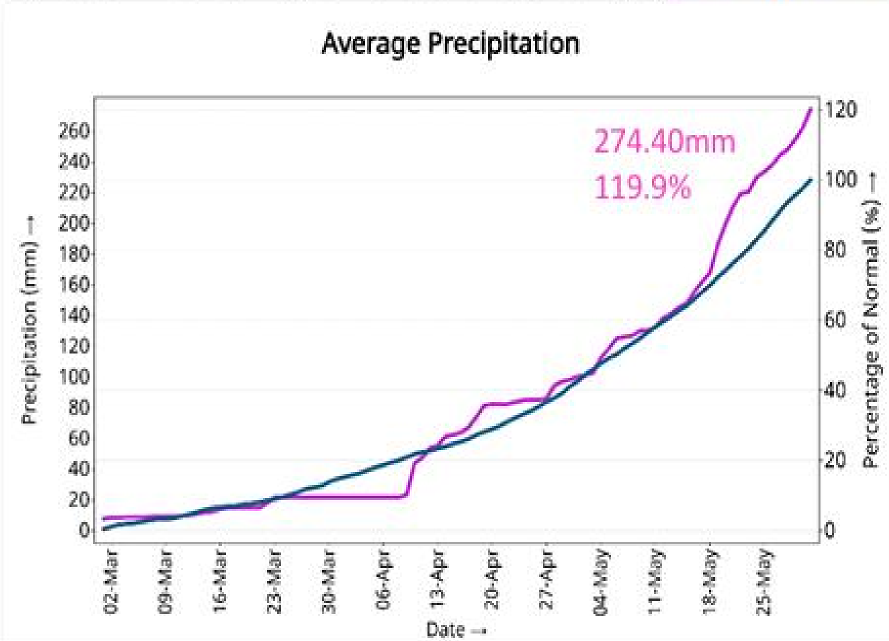
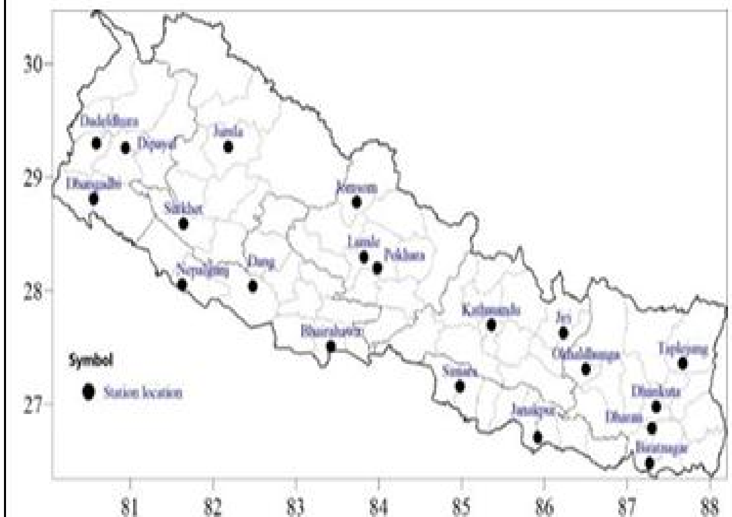
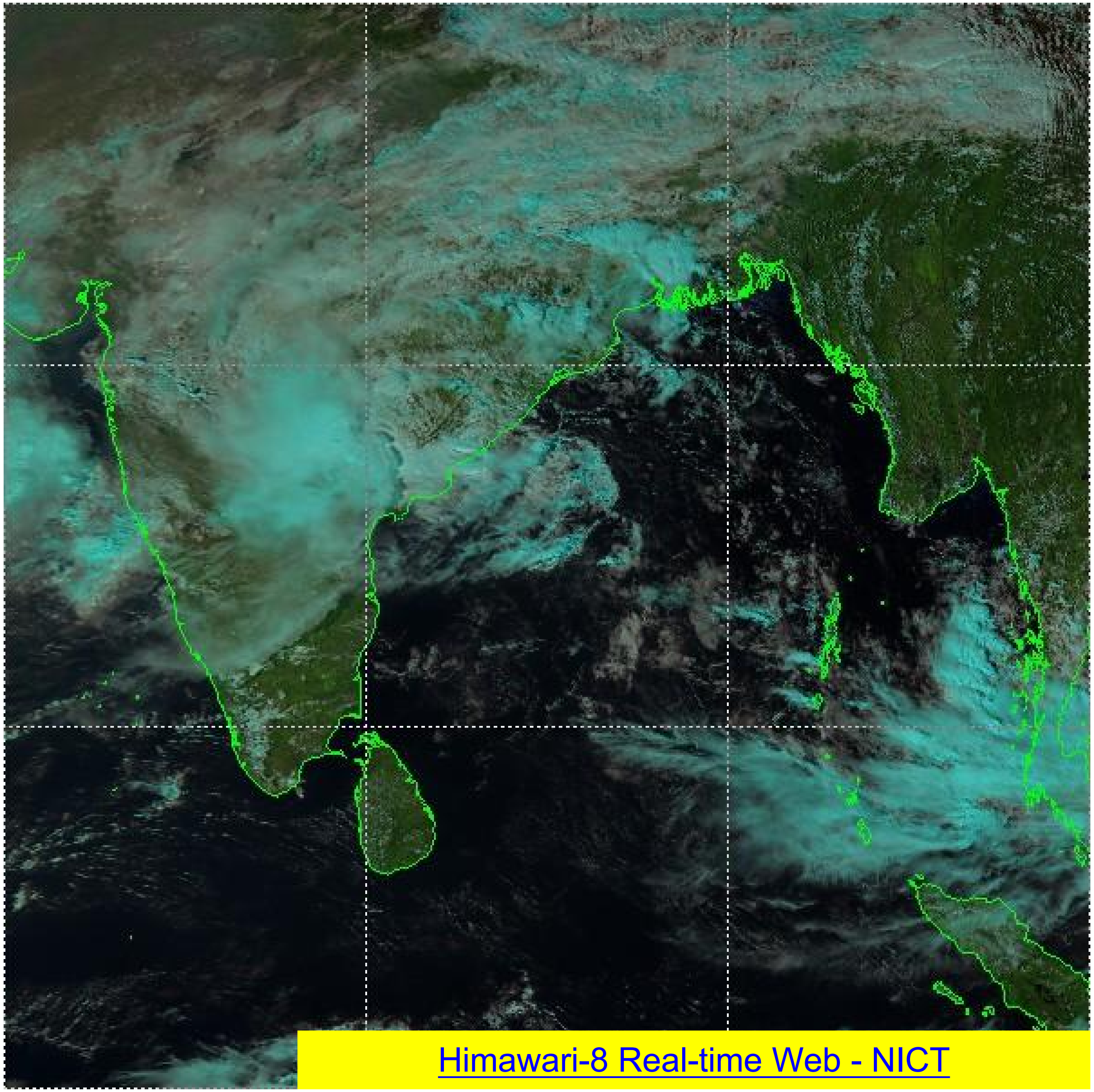
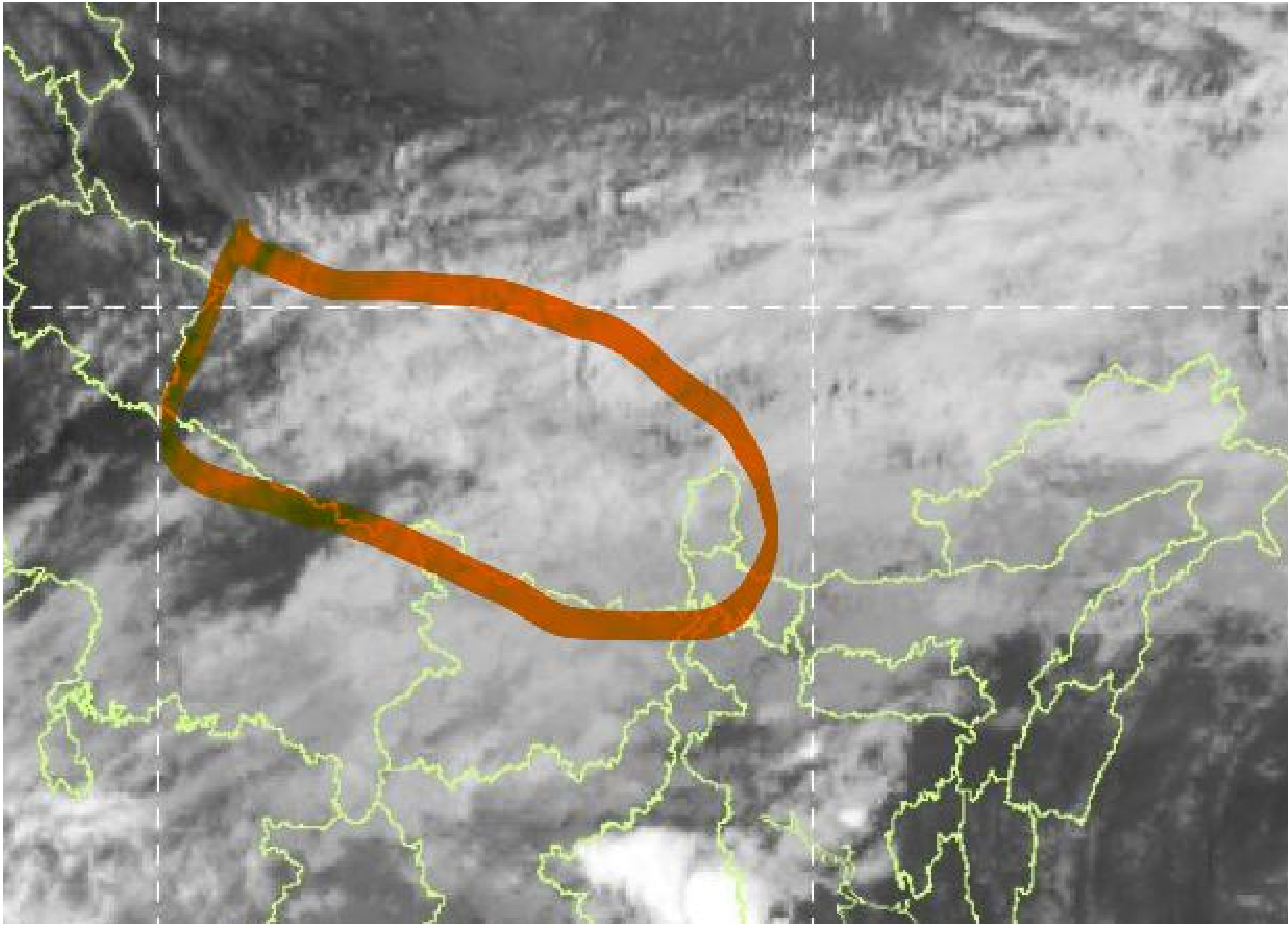
|  |  |
| Figure: Blue solid line indicates the average of daily accumulated normal precipitation of 20 stations during Pre-monsoon season and purple solid line indicates the average of daily accumulated precipitation. | Map: Location map of 20 stations used in the report. |


Himawari-8 Real-time Web - NICT



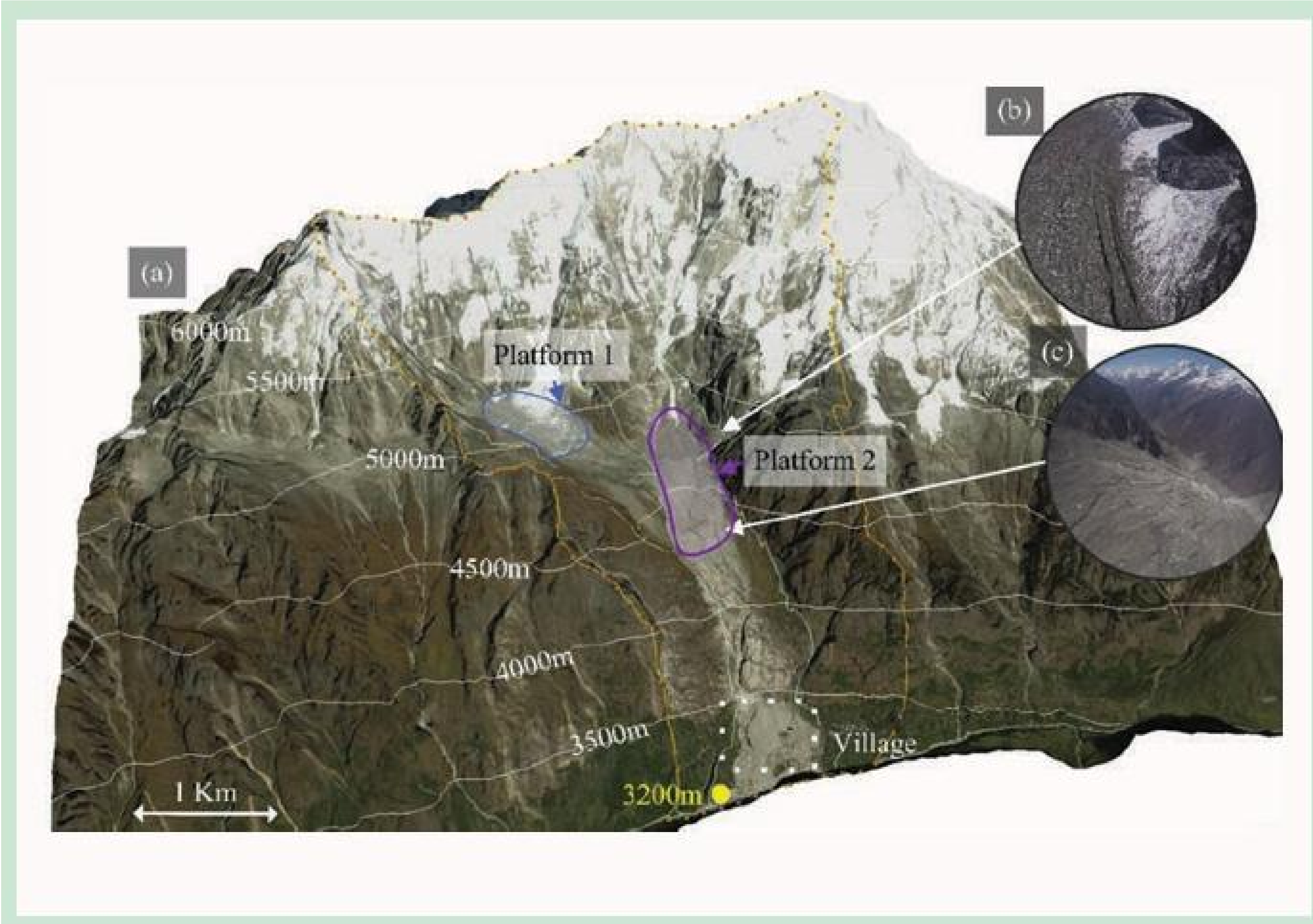



Fig: Multi-stage analysis of the Langtang Avalanche from *Gnyawali et al* (2020)

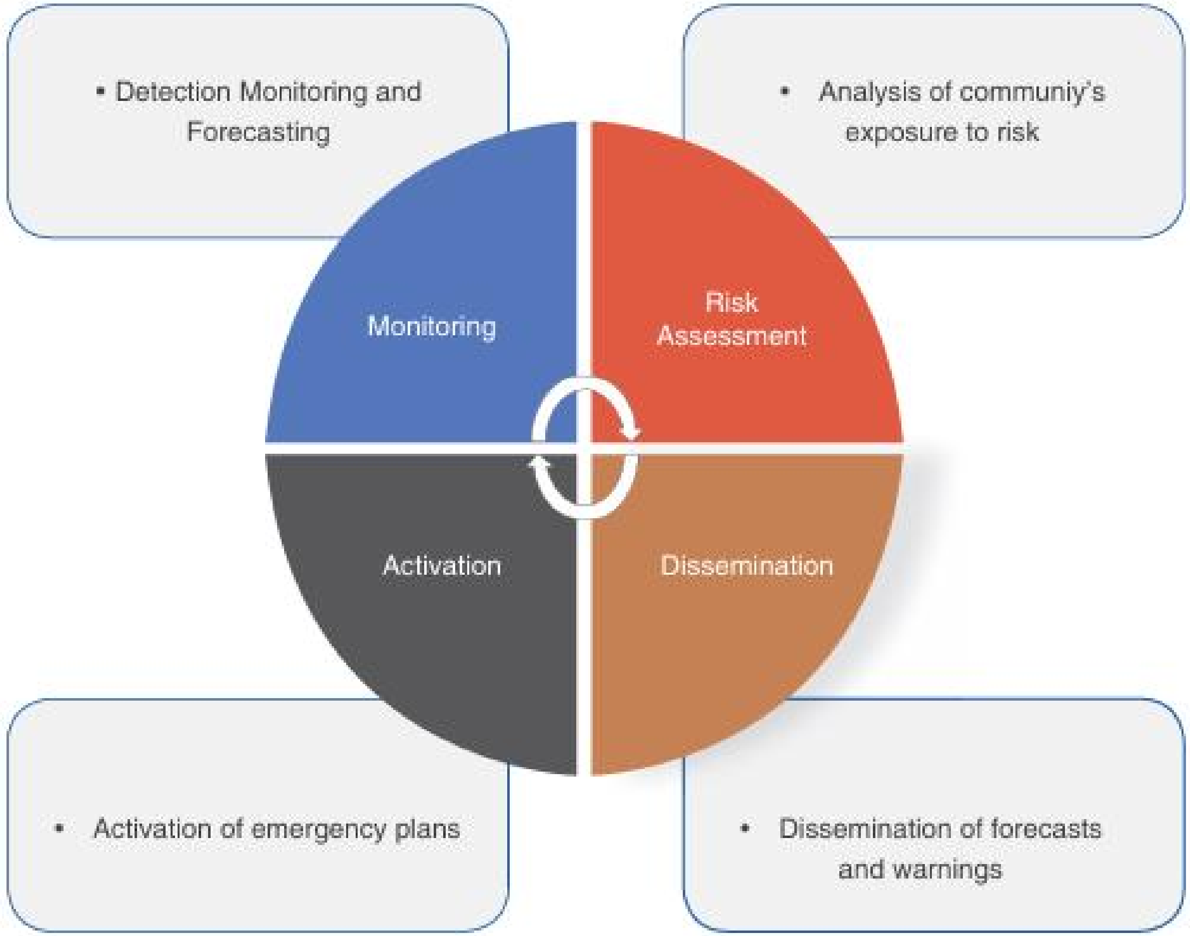
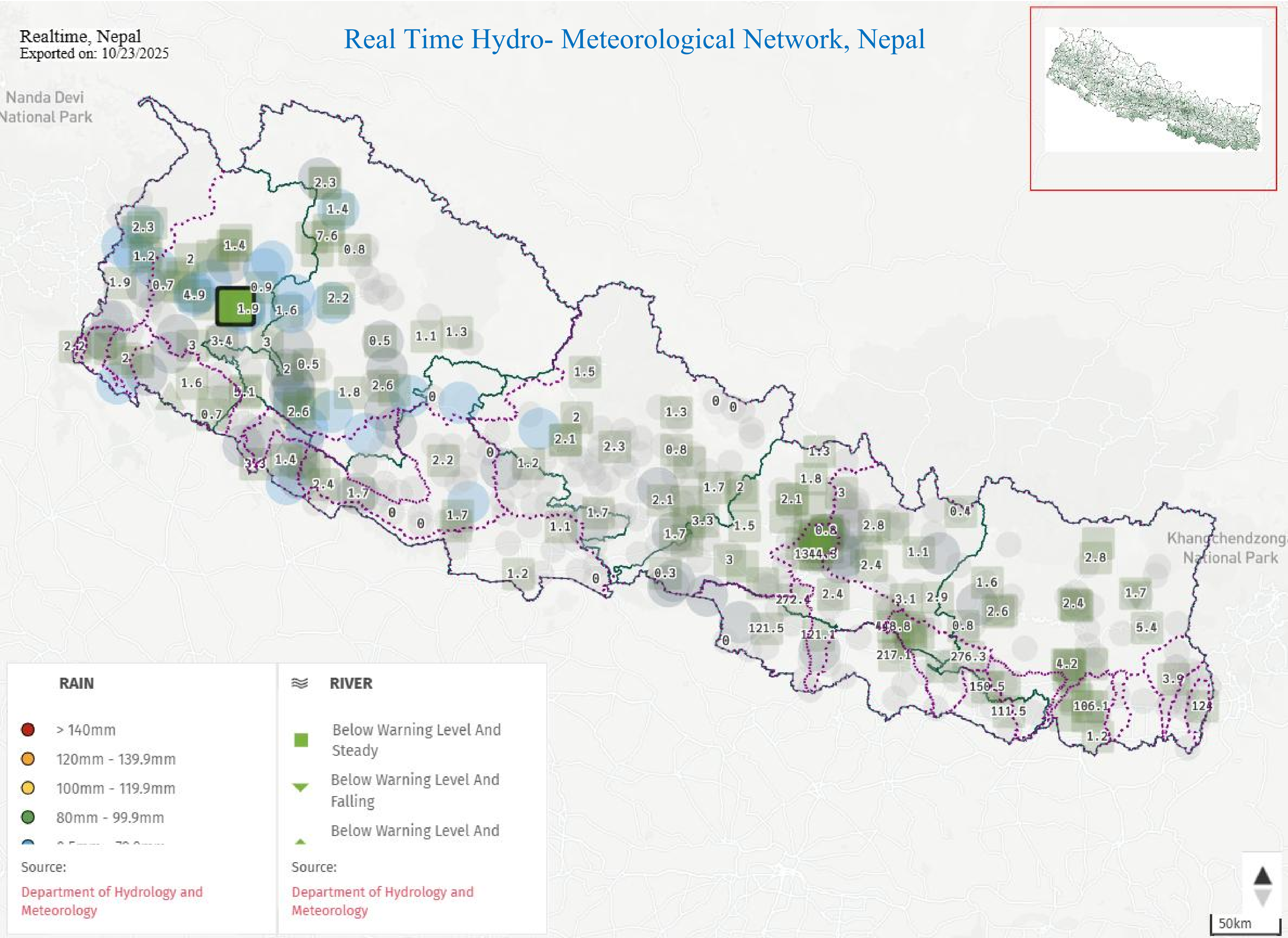



Fig: Four components of early warning systems adapted in Nepal

## Importance of Flood Early Warning Systems:

- Get advance notice of some selected hazards such as floods.
- Early Warning Systems can help to reduce casualties and damages.
- Vulnerable people can be informed ahead of the hazard.
- Can transfer moveable items to safer grounds.
- EWS contribute in protecting and supporting sustainable social and economic development.

# Real Time Hydro- Meteorological Network, Nepal



# Impacts of Floods

- Infrastructure damage and agricultural losses.
- Displacement and livelihood disruption.
- Long-term socio-economic consequences.

# Nepal Disaster Risk Reduction Portal

- Building Information Platform Against Disaster (BIPAD):The platform does not currently support real-time analysis of risk factors or trends.
- Hydrology Portal: Allows users to check rainfall in many localities around the country and see flood warnings.

# Need for Satellite-Based Monitoring

- Sparse ground observation network.
- Difficult terrain for gauging stations.
- Satellites provide consistent and wide-area coverage.

# Satellite Data Used

- Fengyun / Himawari – Meteorological (Rainfall & storm tracking)
- Sentinel-1 SAR – Radar (All-weather flood mapping)
- Sentinel-2 / MODIS – Optical (Post-flood assessment)

# Methodological Framework

- Rainfall monitoring using Fengyun & Himawari,
- SAR flood mapping (Sentinel-1).
- Hydrological modeling and integration into Early Warning System (EWS).

# Fengyun & Himawari for Rainfall Monitoring

- ✓ Provide hourly data and storm trajectory
- ✓ Useful for real-time rainfall estimation

# Sentinel-1 SAR for Flood Detection

- ✓ C-band SAR allows all-weather imaging.
- ✓ Change detection method to map inundation.

# Sentinel-2 and MODIS for Damage Assessment

- ✓ Optical imagery supports NDWI-based flood mapping.
- ✓ Used for post-event analysis and recovery planning.

# Case Study: Koshi River Basin

- Flood event 2021 – SAR mapping vs. ground validation.
- Improved accuracy of forecasts with integrated data.

# Case Study: Narayani River Basin

- Monsoon 2022 flood monitoring.
- Integrated rainfall data improved forecast lead time.

# Case Study: Karnali River Basin

- Flash flood detection using Himawari and Sentinel-1
- Rapid inundation maps for emergency response.

# Integration into Early Warning Systems

- Linked with DHM Nepal's Flood Forecasting and Warning Center
- Web dashboards and SMS alert dissemination

# Challenges/Gaps Assessment

- Needs to introduce a system of flood assessment that follows the standard international practices.
- Plans and design of new natural disaster mitigation measures.
- Current deficiencies in flood forecasting are being addressed through several projects financially supported by World Bank, UNDP, etc.
- Regional Cooperations: Cross-border data sharing with neighboring countries

# Conclusions

- Satellite-based systems are vital for flood monitoring.
- Integration of multi-sensor data enhances early warning.
- Regional/International cooperation is key to success.

Heartly Acknowledged to: WMO, CMA, HMD

# THANK YOU

## Any questions??

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