European Geosciences Union

세종대학교
SEJONG UNIVERSITY

Komar University of Science and Technology, Iraq

Dormant and Active Landslides Classification Using Machine Learning Algorithms Coupled With Geological Field Inspection: Pohang Case Study

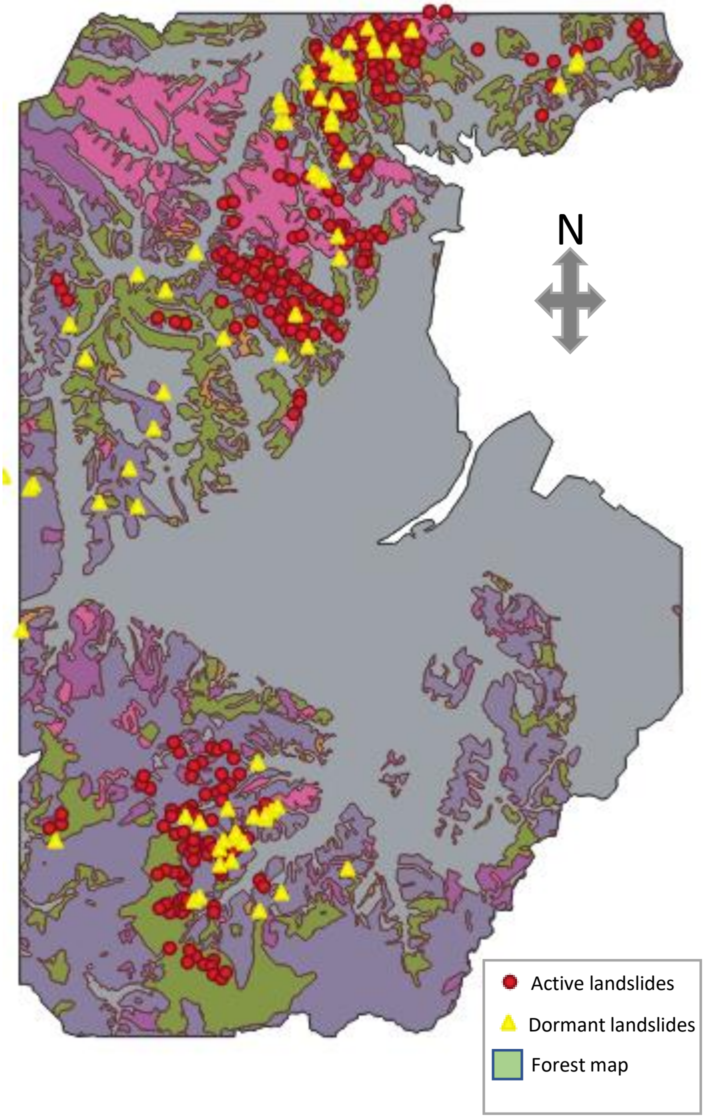
Omar F. Althuwaynee (1,2), In-Tak Hwang (1), Hyuck-Jin Park (1), Sang-Wan Kim (1) , Ali Aydda (3)

(1) Department of Energy and Mineral Resources Engineering, Sejong University, 209 Neudong-ro Gwangjin-gu, Seoul 05006, Republic of Korea, omar.faisel@gmail.com*

(2) Department of Civil Engineering, Komar University of Science and Technology, Sulaimani, Kurdistan Region 46001, Iraq

(3) Department of Geology, Faculty of Sciences, Ibn Zohr University, B.P 8106, Agadir 80000, Morocco

Outlines



Study area characteristics

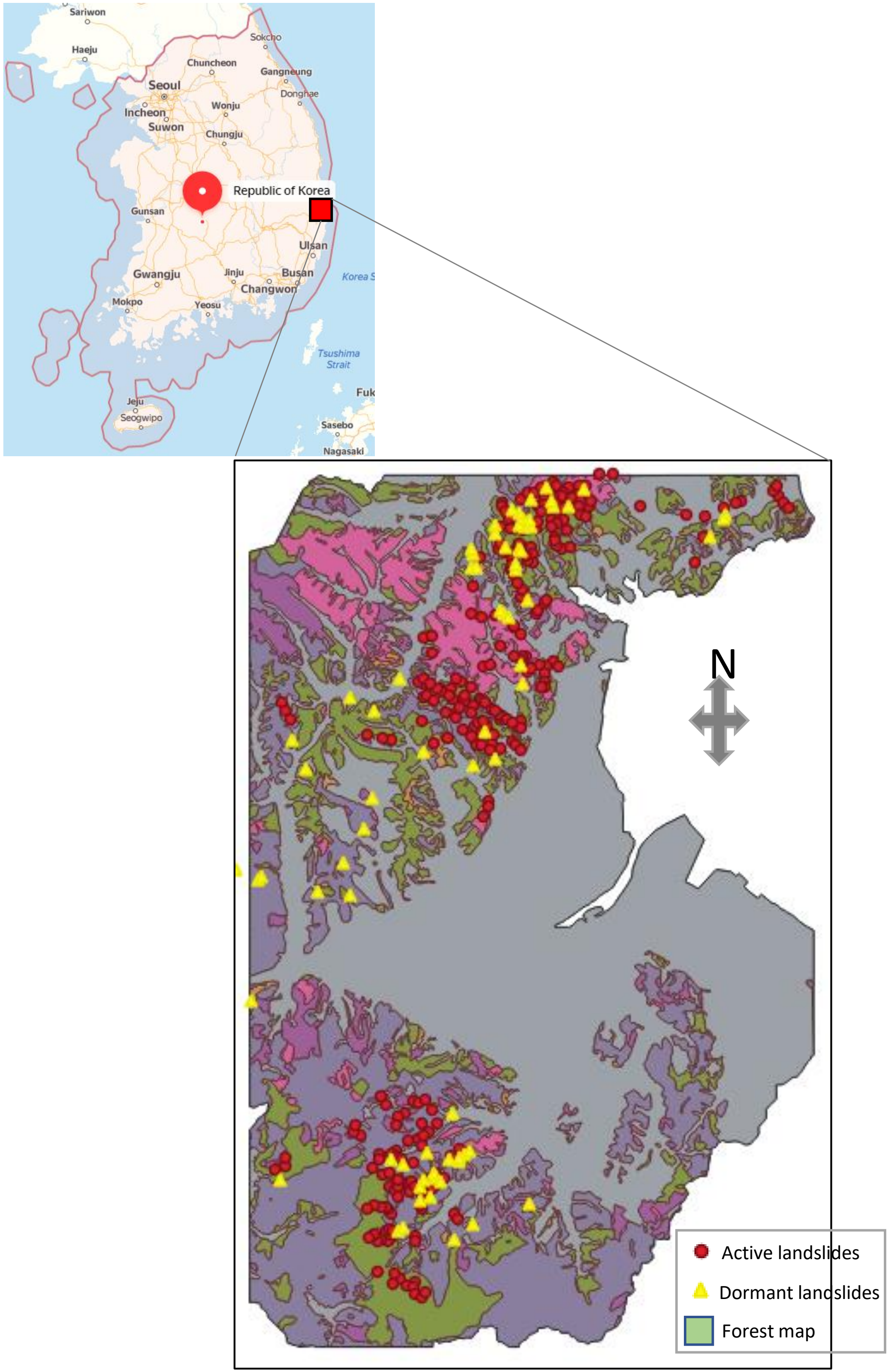
Problem statement, and objectives

General process overview

Detailed methodology of Stage 1

Initial results

Conclusion



- In 1998, intense rainfall events hit the Pohang state, south west of Korea.

- which results in highest number of landslides registered in this area

- Generally the area has a relatively short history of landslide inventorying.

Problem statement

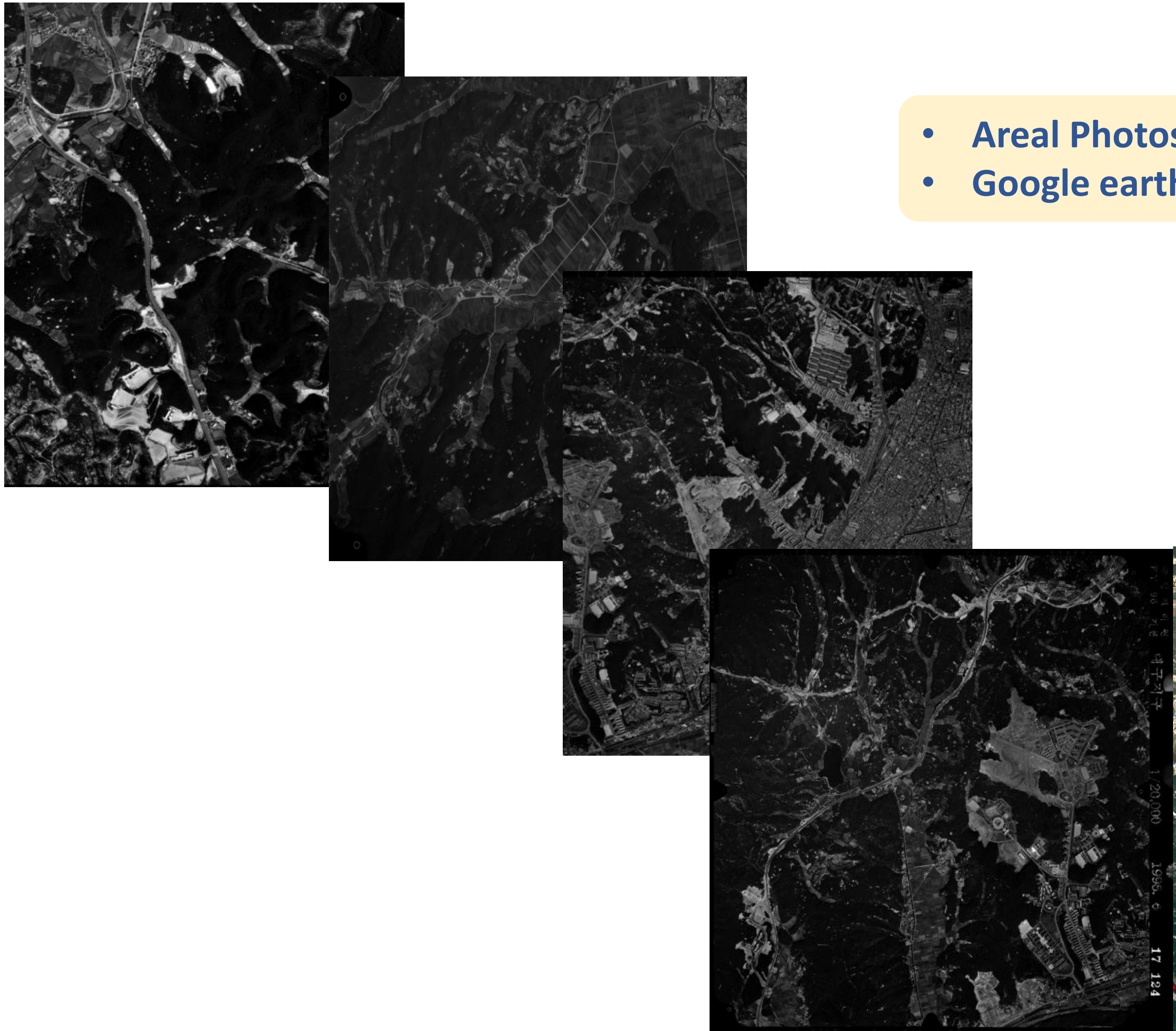
- The current inventory was digitized using Aerial photographs (lack of photogeological stereoscopic analysis of the aerial images) and coupled with basic field verification (due to limited funding available).

- We notice some slopes area covered with deformed forest types that is similar in texture to that seen in digitized locations of inventory.

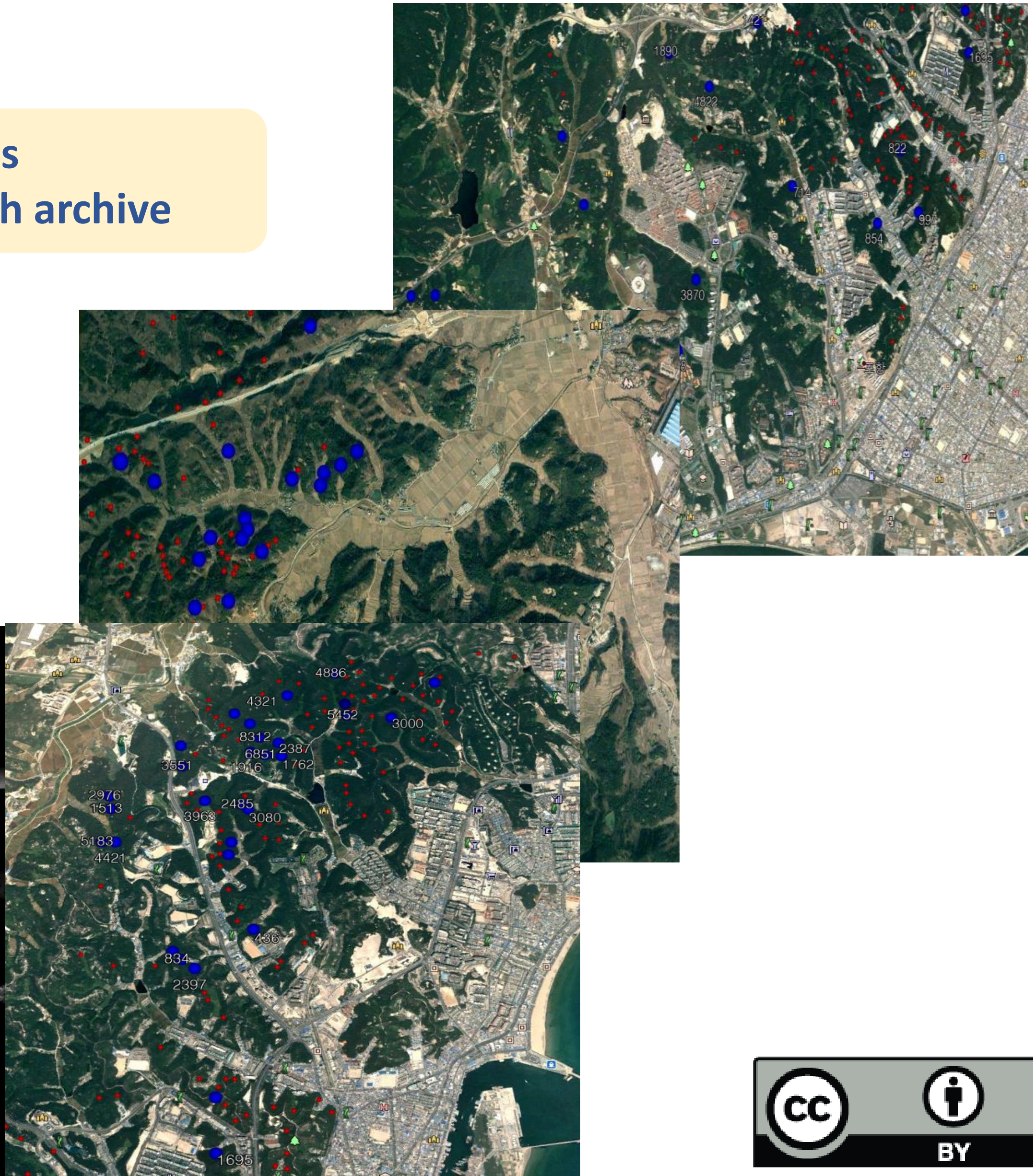
Leaving the applied susceptibility maps models performed with high degree of **Vagueness** (*poor documentation*) **and Ambiguity** (*disagreement on the definition of objects in a spatial data*) **uncertainty**.

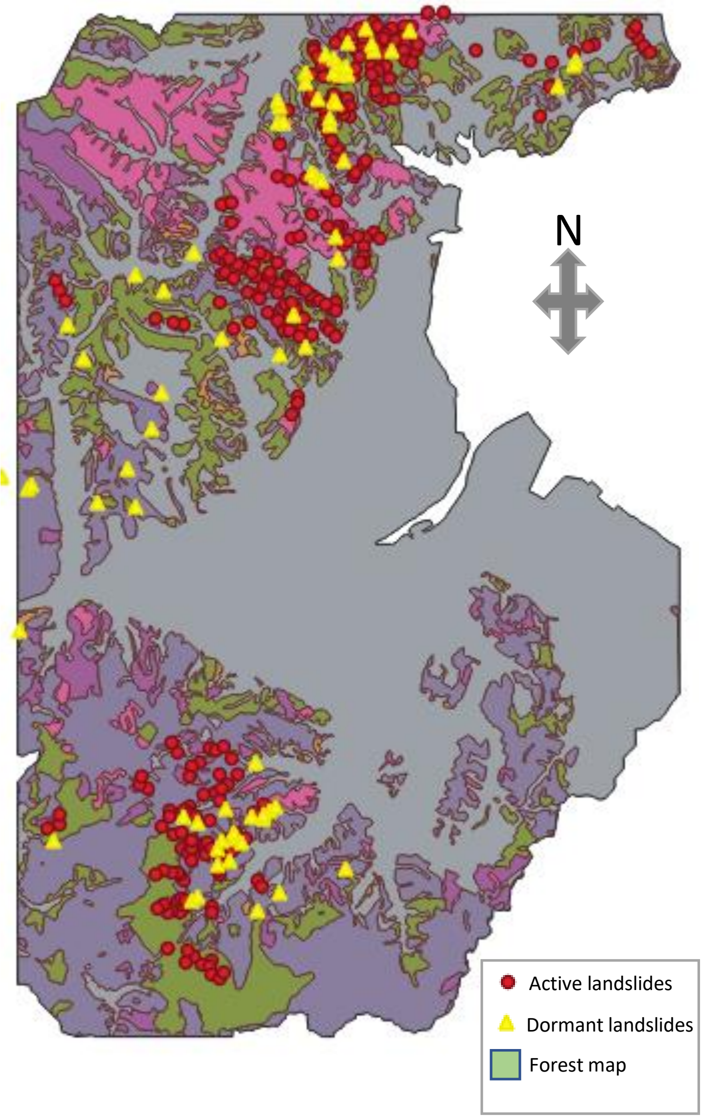
European Geosciences Union

Inventory verification/updating



- Areal Photos
- Google earth archive





Research hypothesis

- The available landslides inventory might not complete.
- additional investigation including field work to audit the landslides incidents is highly needed.

Research objective

We assumed that, some dormant slopes caused by the 1998 event can be reactivated with the current extreme (uncontrolled) uses of slopes by human activities (constructions of real estate's projects).

A research initiative carried to audit the landslide inventory using

- freely available aerial photographs
- the time tuning function in Google earth for aerial pictures archives.
- ML algorithms to produce susceptibility map to facilitate and reduce the filed work time and cost.

European Geosciences Union

Dormant and active slides inventories

Methodology Framework

Stage 1

DSM & LSM

Unsupervised ML: clustering algorithms

Supervised ML: Classification algorithms

Uncertainty Quantification (UQ) of Epistemic and Aleatoric errors

Why stage 1?

First assessment to derive more evidences, and test if the soft leaning has the ability to overcome the need for costly filed work. Moreover, to study the significant differences between the dormant areas and previous active incidents if any.

Stage 2

Field verification

High to moderate Landslide and Dormant susceptible areas.

low susceptible Dormant areas → **Advanced investigation**

UAV observation and Soil tests inspections

Why stage 2?

Cost effective scientific observation using random locations to verify the used inventory as well as update the inventory. We assume that next landslide will be motivated by human induced rather than rainfall event.

Stage 3

Diluvial And Alluvial depth Contour Mapping

Boreholes network design

Geological inspection for collected samples

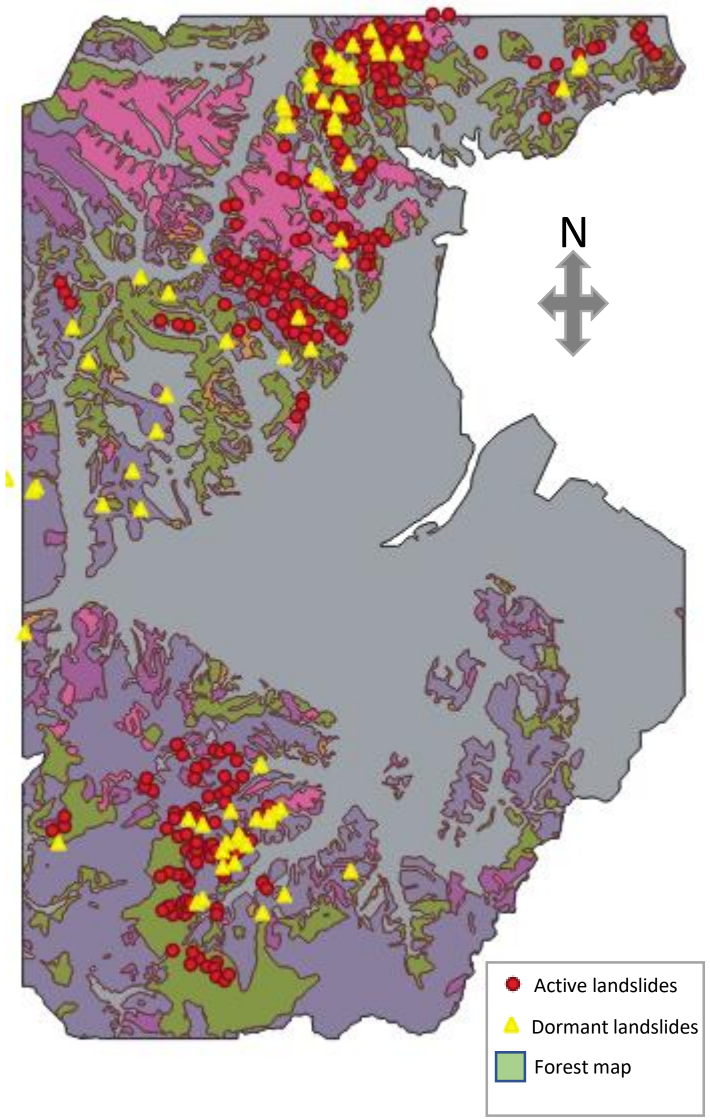
Geostatistical analysis using CoKriging analysis

Why stage 3?

A Deterministic approaches to support the LSM by giving 3rd dimension about the condition of the slopes that physically is more vulnerable than adjacent slope which carry the similar probability score

European Geosciences Union

Stage 1



Automatic extraction of training locations

+ using 2 spatial representations

- Grid based units
- Slope based units

Produce Dormant susceptibility map (DSM) and Landslide susceptibility map (LSM) using optimized ML models of:

+ supervised classification ML with hyperparameter

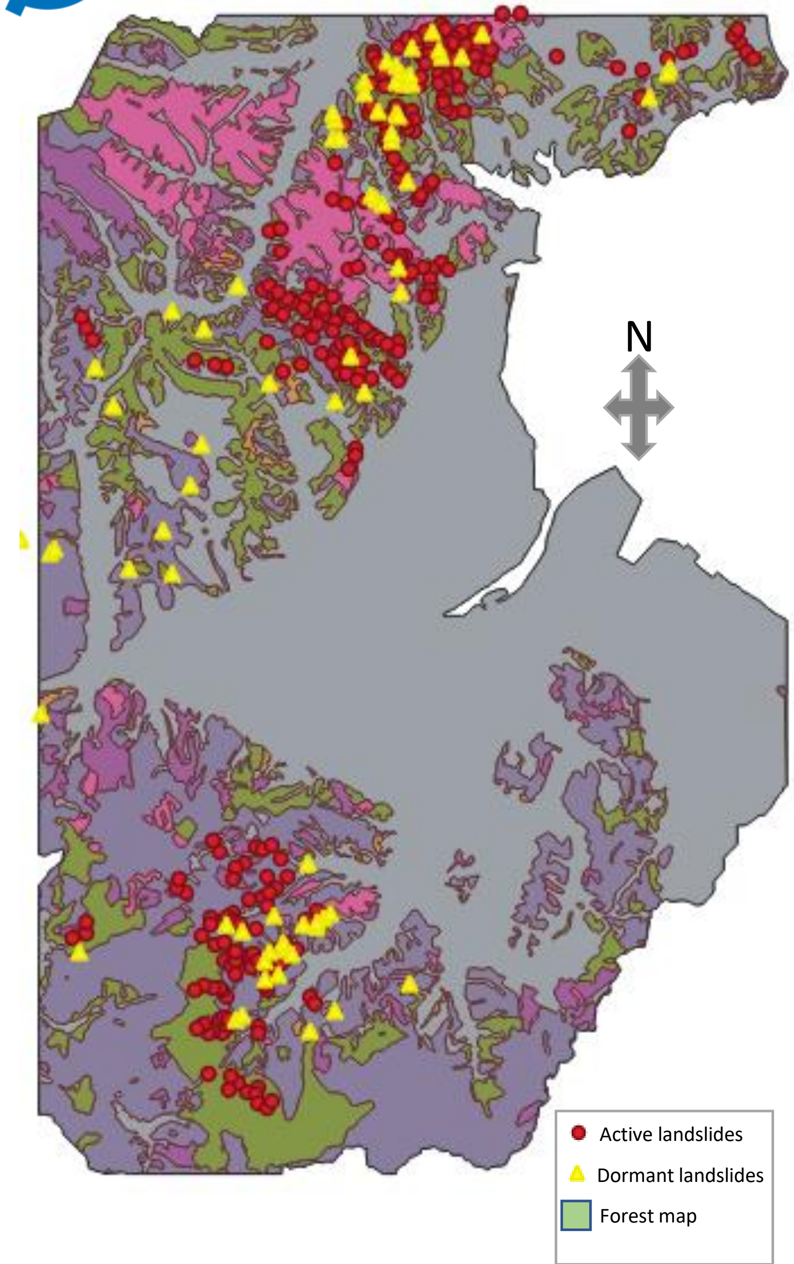
- eXtreme Gradient Boosting algorithms and
- Ensemble Random Forest

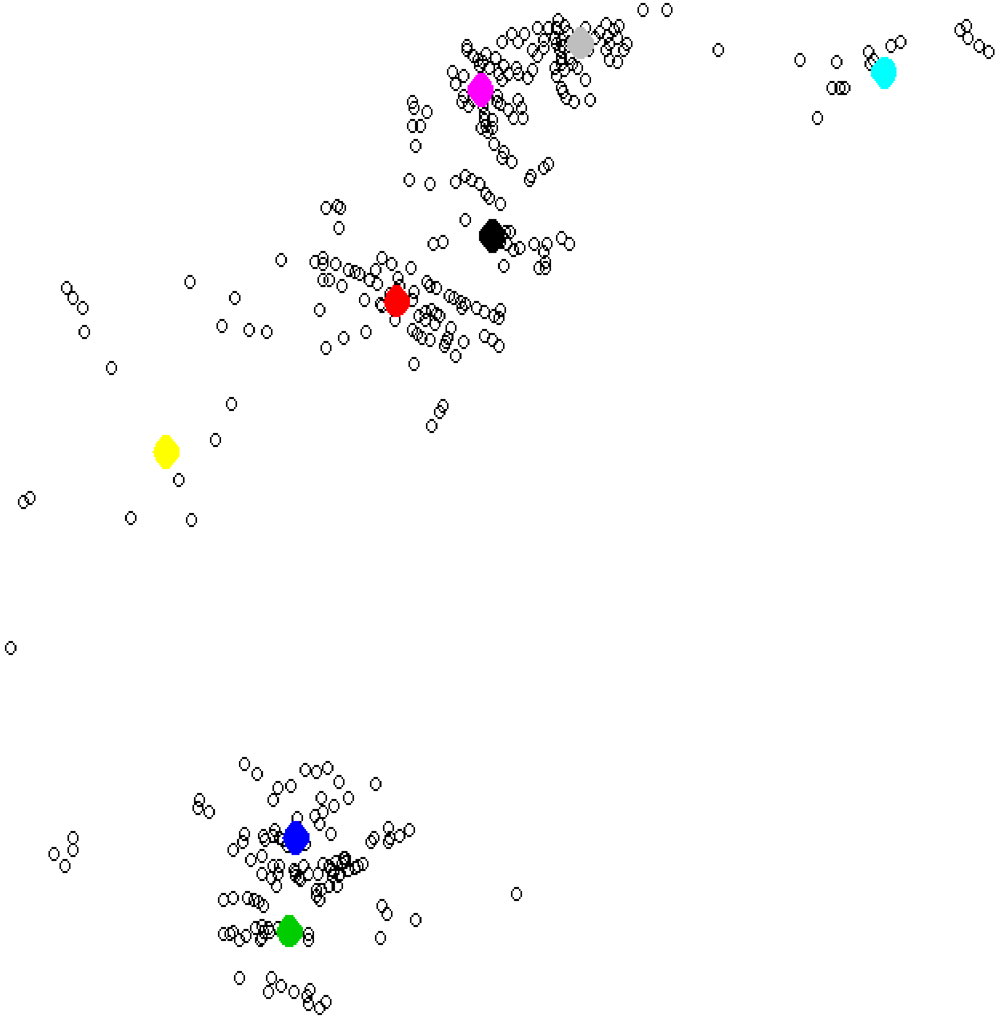
+ Unsupervised ML using

- Hierarchical Cluster (HC) Analysis
- Expectation-Maximization using Gaussian Mixture Models (EM/GMM)
- Affinity propagation
- Mini Batch K-means

European Geosciences Union

Unsupervised ML algorithm: *mini-batch-kmeans* clustering

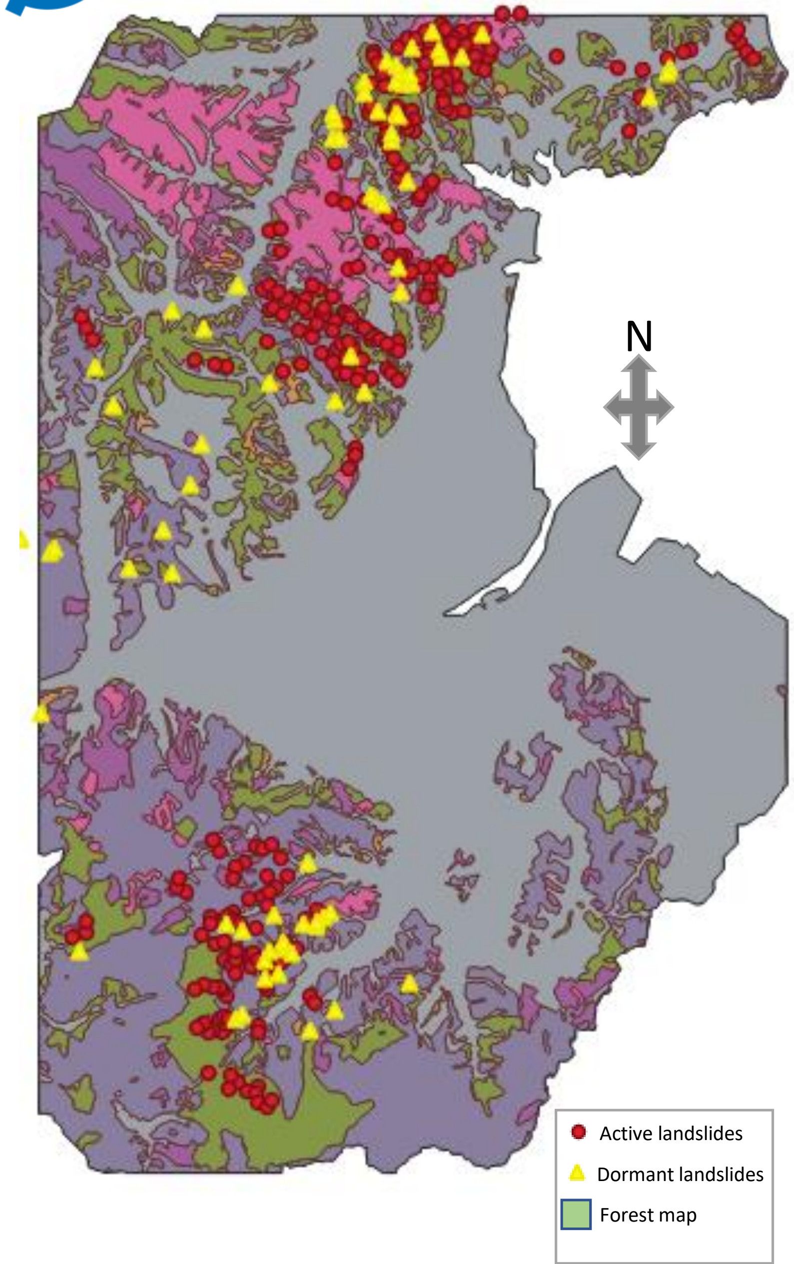




“optimizing the parameters might reveal better interpretation and the Validation is highly needed”

Fig.1 Possibility of valid agreement between the distribution of landslides and Centers of Mini-batch-kmeans. Colors represent the clusters center.

Unsupervised ML algorithm: *Expectation-Maximization (EM) Clustering using Gaussian Mixture Models (GMM)*



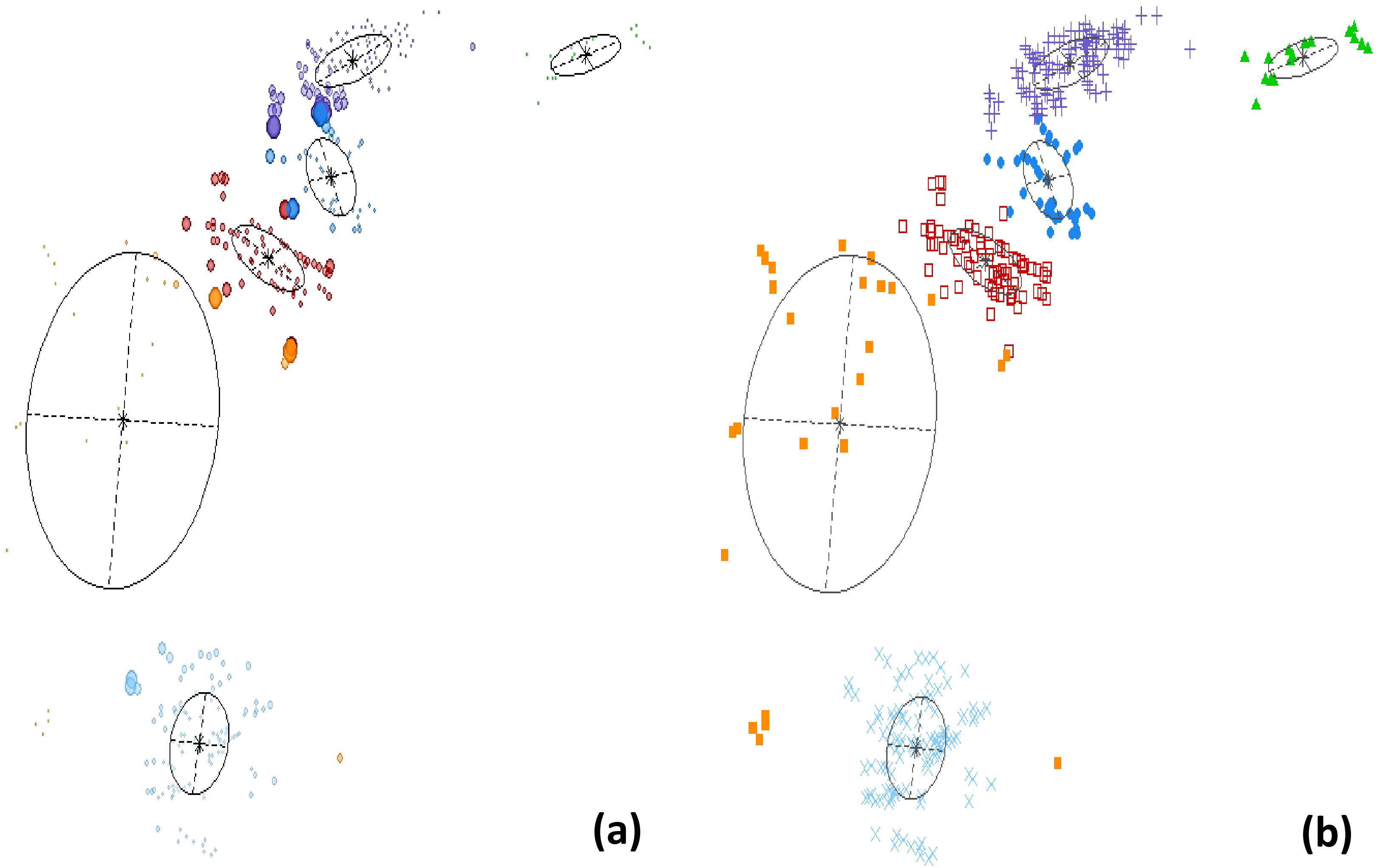
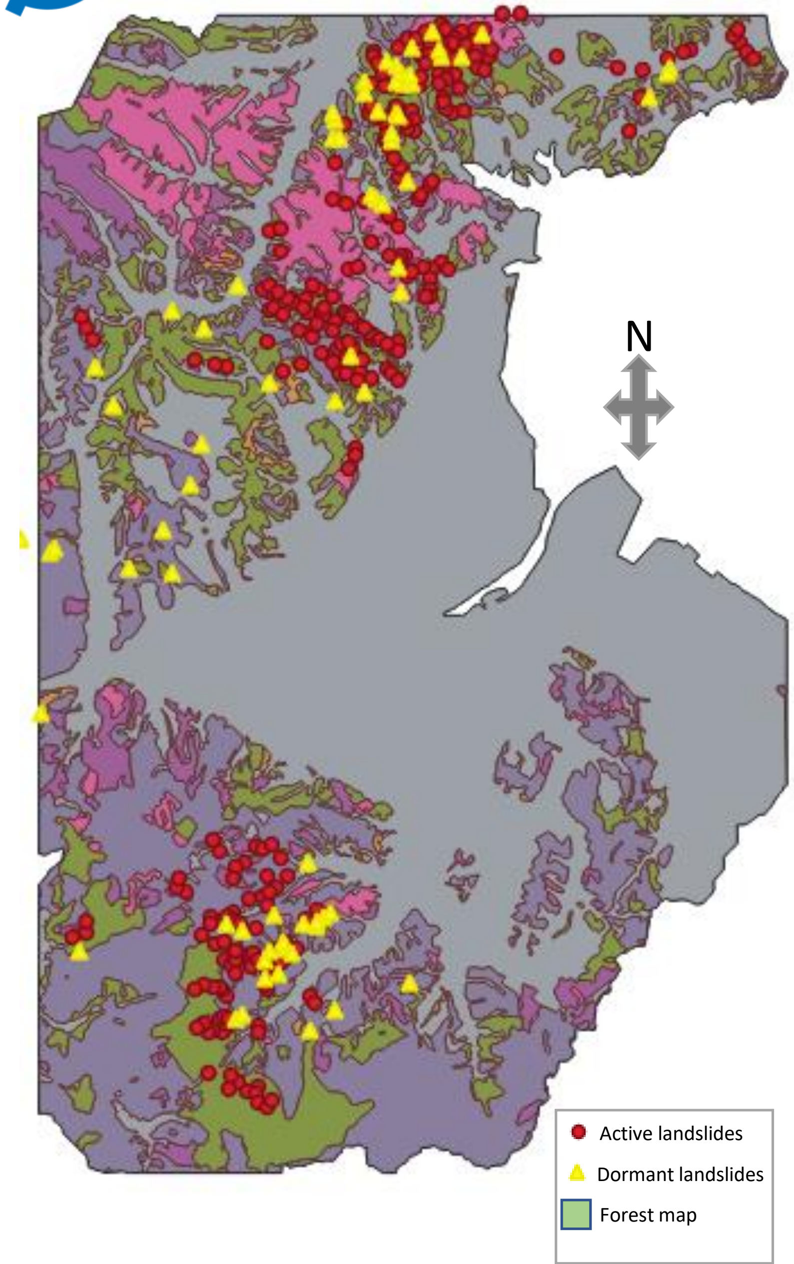


Fig.2 a) Uncertainty of clustering results obtained by EM using GMM, **b)** Classifications results using 6 centers of GMM

Unsupervised ML algorithm: *hirarchical clustering*



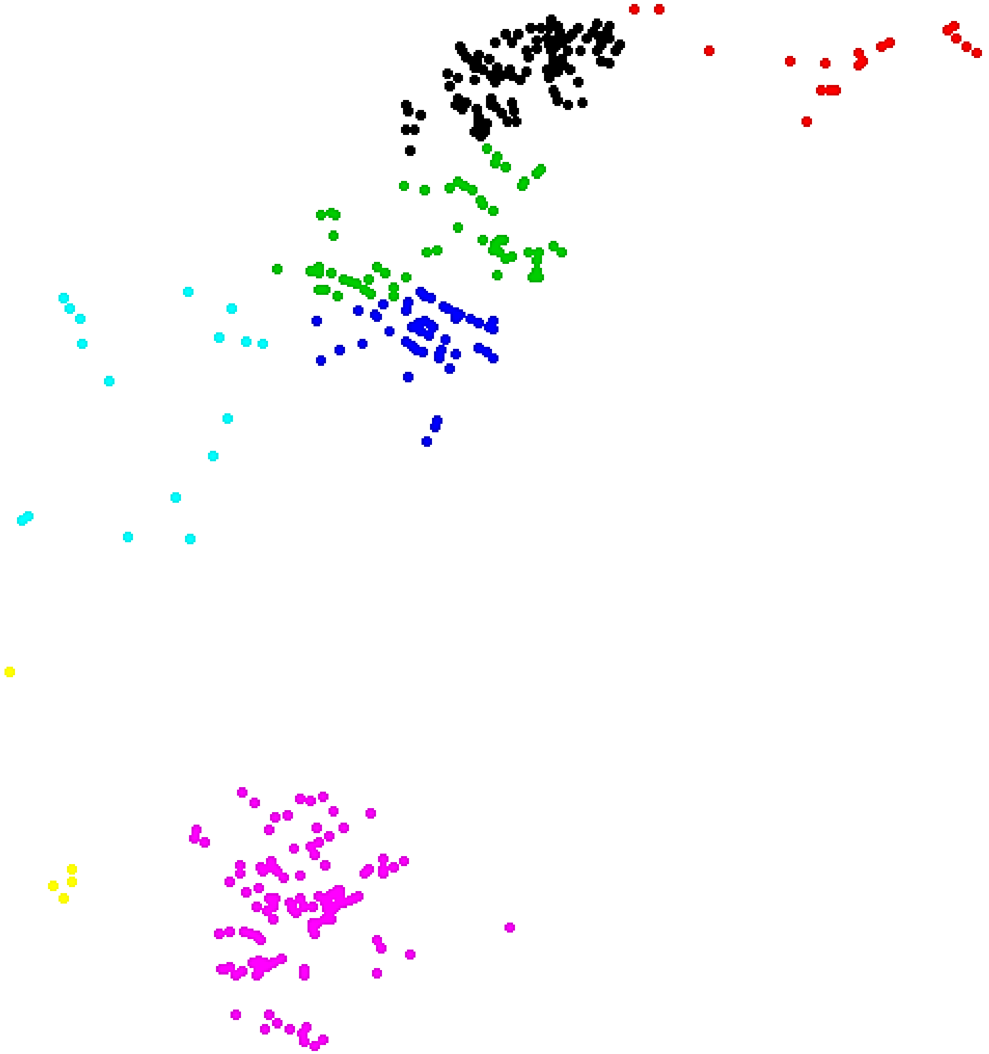
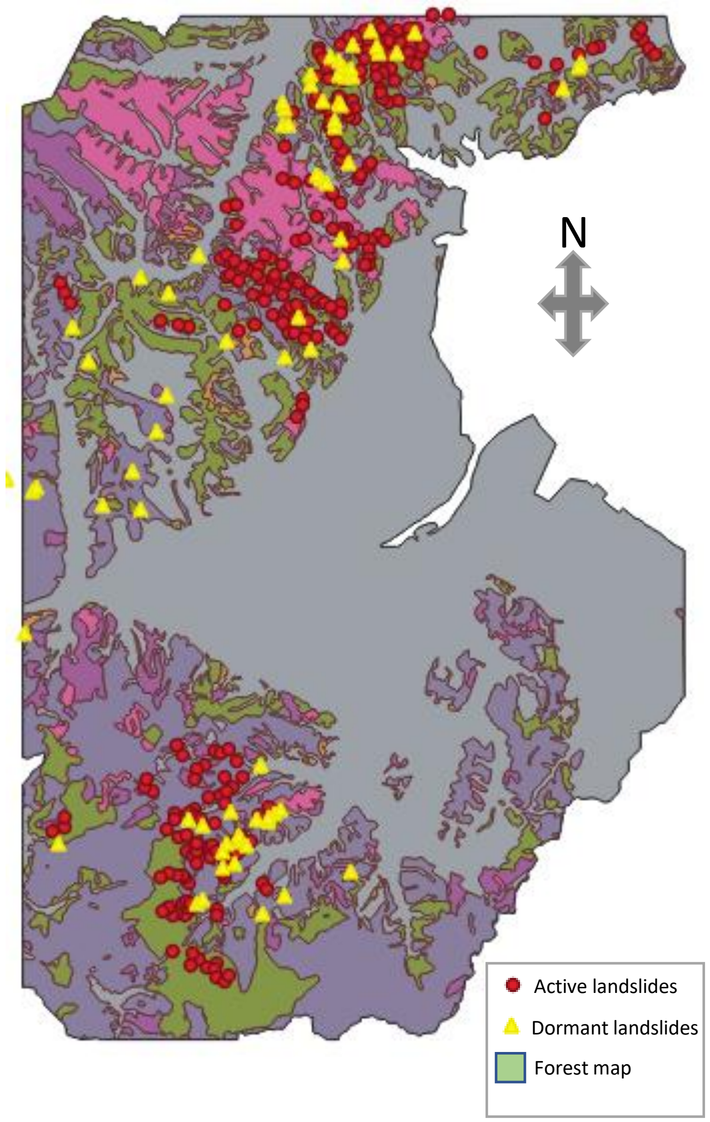


Fig.3 Results of Hirarchical clustering showing low agreement with observed loc.

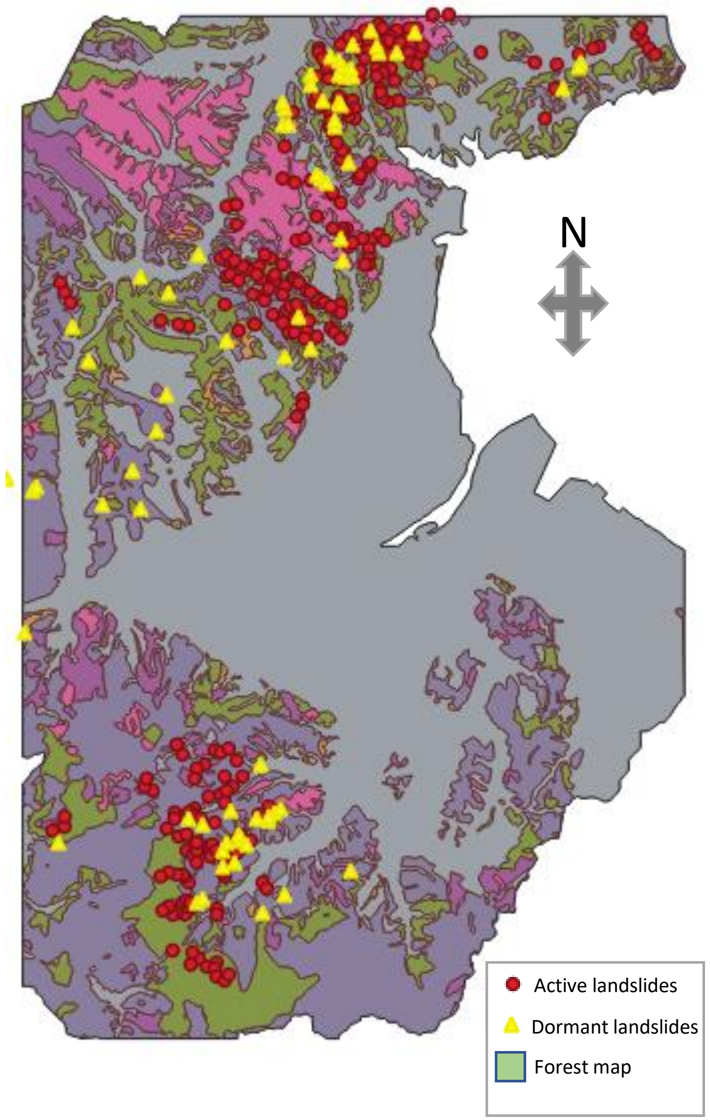
Stage 1..continue..



+ Uncertainty Quantification (UQ) of Epistemic uncertainty (modeling weights uncertainty) and Aleatoric variability (randomness in data).

- **Statistical Analysis :** statistical Moments, Confidence Interval, Correlations Analysis, Principle Component Analysis (PCA)
- **Sensitivity Analysis :** Morris One at A Time (MOAT), Sobol' Sensitivity Analysis, extended Fourier Amplitude Sensitivity Test (FAST)
- **Surrogate Modeling:** Least Angle Regression, Bayesian Neural Networks (BNN)
- **hyper-parameter Optimization**: deterministic and probabilistic methods: Shuffled Complex Evolution (SCE), Dynamical Dimensionally Search (DDS), Adaptive Surrogate Modeling based Optimization (ASMO).

Conclusion



- ✓ Data collected by aerial photos have great amount of uncertainty of ambiguity and vagueness as incomplete/undocumented inventory.
- ✓ Application started with general susceptibility mapping for active and dormant landslides areas. This step, later, will reduce the time/cost of field work (UAV and soil tests) to verify the used inventory as stage 2.
- ✓ Diluvial And Alluvial depth contour map, with addition to slope degree map, will be a valid guide for new constructions locations and safety preparedness.
- ✓ In light of these results, we will make some recommendations for usage and interpretation of UQ methods in hazard mapping.

European Geosciences Union

Thank you..#StayHome #KeepSafe

세종대학교
SEJONG UNIVERSITY

Komar University of Science and Technology, Iraq