CREST-OR

Improving **C**ommunity **Re**silience and **S**ustainability **T**hrough **O**perational **R**esearch Capacity Building in Southeast Asia

Scoping Workshop, 15-16 July 2021

Machine learning in natural hazards

Bùi Quang Thành, Nguyễn Quốc Huy, Vũ Văn Mạnh

July 2021

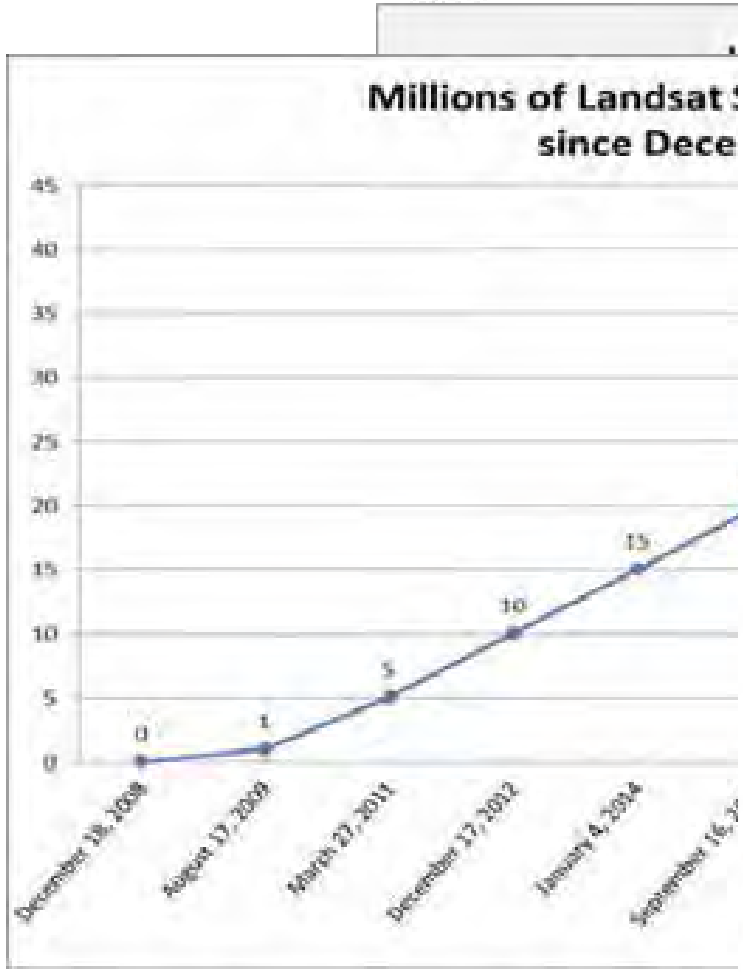
Agenda

- Remote sensing in supporting decision making
- Machine learning in LULC, natural hazards
- Landuse / Landcover classification
- Landslide detection
- Susceptibility mapping (Flood, Landslide)
- Early warning
- Summary

RS in supporting decision making

- Remote sensing technology to support sustainable urban development
- Meet the ever-increasing demand from city-based populations.
- Earth observation to support natural hazard analysis, urban zoning, population density mapping and planning the cities of the future, traffic management

RS in supporting decision making



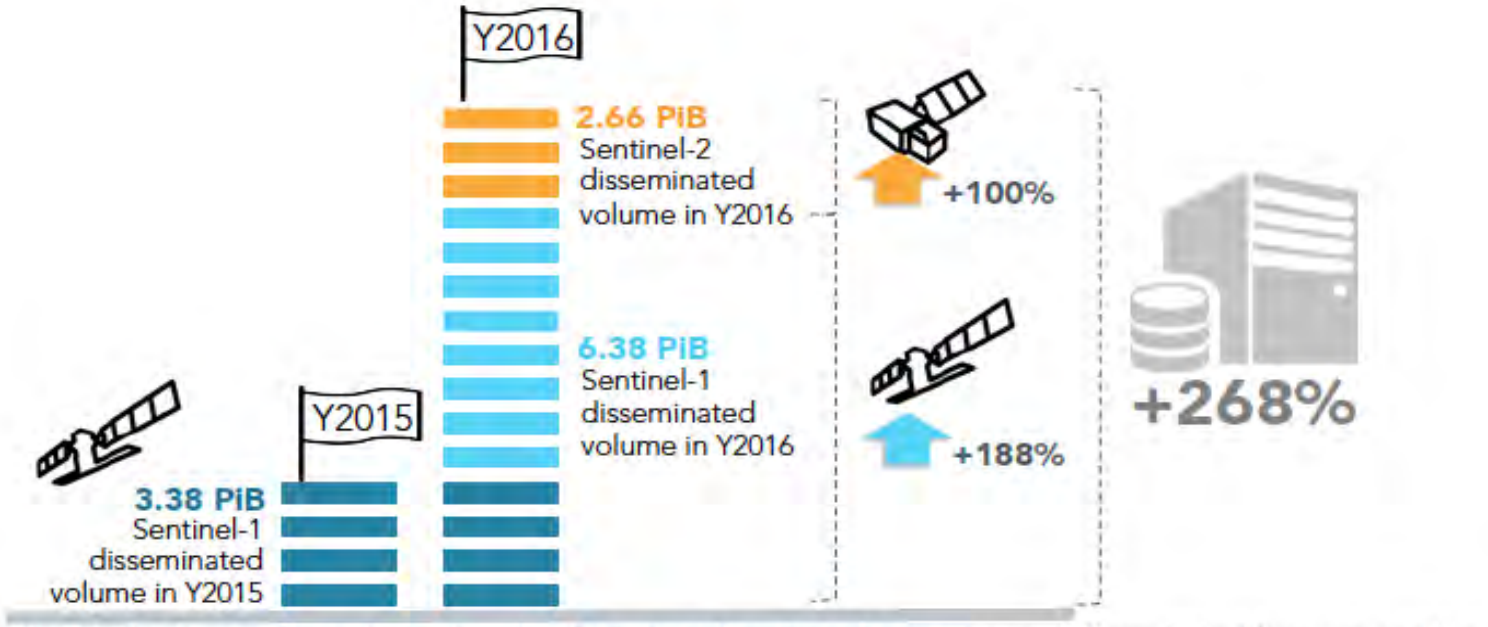


Figure 22: Total volume of products downloaded since the start of operations, differentiated by year and by mission

esa

Digital earth/open – driving forces for remote sensing development

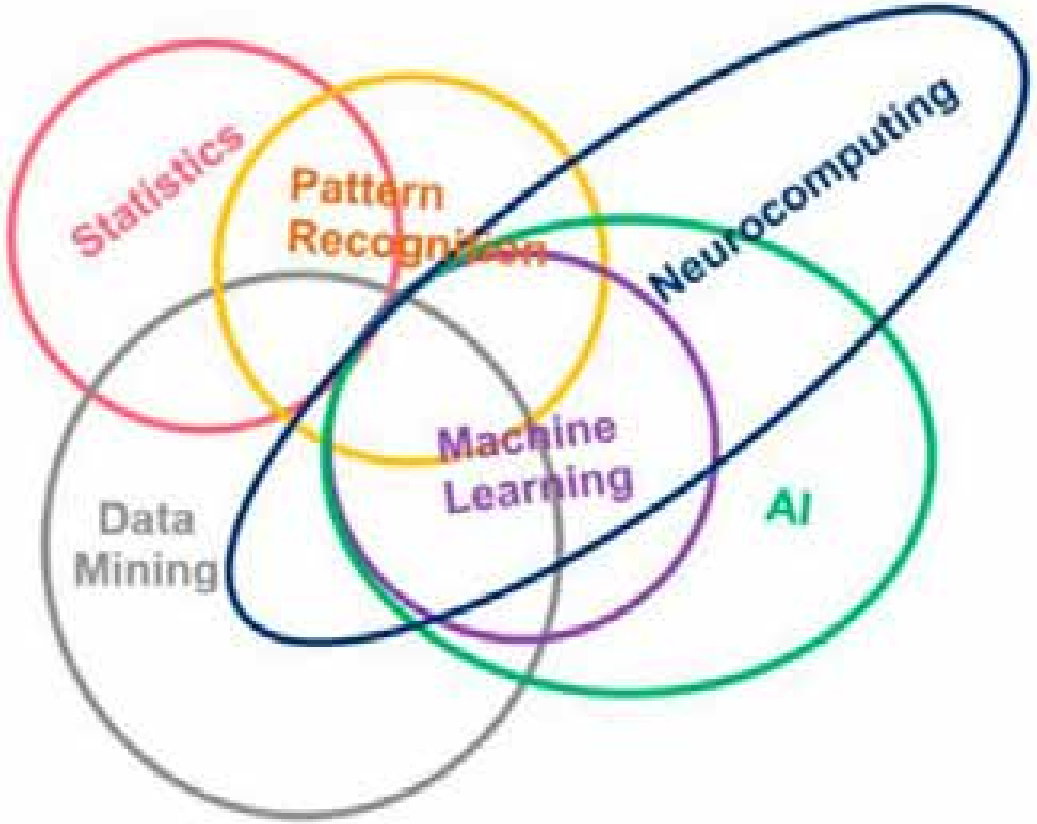
(USGS. 2016)

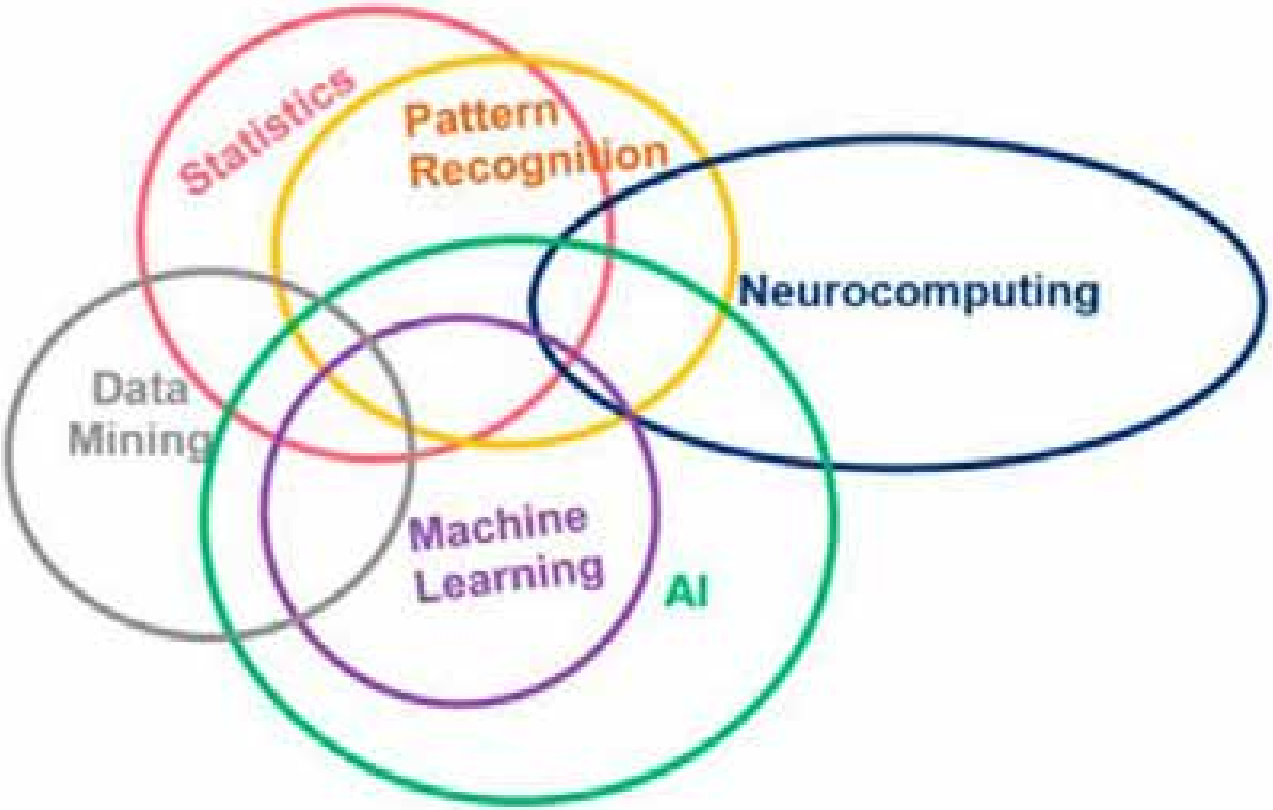
RS in supporting decision making

- Air pollution
- Biodiversity
- Urban and urbanizations
- Climate change and GHG emission
- Food securities
- Ocean research and ocean technology
- Water resources
- ……

- Natural hazards:
  - Landslide, flashflood susceptibility
  - Early warning
- Urban management
  - LULC classification
  - Energy
- ….

Machine learning in LULC, natural hazards

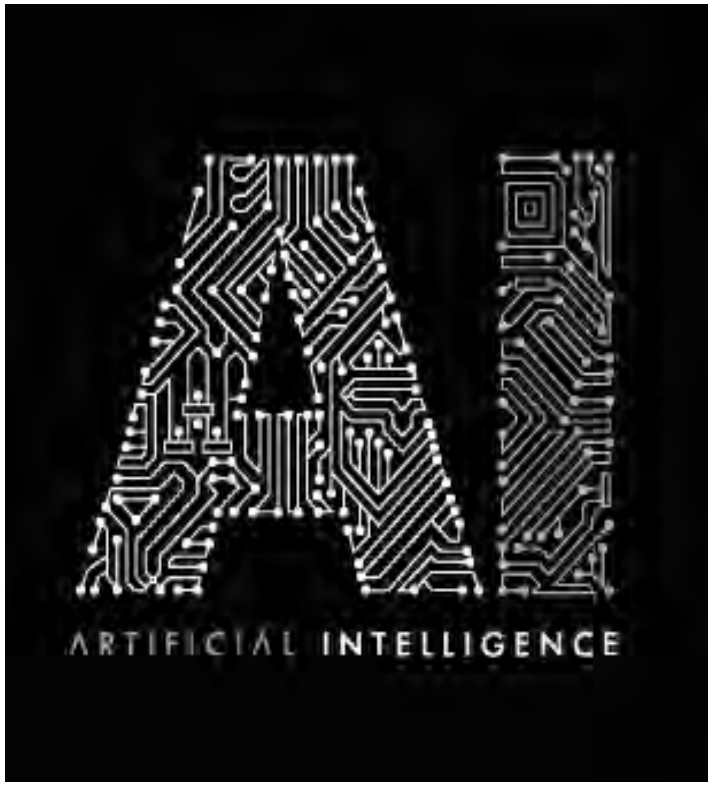


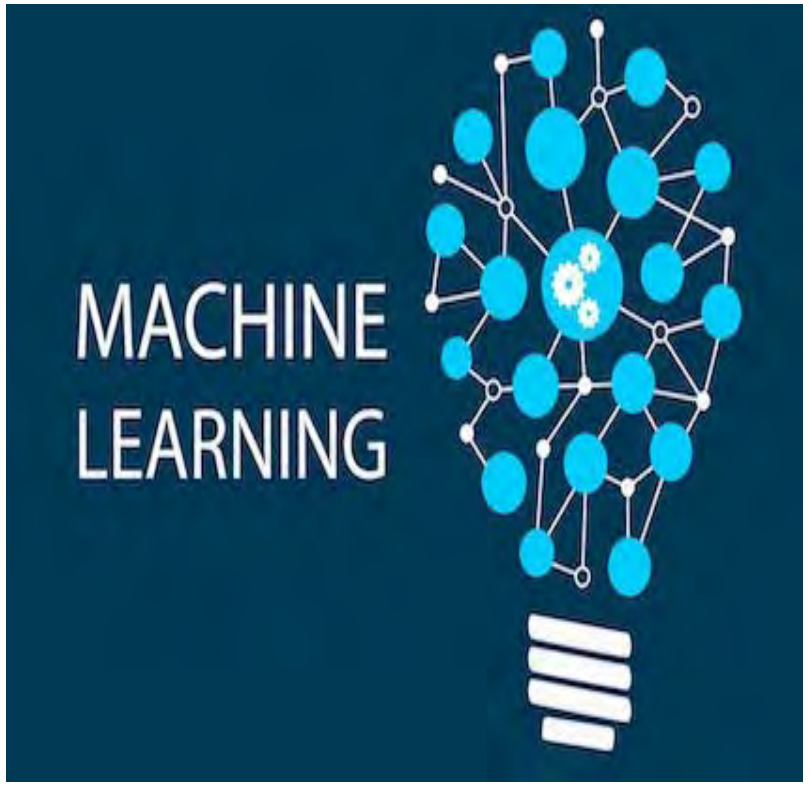


https://www.sciencedirect.com/science/article/abs/pii/S0012825220302713

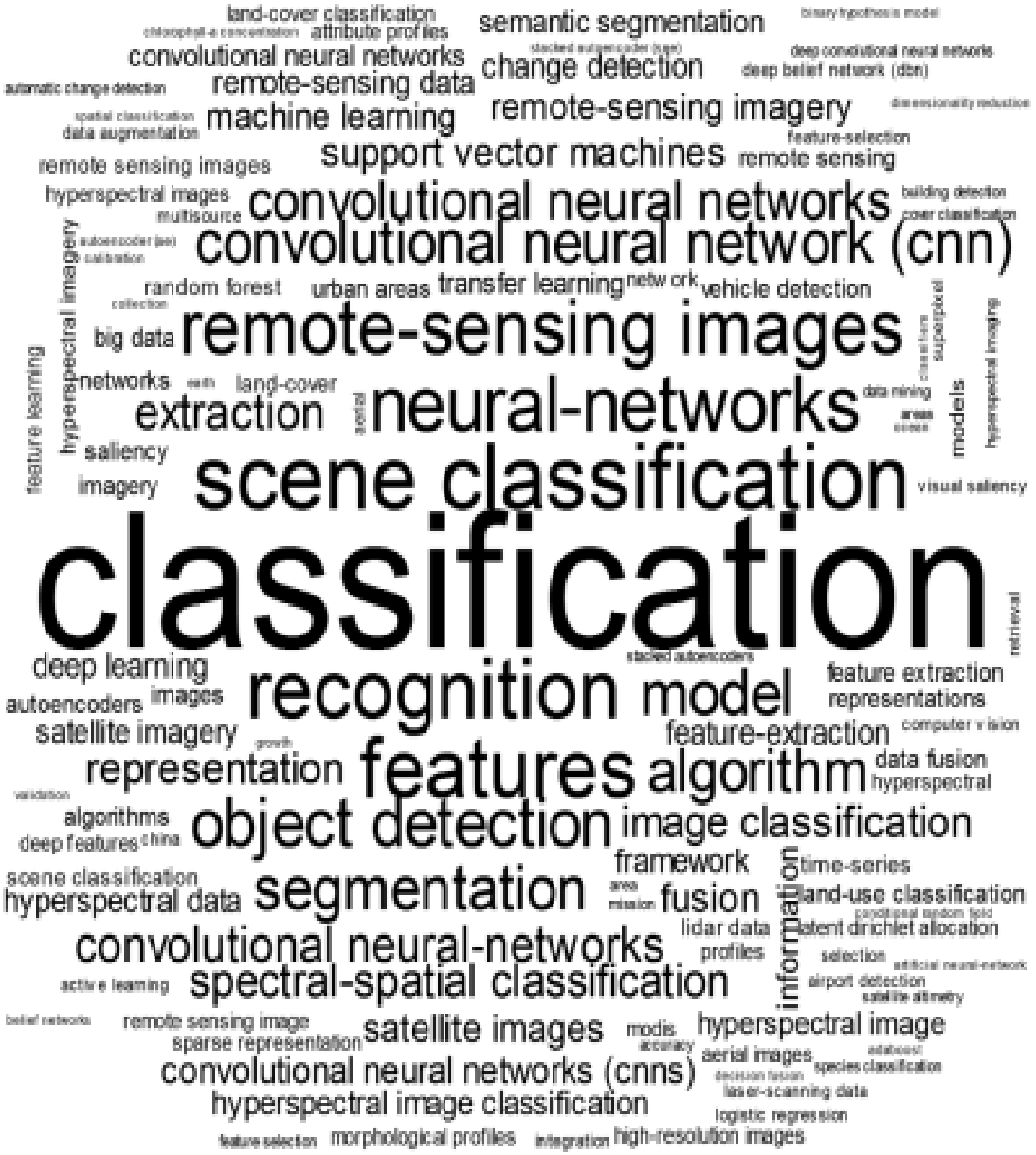
Machine learning in LULC, natural hazards

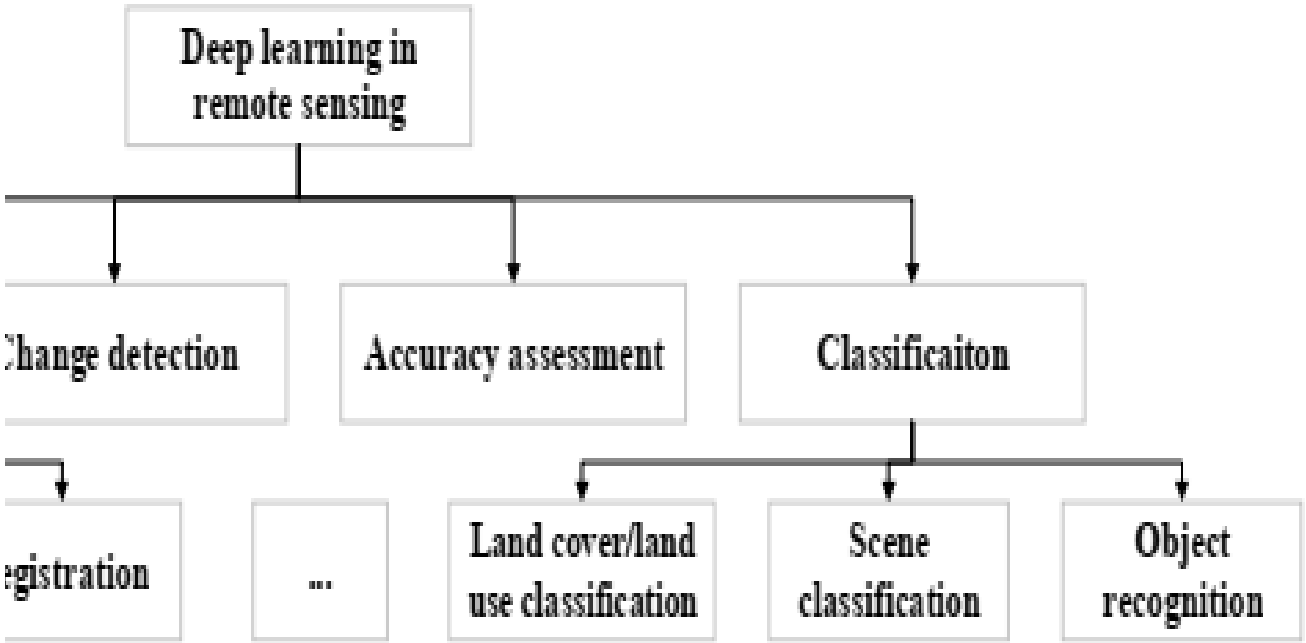
Machine learning in LULC, natural hazards



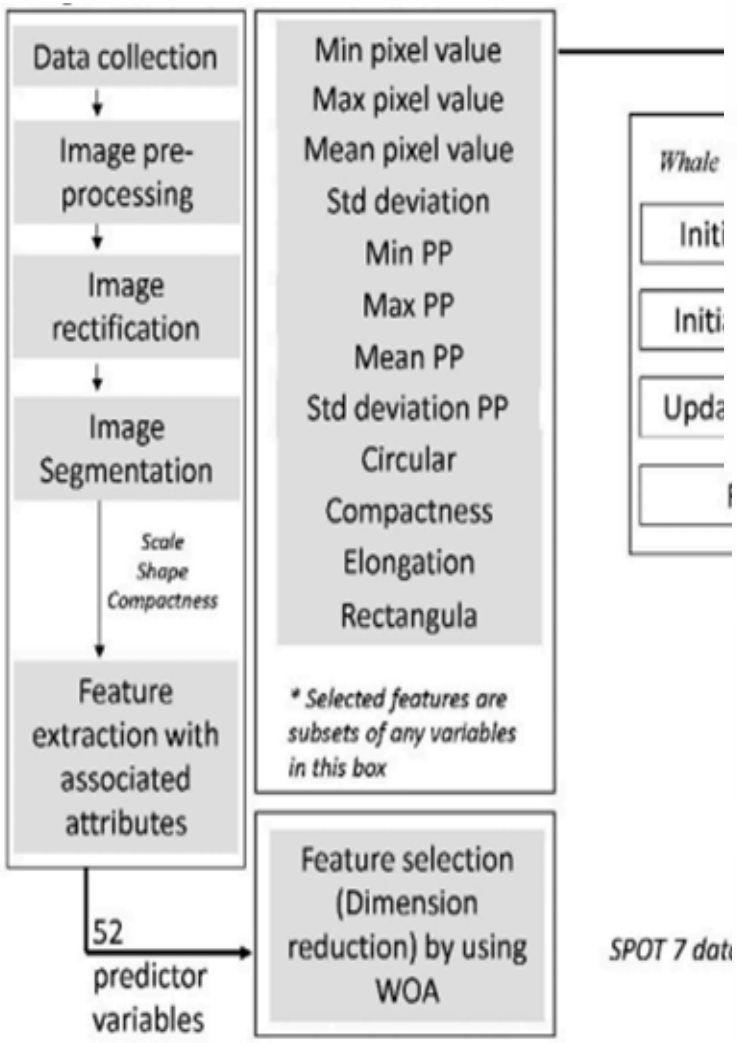


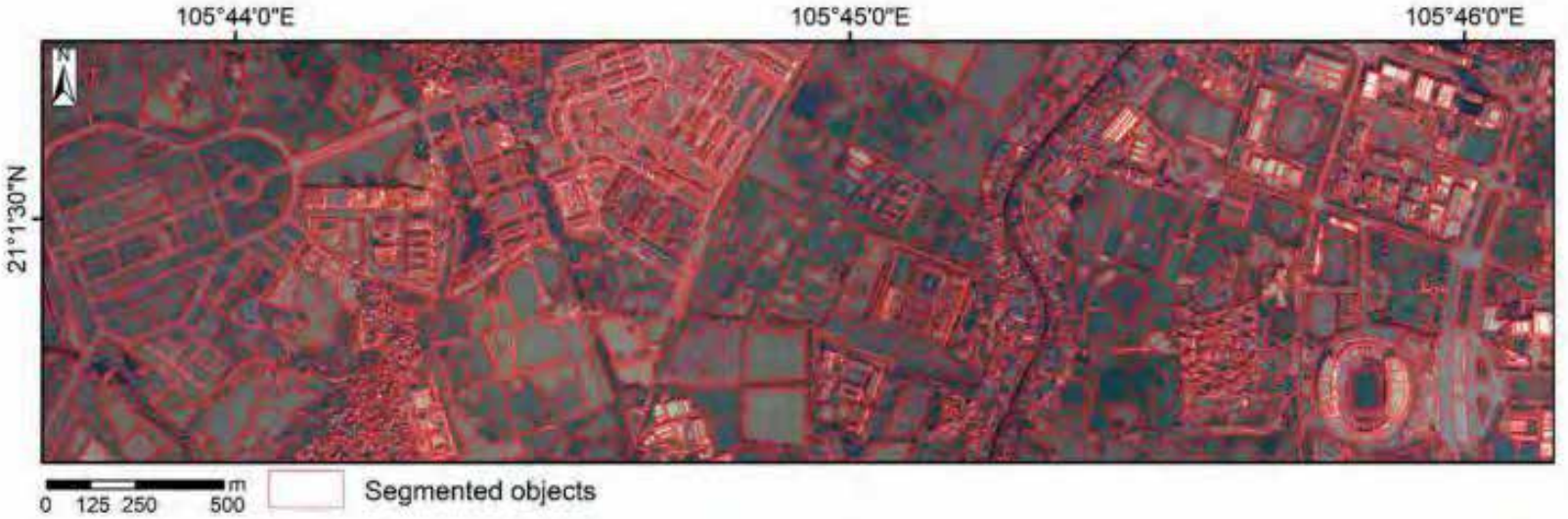
LULC classification

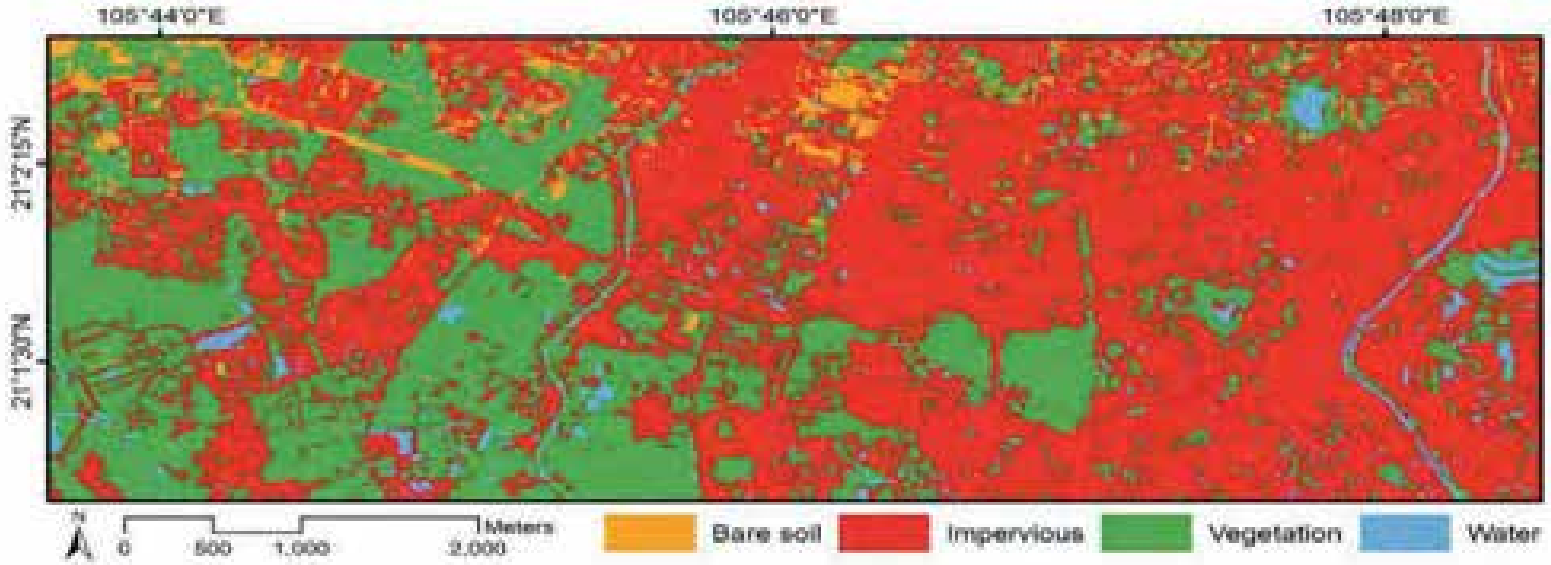




LULC classification







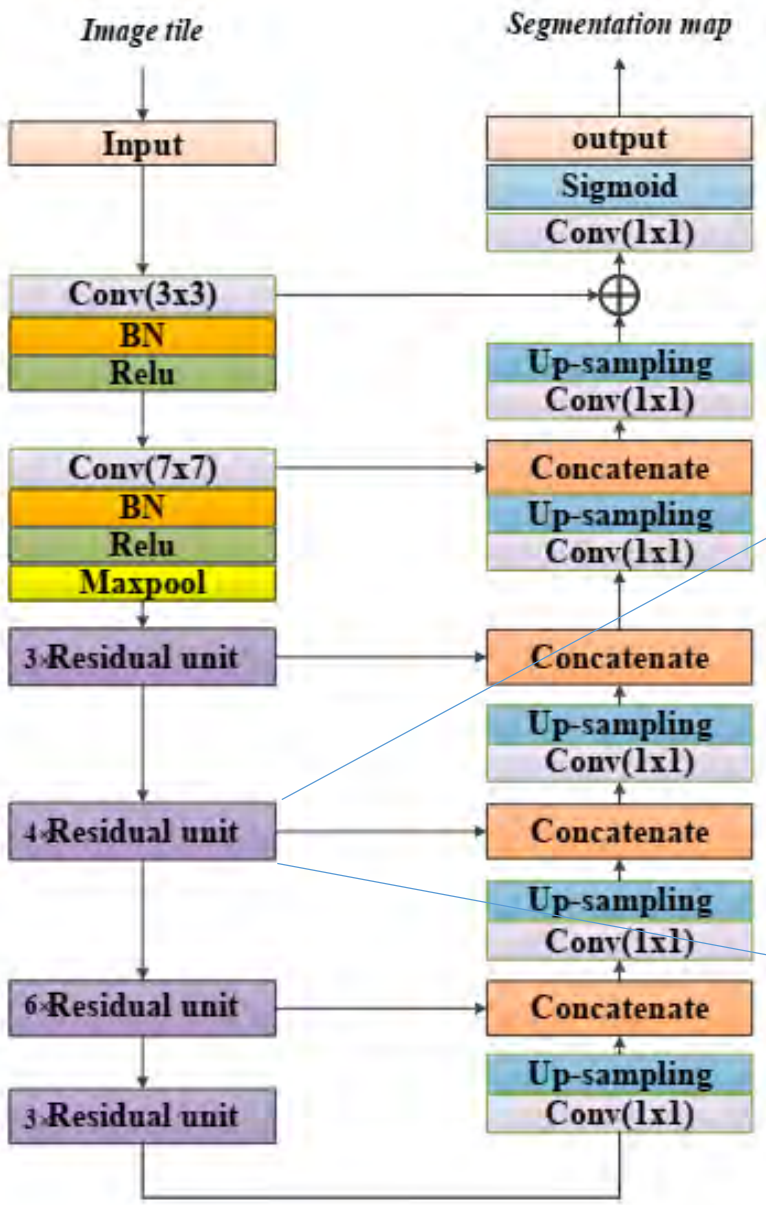
Landslide detection

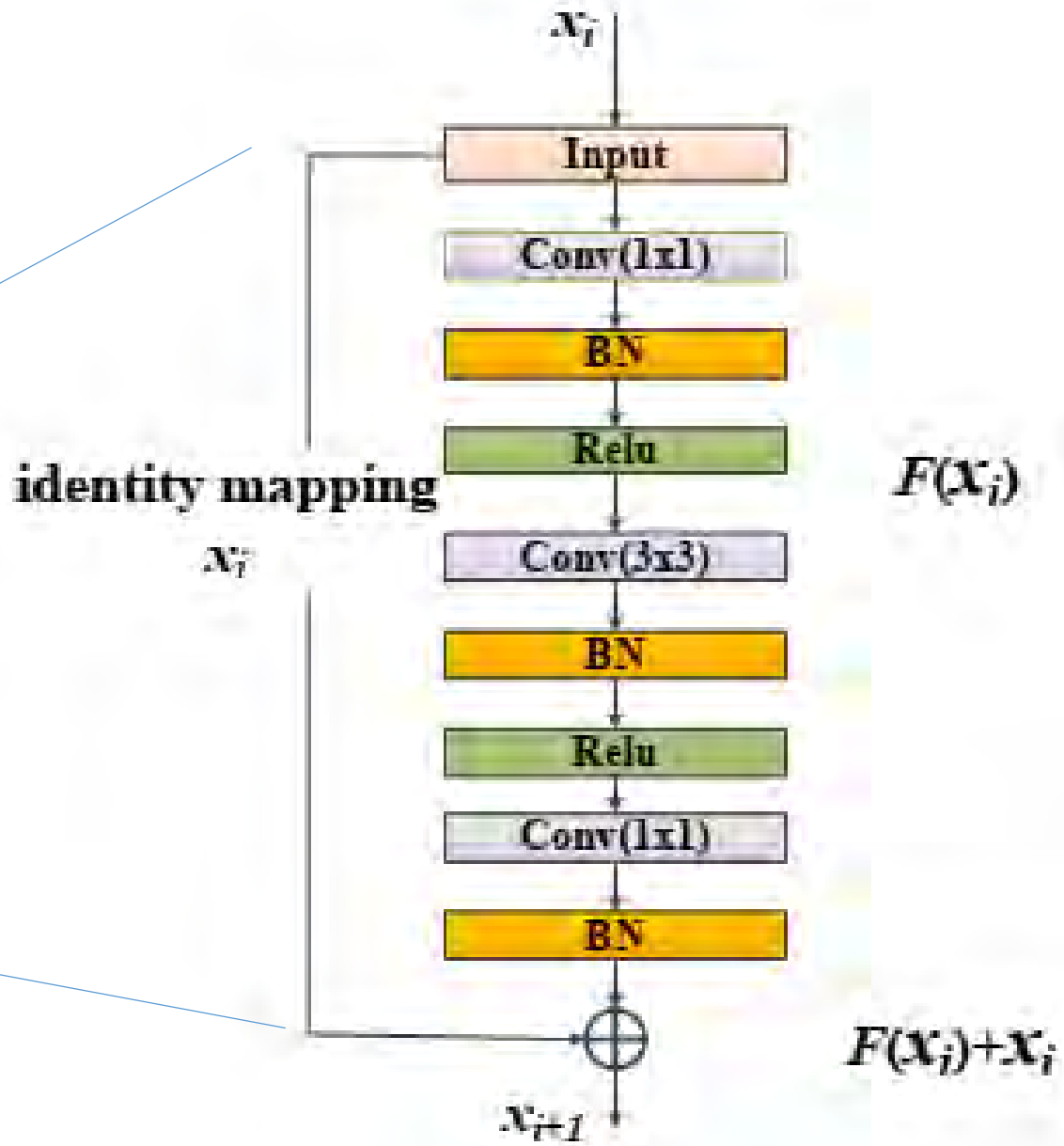
GeoEye-1

0.5 m Pan

1.65 m Multispectral

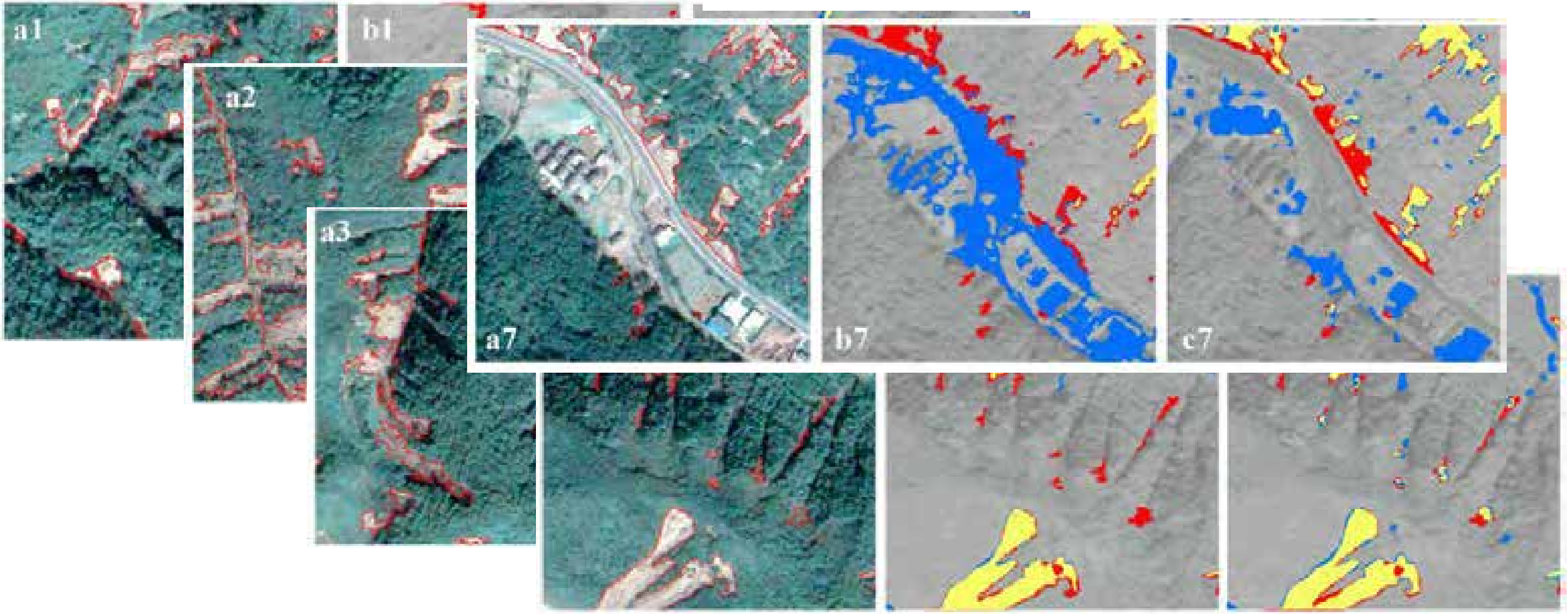
Landslide detection



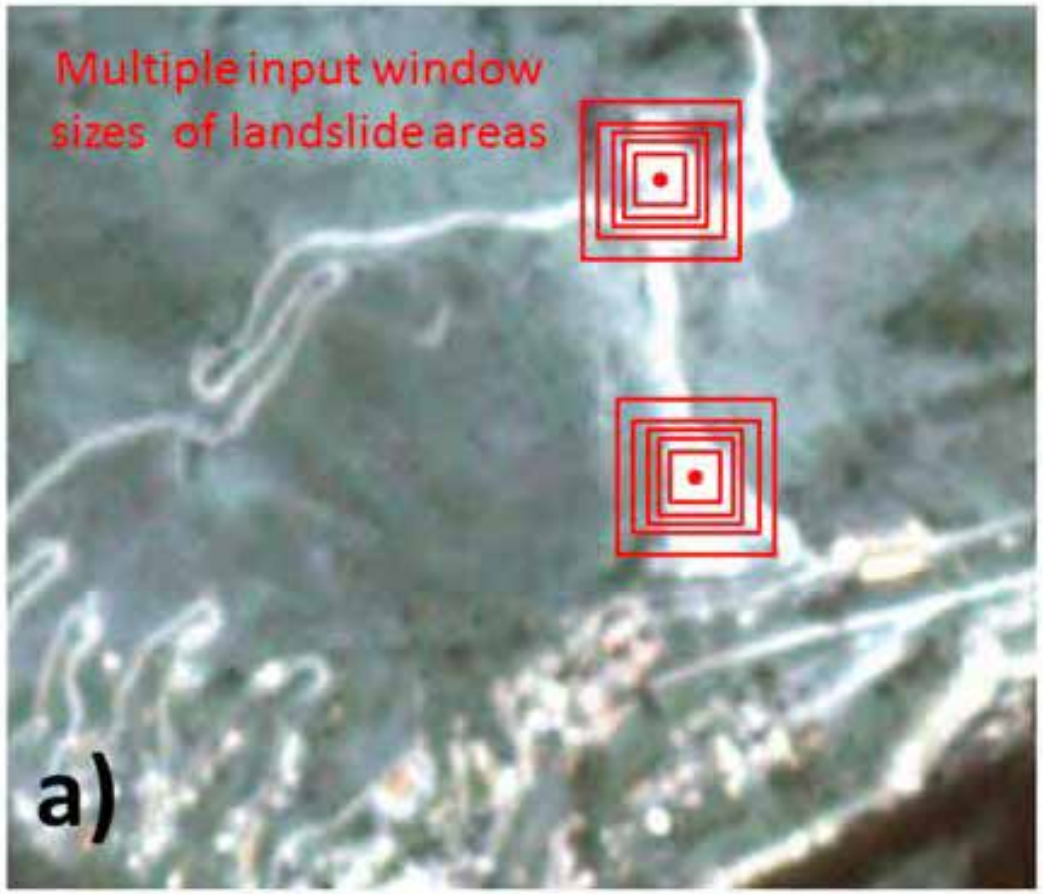


Landslide detection

Model	Precision (%)	Recall (%)	F1 (%)
U-Net	0.93	0.70	0.80
ResU-Net	0.96	0.83	0.89



Landslide detection

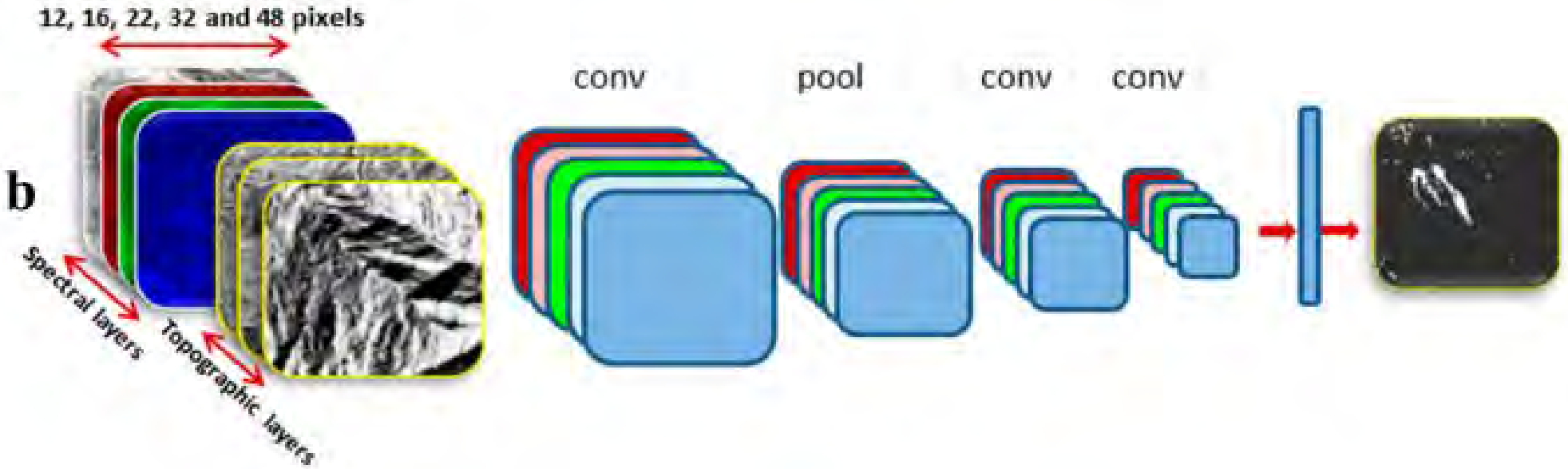


Kích thước mảnh với tâm là điểm trượt

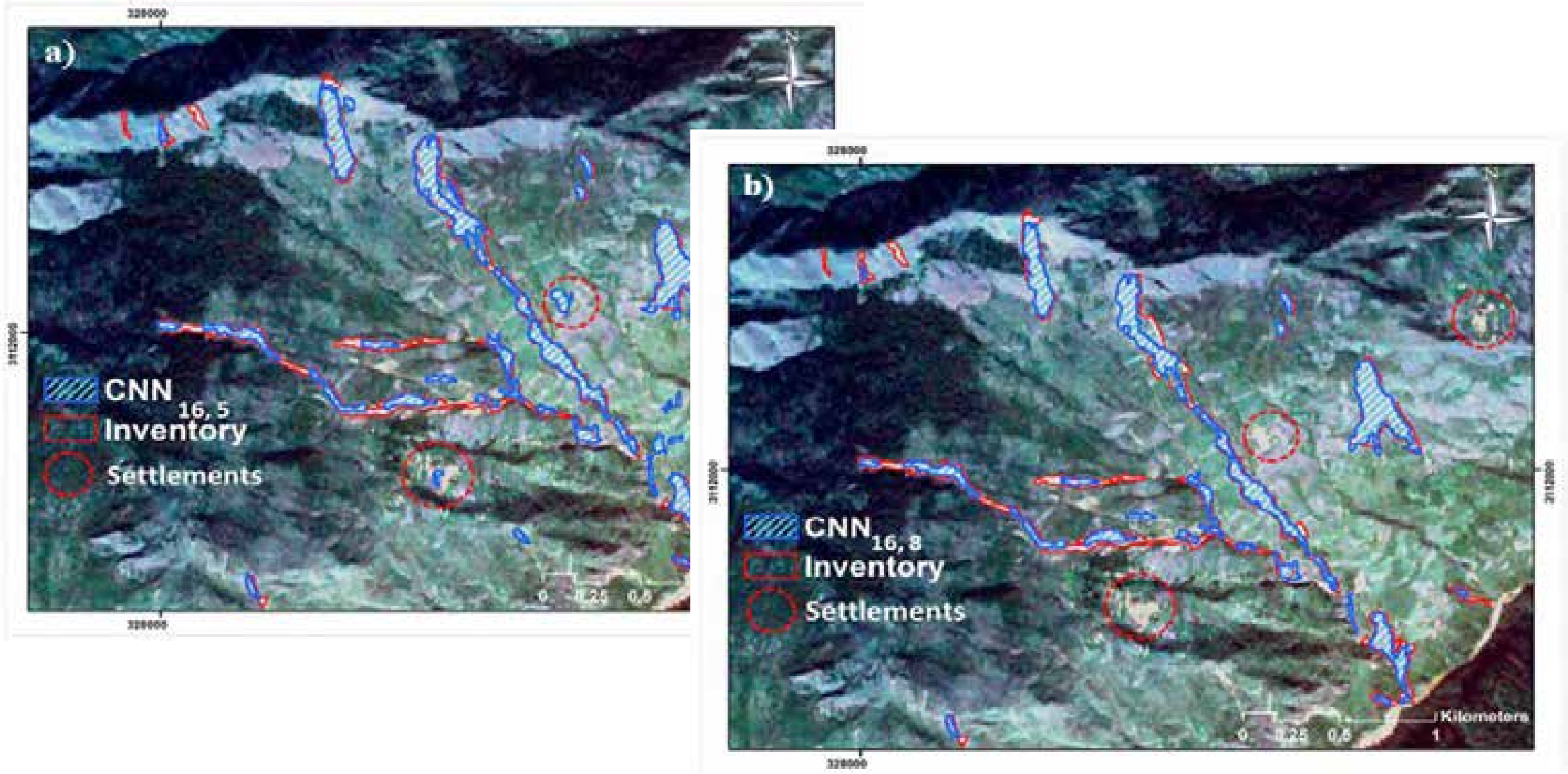
Kích thước mảnh với tâm là điểm Không-trượt

Landslide detection

Kích thước mảnh đầu vào khác nhau



Landslide detection



Landslide detection

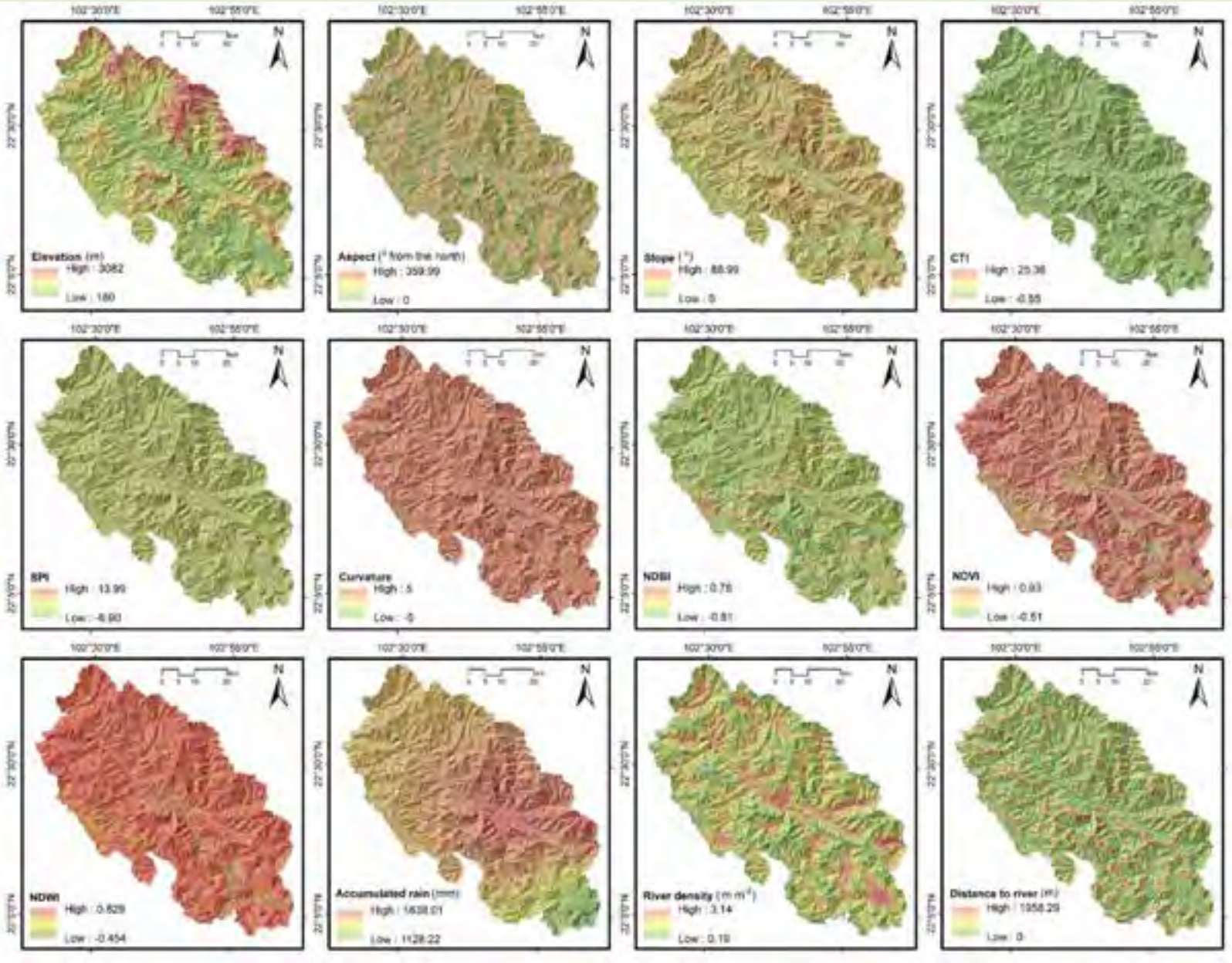
- Landslide detectable using Deep learning
- High spatial resolution images (Worldview, GeoEye, UAV…)
- Spatial resolution upscaling

Susceptibility mapping

- EES – Environmental Earth Science,
- GEM – Geomorphology,
- NAT – Natural Hazards,
- LAN – Landslides,
- ARA – Arabian Journal of Geosciences,
- NHE – Natural Hazard and Earth System Sciences,
- ENG – Engineering Geology,
- GNH – Geomatics Natural Hazard Risks,
- GEO – Geocarto International,
- CAT - Catena,
- JMS - Journal of Mountain Science,
- SCT – Science of Total Environment,
- REM – Remote Sensing,
- BOE – Bulletin of Engineering Geology and the Environment,
- ISP – ISPRS International Journal of Geo-Information,
- RSE – Remote Sensing of Environment,
- ASB – Applied Science,
- COM – Computer and Geosciences

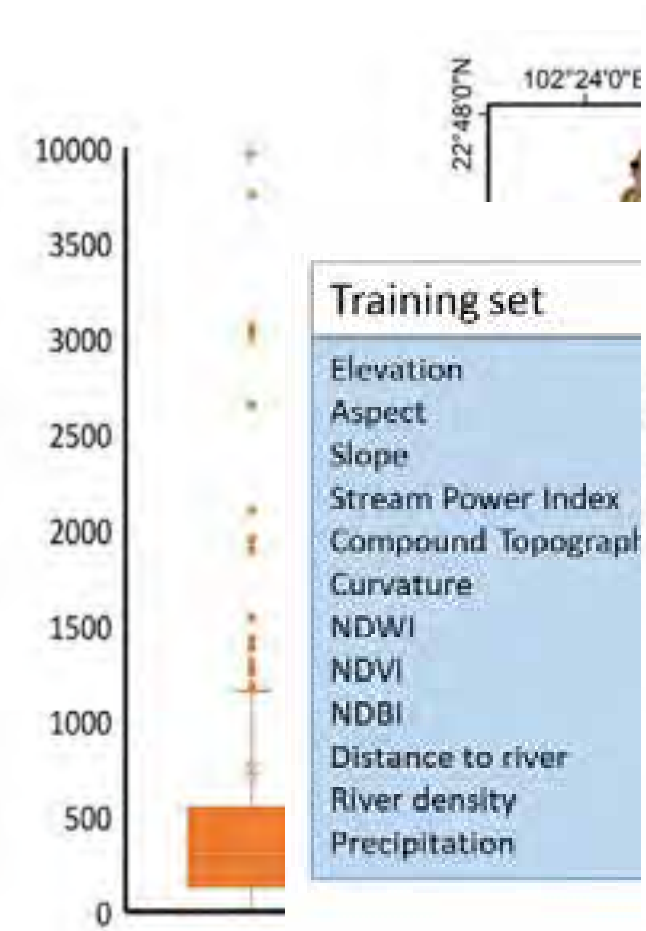
https://www.sciencedirect.com/science/article/abs/pii/S0012825220302713

Landslide susceptible map



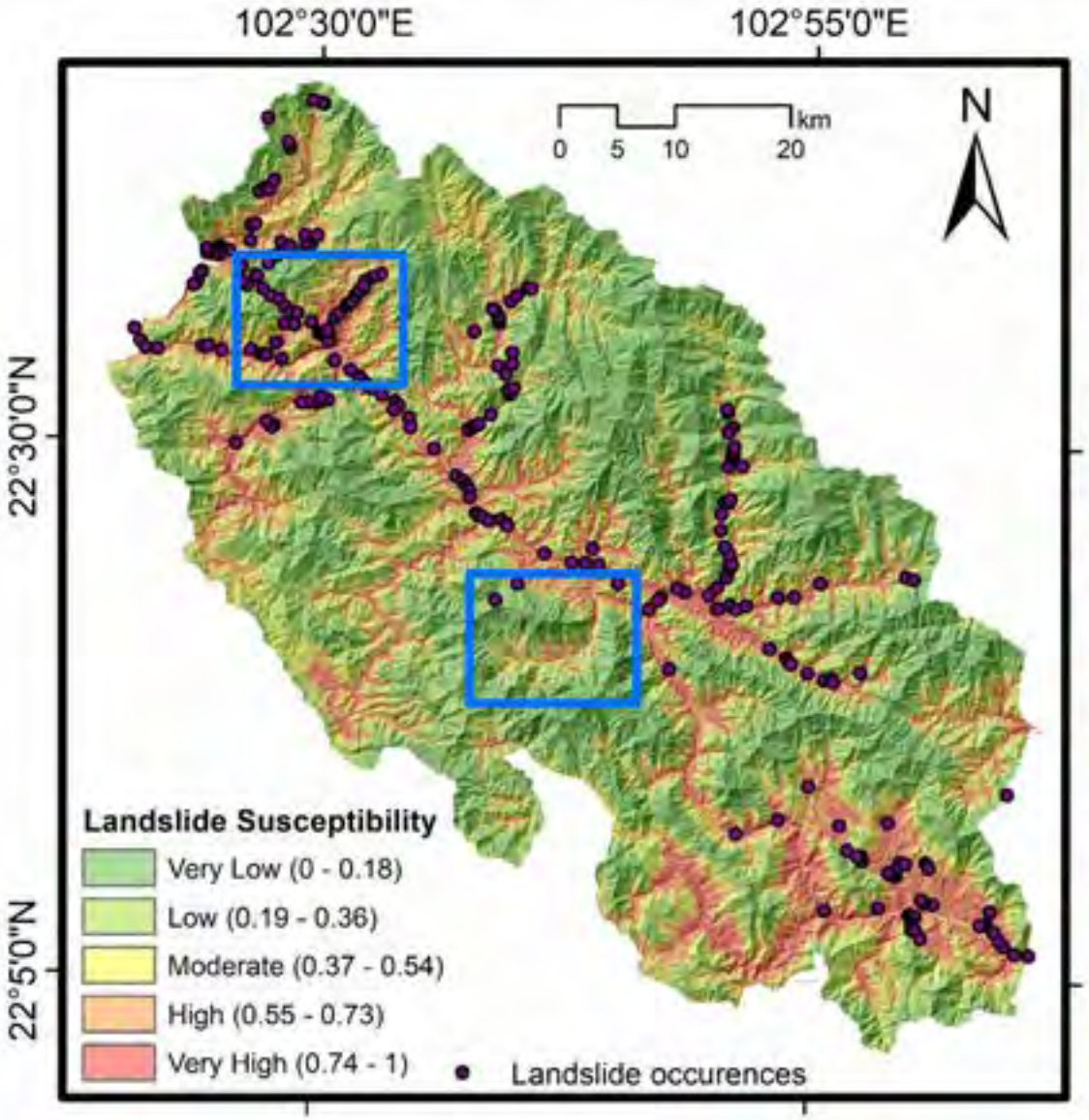
Input datasets

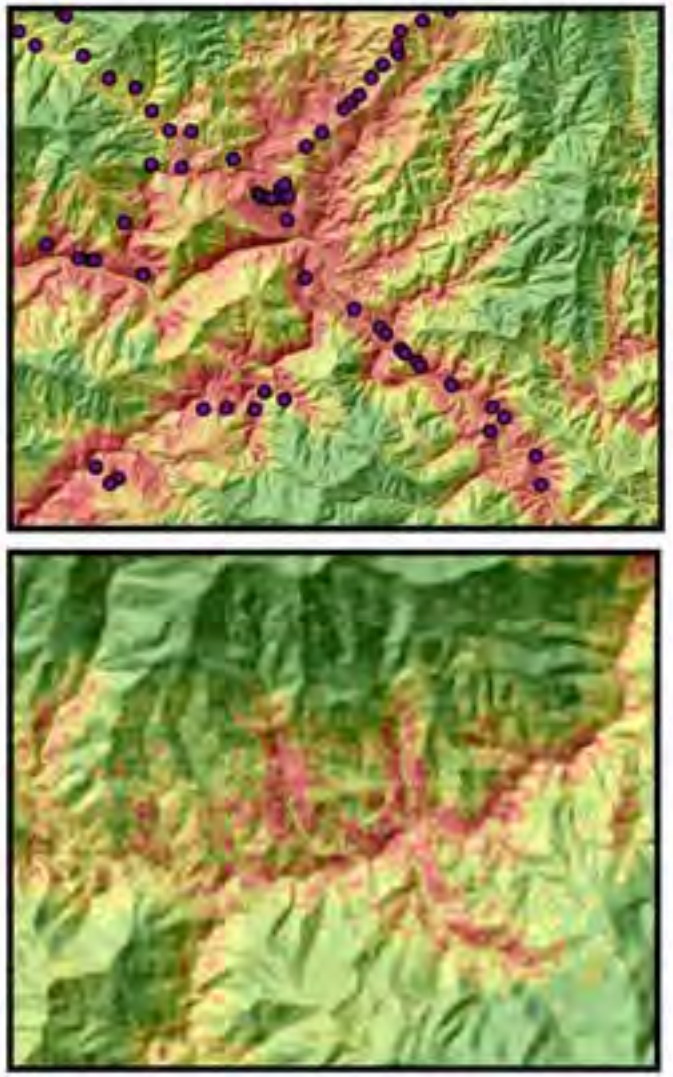
Landslide susceptible map



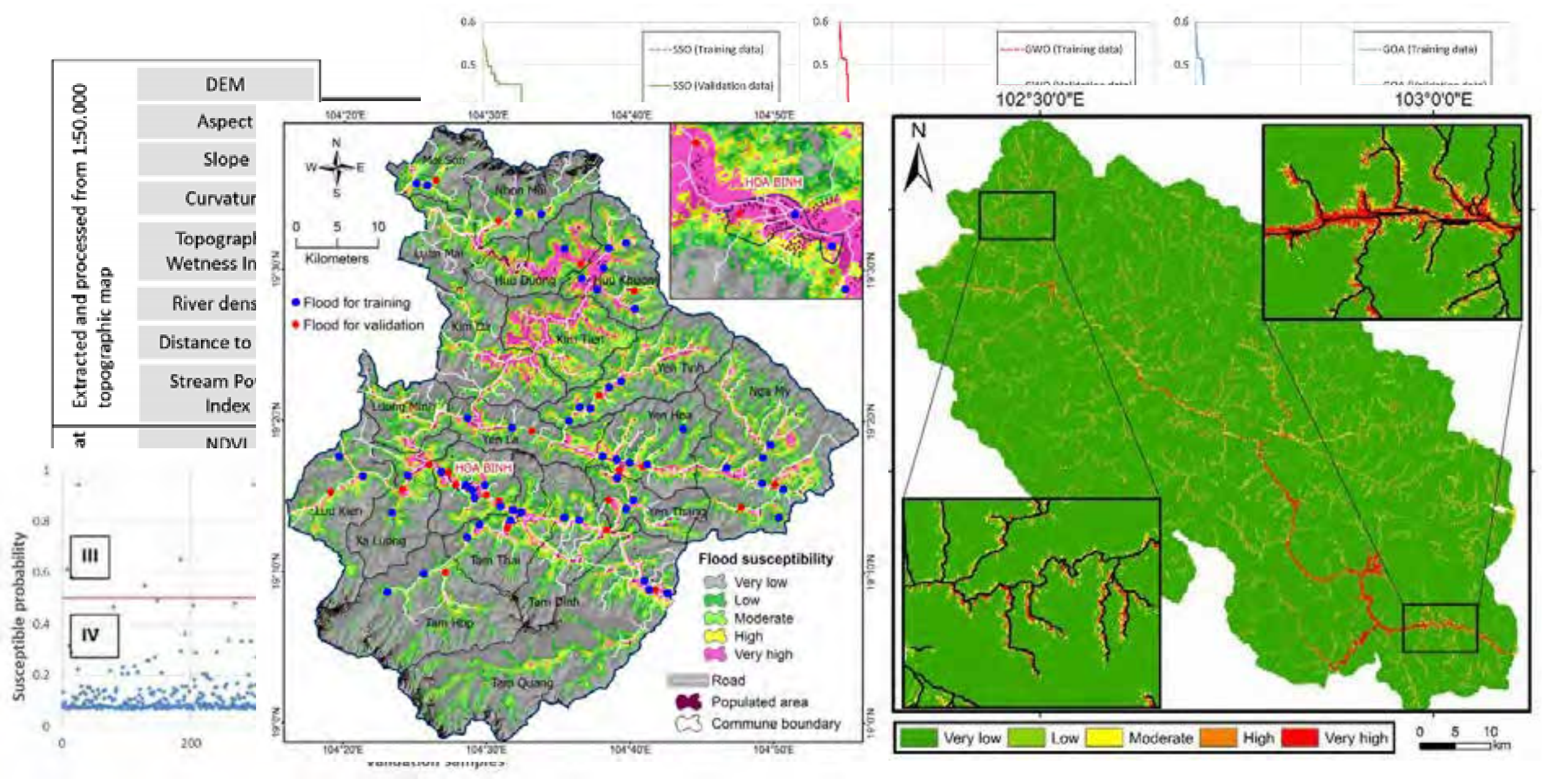
Training set

- Elevation
- Aspect
- Slope
- Stream Power Index
- Compound Topograph
- Curvature
- NDWI
- NDVI
- NDBI
- Distance to river
- River density
- Precipitation



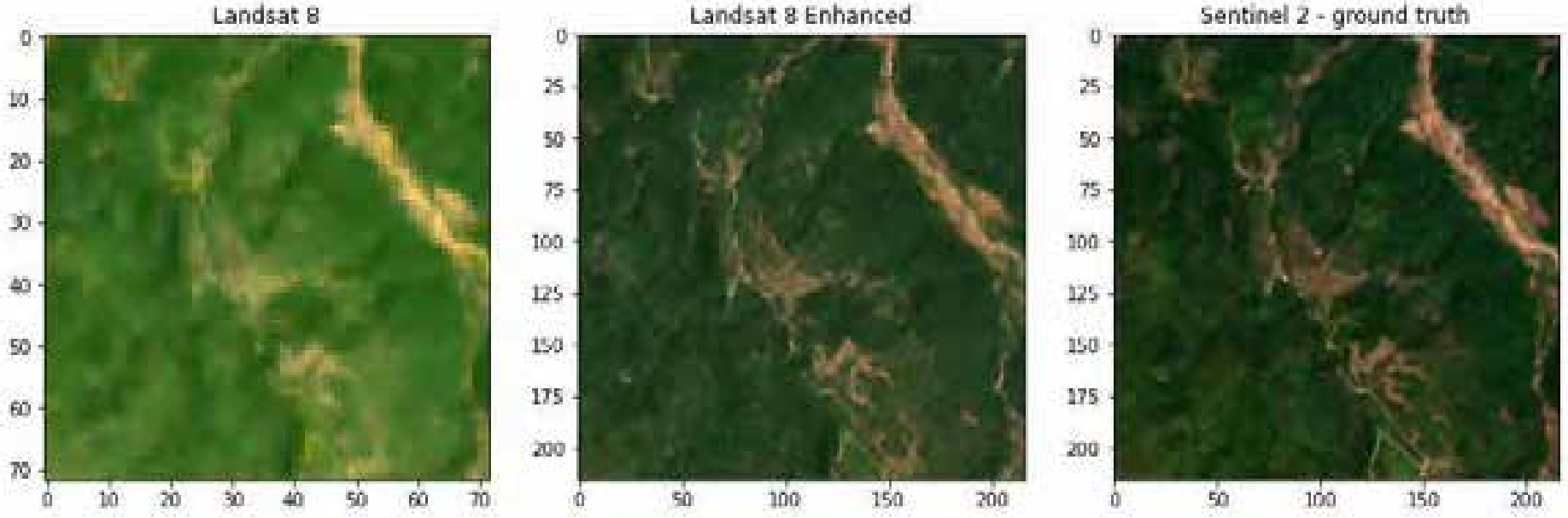


Flood susceptible map



Susceptibility mapping

- Numerous studies
- Basic maps for hotspot studies (more detail in higher scale)
- Implemented with mid spatial resolution images (with Landsat, Sentinel)



Early warning

Data-based early warning

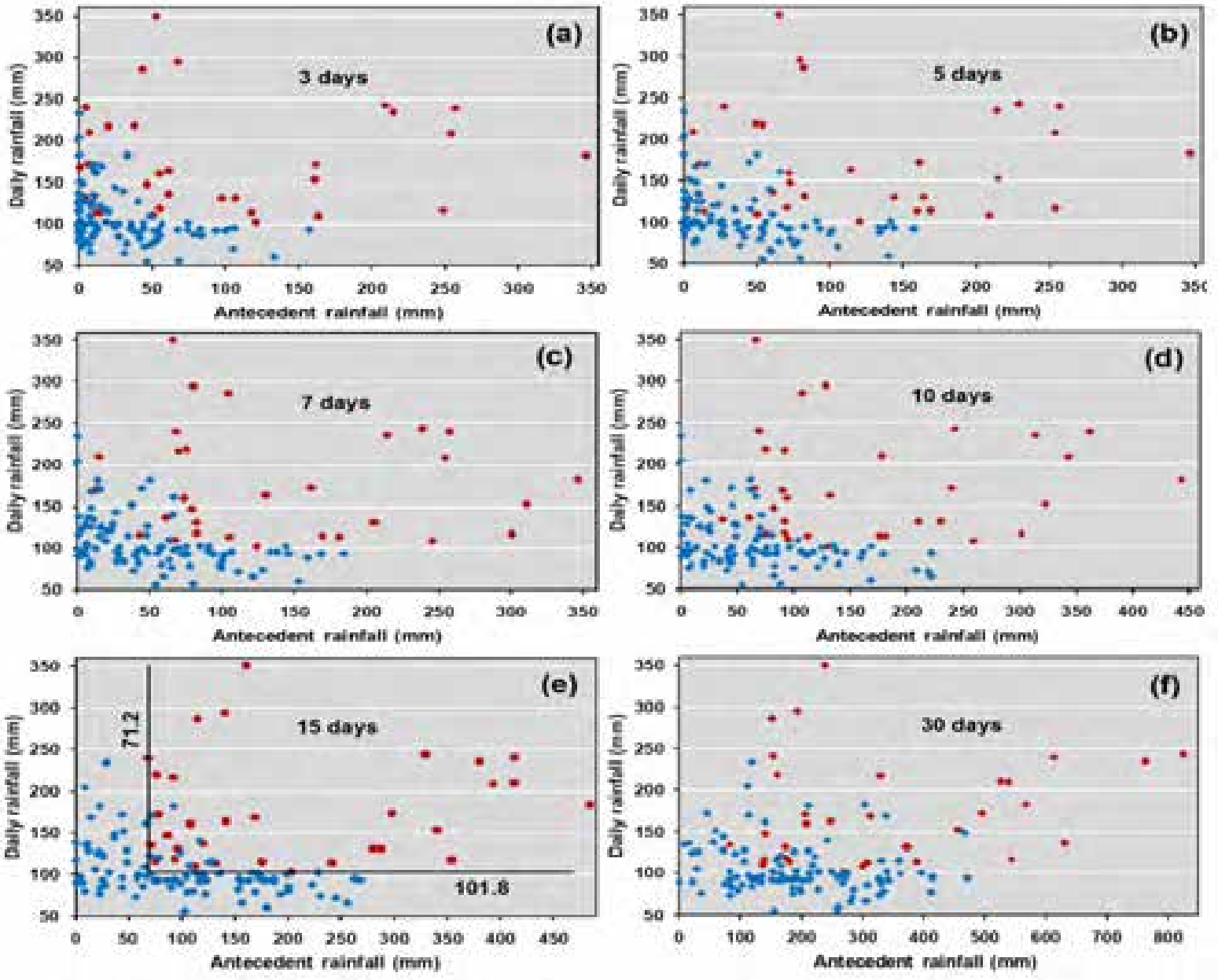
- Weather forecast
- Rain thresholds potentially trigger landslides
- Field monitoring (temp, rain, movement sensor, underground water level…)
- Data from field surveys
- Landslide, Flood susceptible maps and hotspot zoom in

Early warning

Achievement in Vietnam

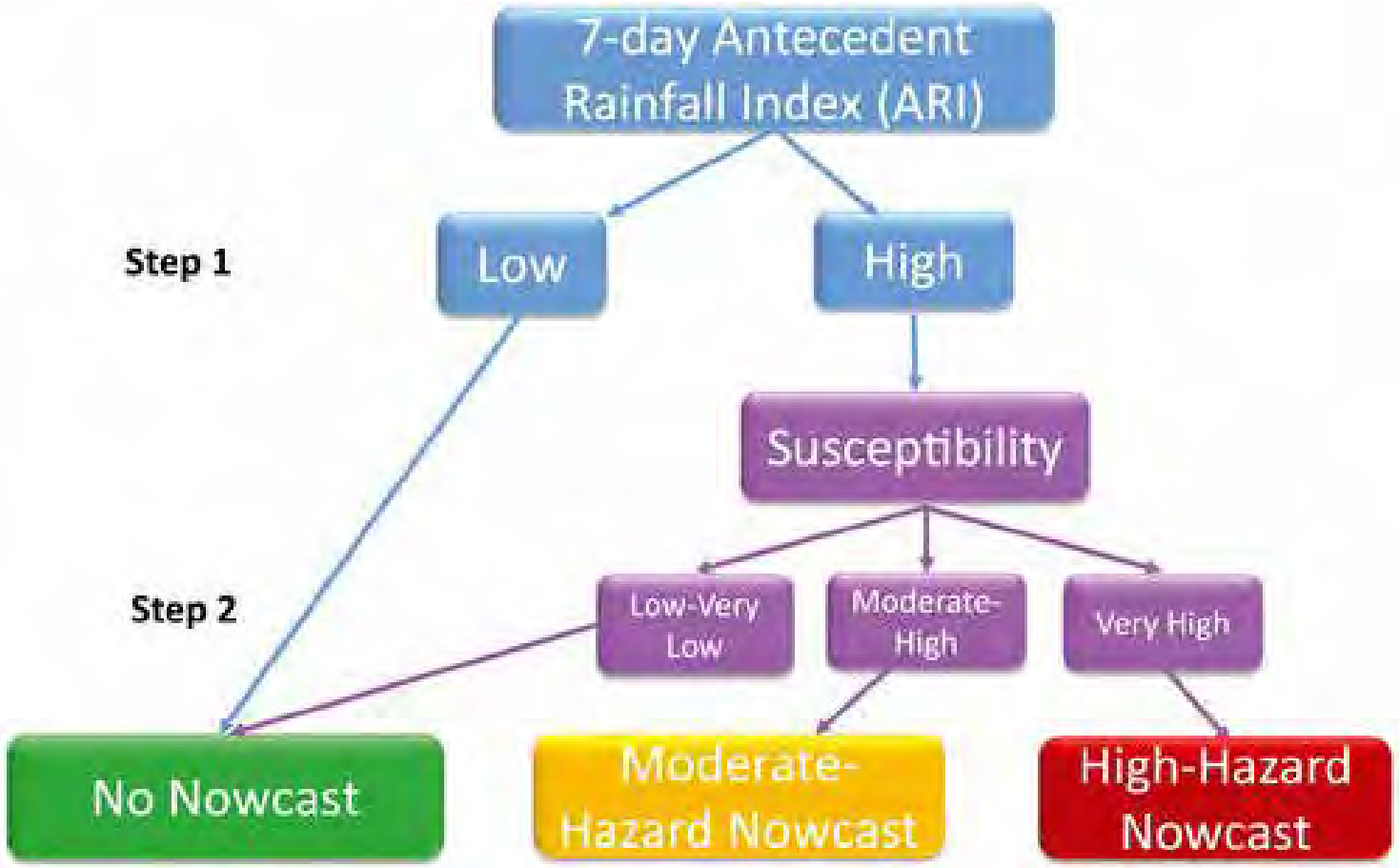
- Multiple scale susceptible maps
- Technical profiles (soil structure, forest covers…) of several hotspots
- Landslide location database (point, polygon)

Early warning



Rain accumulation (7, 10, 15, 30 days) to define thresholds which trigger landslides

Early warning

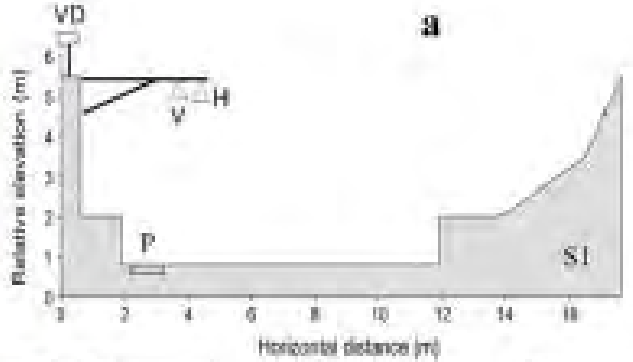


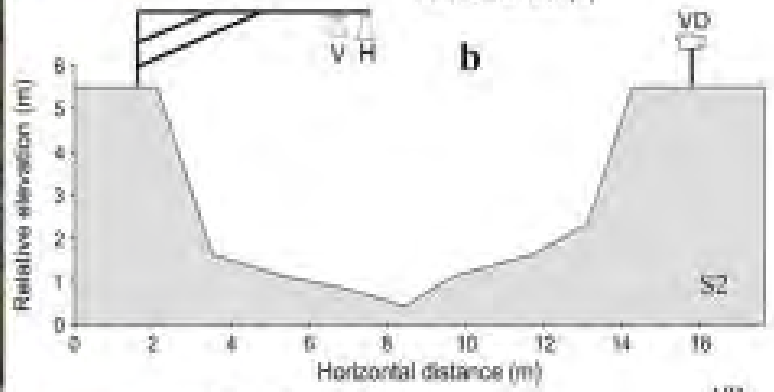
$$ARI = \frac{\sum_{t=0}^{6} w_t P_t}{\sum_{t=0}^{6} w_t} \qquad w_t = \frac{1}{(t+1)^2}$$

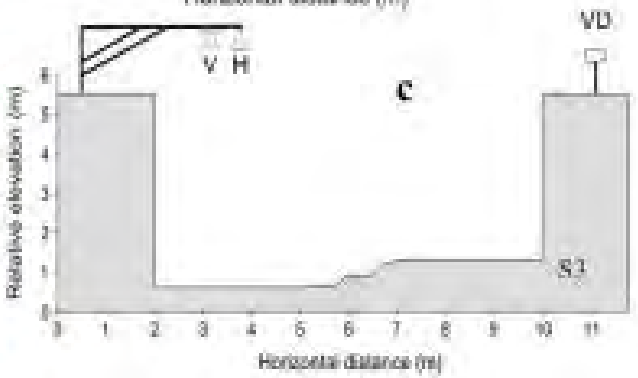
P_t rain amount of day t , t=0 day of forecast, t=6 days before day of forecast

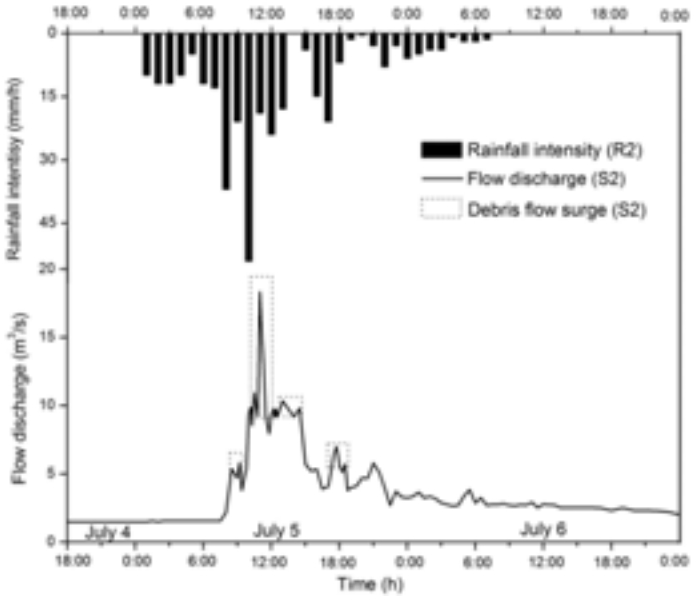
https://doi.org/10.1002/2017EF000715

Early warning



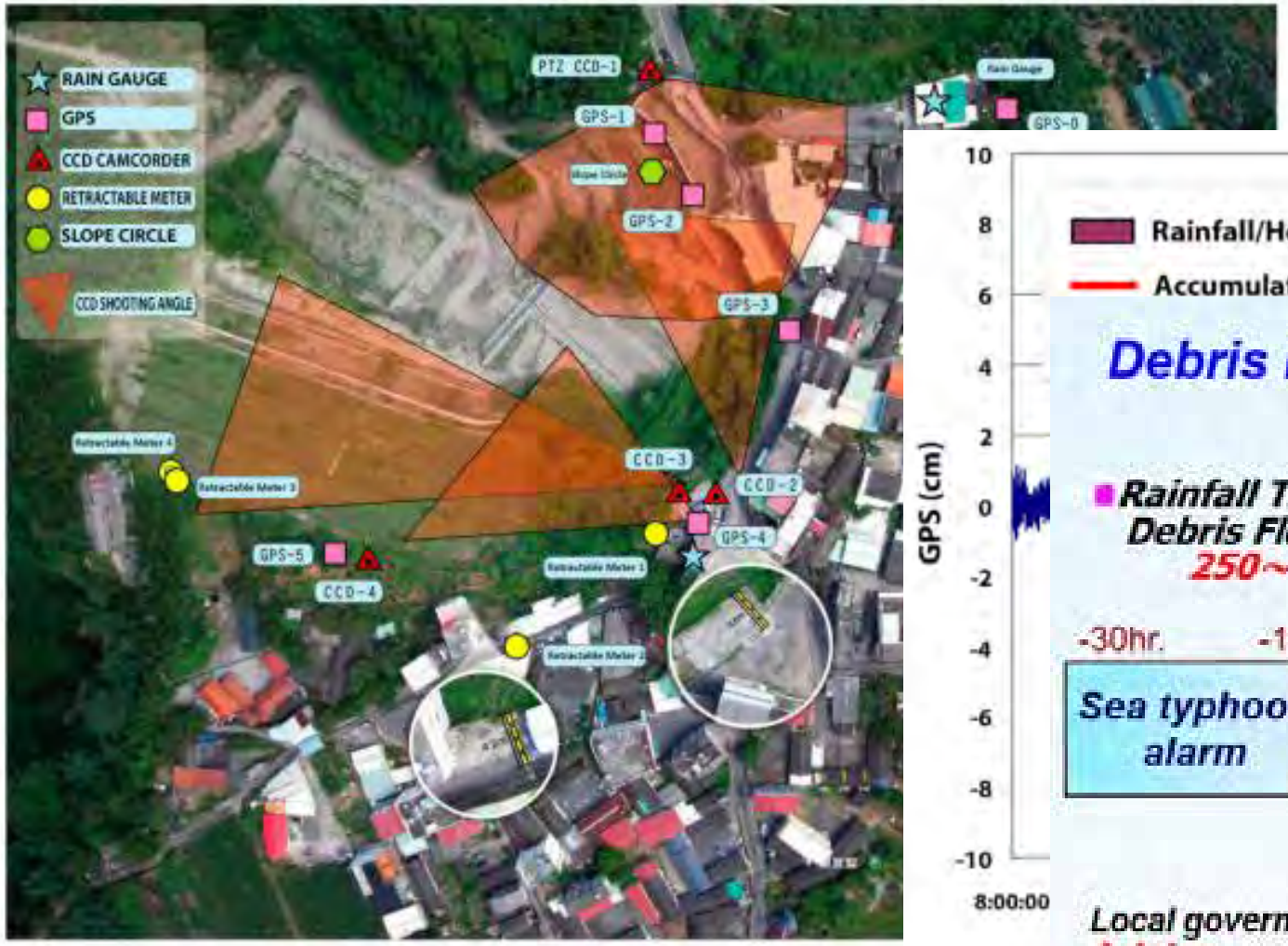




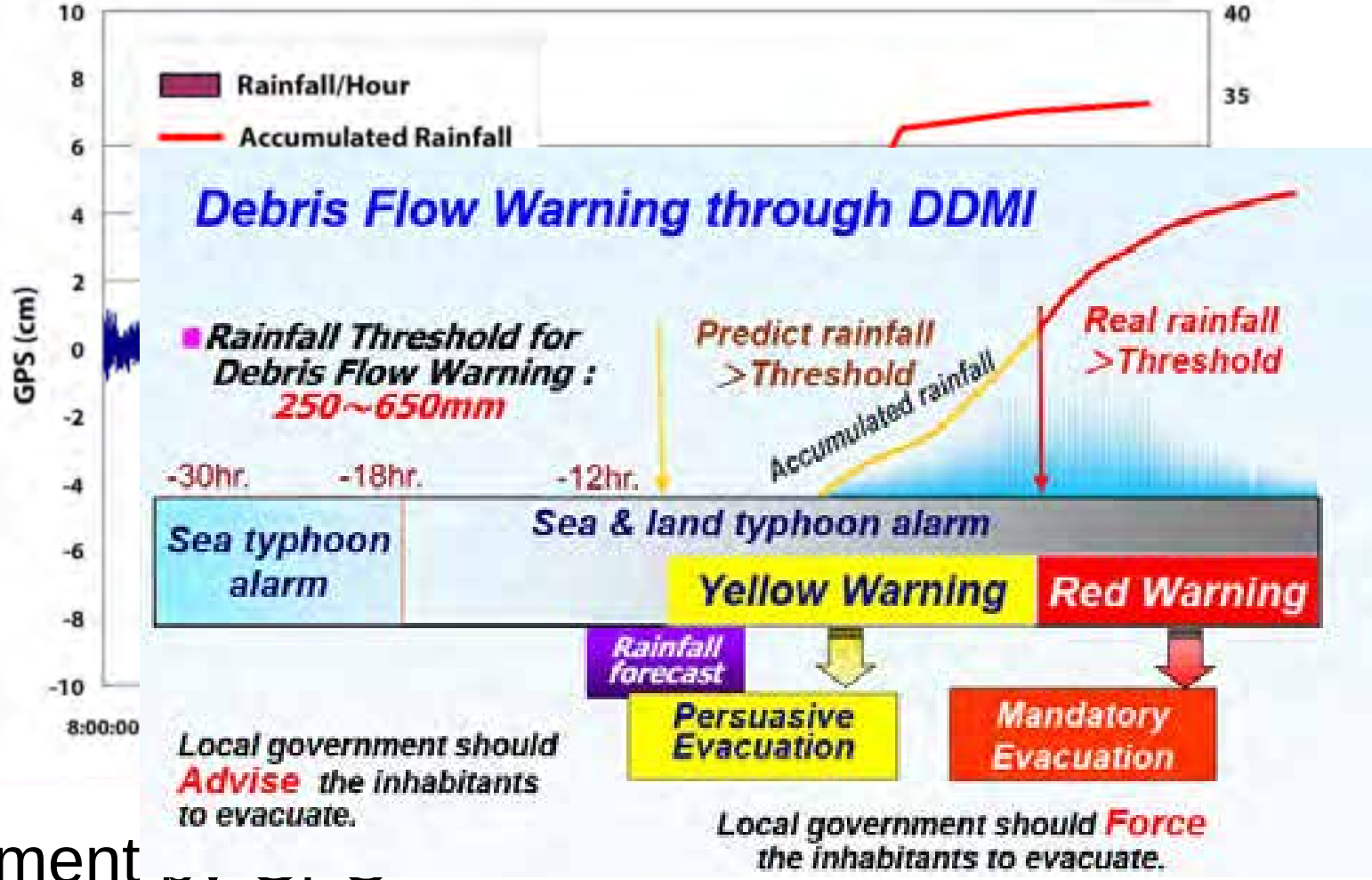


https://www.sciencedirect.com/science/article/abs/pii/S0169555X18303210

Early warning



Sensor location



Rain accumulation and movement by [illegible]

https://www.mdpi.com/2076-3417/10/19/6718

Early warning

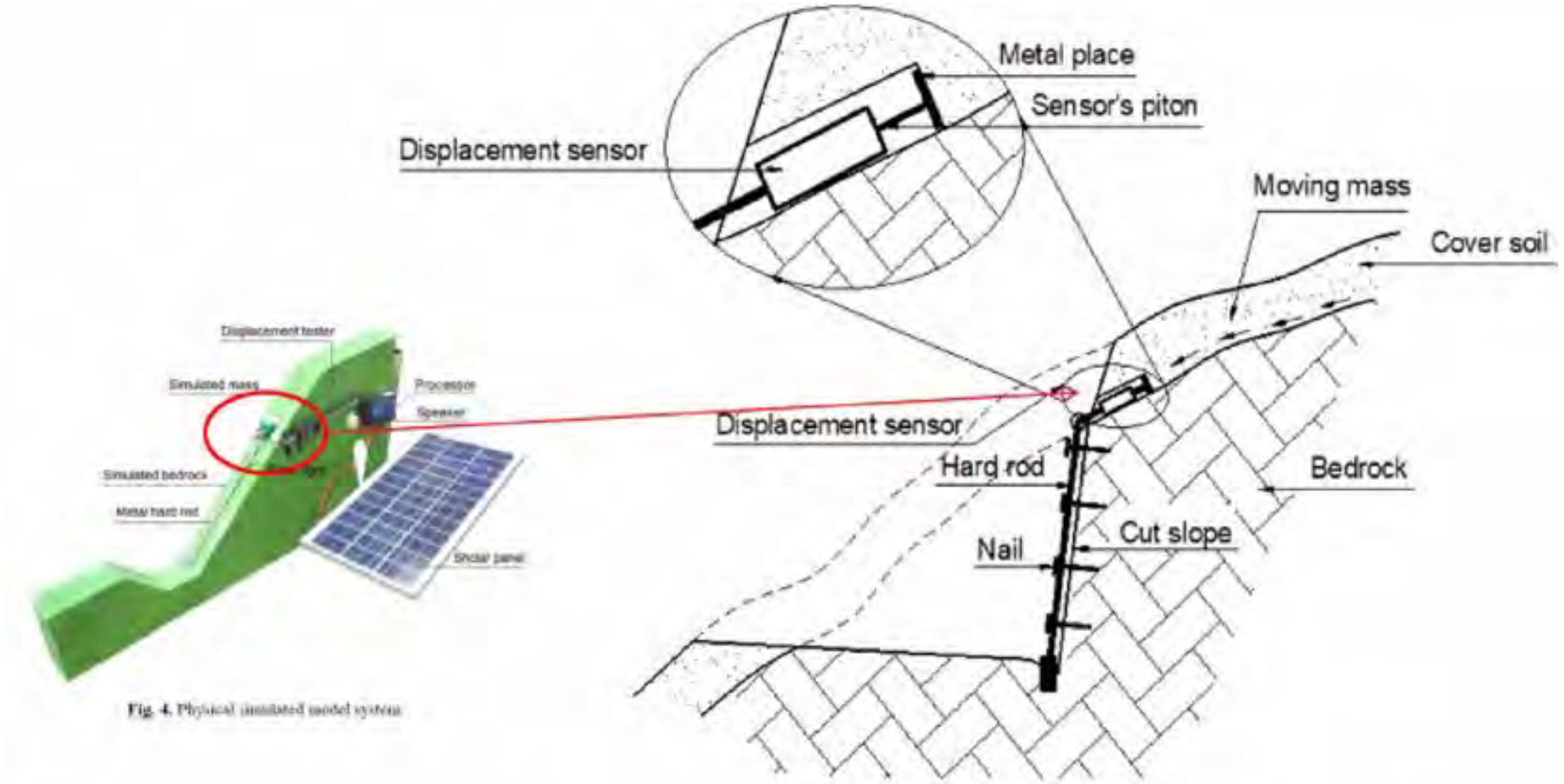


Fig. 4. Physical simulated model system

Early warning

Summary

- Limited rain gauge stations
- Susceptible maps with mid spatial resolution (landslide areas normally several pixel size)
- Limited historic landslide data, weather data. Difficult to define thresholds triggering landslides (require large dataset)
- Limited profiles of landslide hotspots

Summary

- Automatic detection of landslides using
  - Deep learning with high spatial resolution images
  - Collection of weather data when landslides occur
- Installation of sensor for early warning
- Early education of satellite data and their uses

Thanks