Combining Participatory Mapping, Cloud Computing and Machine Learning for Mapping Climate Induced Landslide Susceptibility in Lembeh Island, North Sulawesi.

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Yayasan TERANGI

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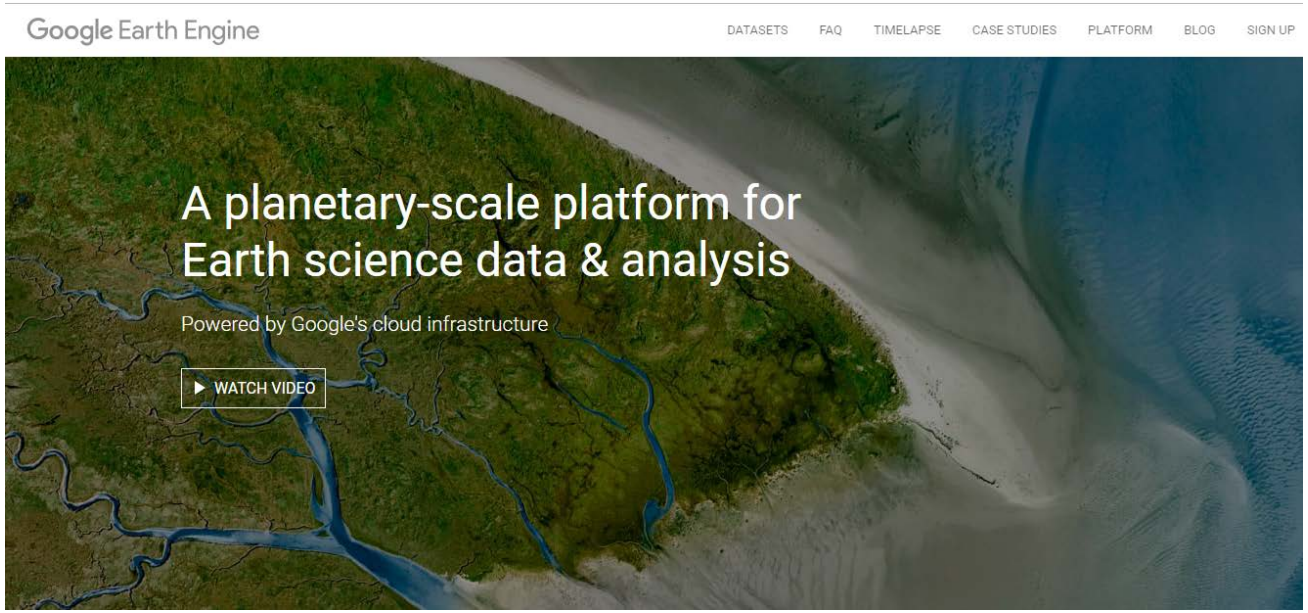
Introduction

- Lembeh Island in Bitung, North Sulawesi are mountainous and high slope area
- Landslide risk mapped by BNPB
- Local community experience landslide outside the predicted area
- Data difficult to find

Introduction

- Google Earth Engine
- Cloud platform for geospatial data analysis
- Includes terabytes of Earth Observation Data
- Ability to collect and manipulate large data
- Integrated Machine Learning
- Potential to be used for landslide modelling



Objectives

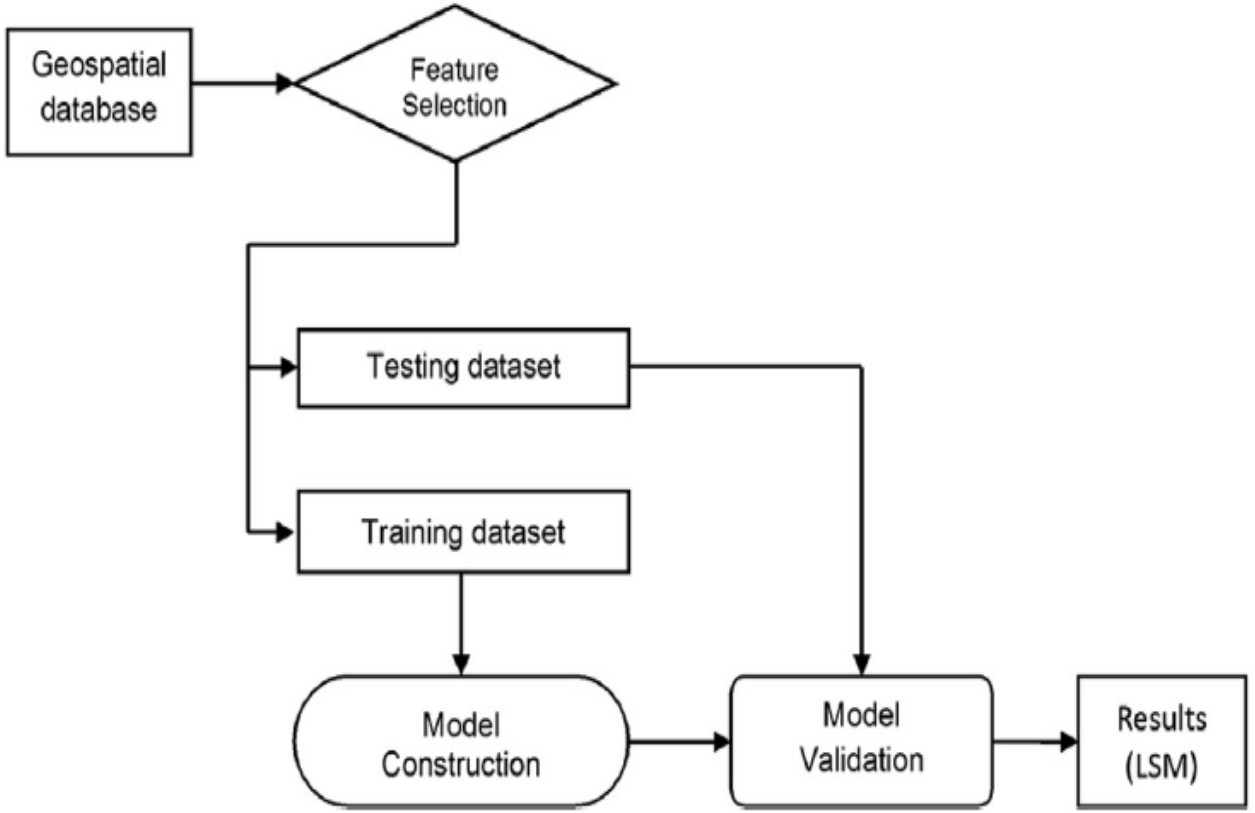
- Map landslide prone areas
- First test in implementation of landslide modelling with GEE and machine learning
- Provide input for disaster management in Lembeh Island

Methodology

- **Lembeh Island in Bitung, North Sulawesi**
- **3 villages: Kareko, Pintu Kota, and Pasir Panjang**
- **Field survey and interview to local community on landslide occurences in the last 5 years**

Methodology

- Landslide modelling with machine learning (Pham 2016)
- Geodatabase includes Landslide Occurrence and Environmental variables
- Landslide occurrence were split to training (70%) and testing 30%) datasets
- Variables include: SRTM Digital Elevation Model, Sentinel 2 multispectral image, Climate Hazards Group InfraRed Precipitation with Station data



Methodology

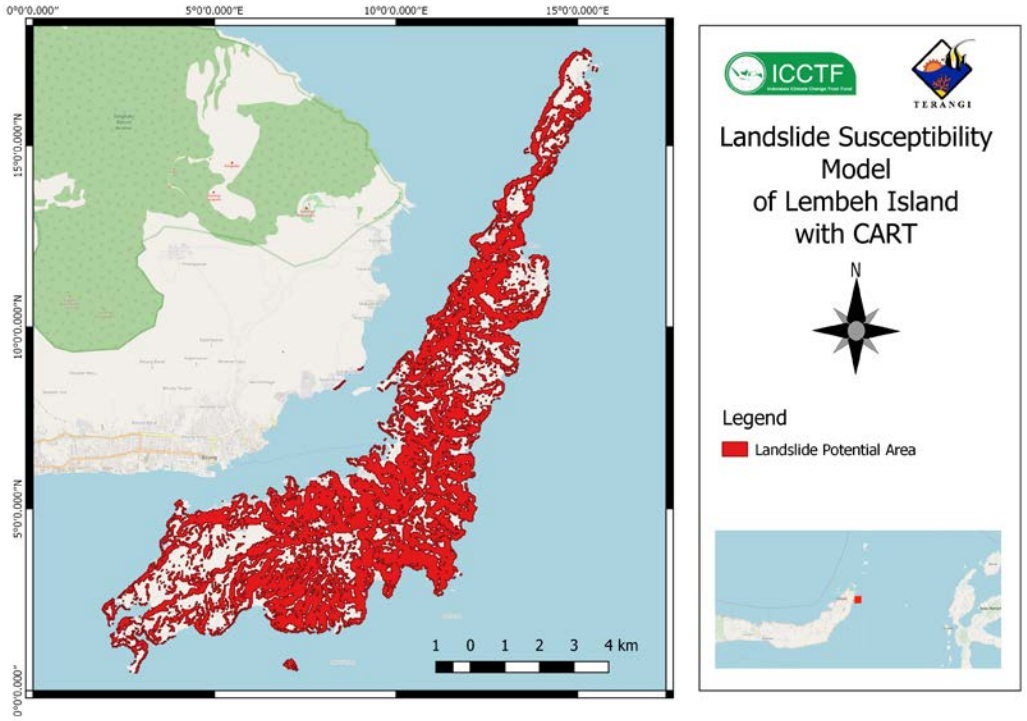
- DEM -> Terrain Modelling -> Altitude, Slope, Curvature, Aspect
- Sentinel 2 -> Cloud Masking -> NDVI
- CHIRPS -> Data Reduction -> Kriging Interpolation -> 1 year Maximum and Mean
- Machine Learning Algorithm: CART (Breiman et al. 1984), Random Forest (Breiman 2001), GMO Maximum Entropy (Mann et al. 2009), Naive Bayes (Russel 1995), and SVM (Cortes & Vapnik 1995).
- Training Accuracy -> Confusion Matrix
- Testing Accuracy -> Error Matrix

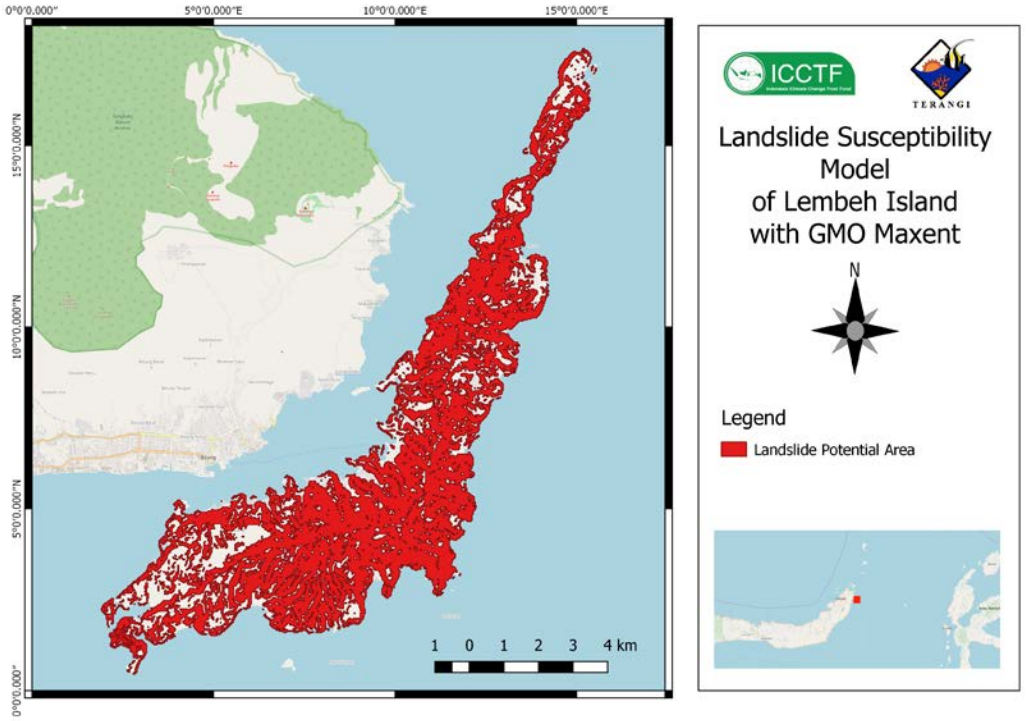
Results

- **Predicted landslide prone area is from 30.91 km2 (Random Forest) to 40.25 km2 (GMO Maxent).**
- **With only 50 km2 of land area, that means around 62% to 80% of land in Lembeh Island is susceptible to landslide**

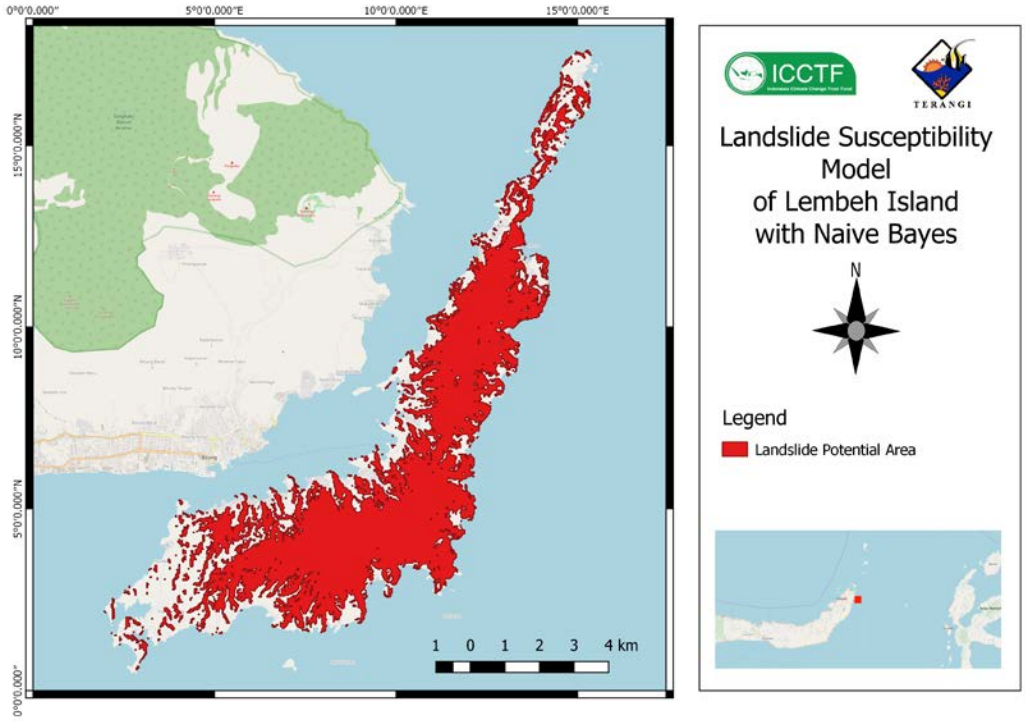
No	Algorithm	Area (sq km)	Percentage
1	Random Forest	30.918	62%
2	SVM	39.983	80%
3	CART	34.265	69%
4	GMO Maxent	40.245	80%
5	Naïve Bayes	36.063	72%

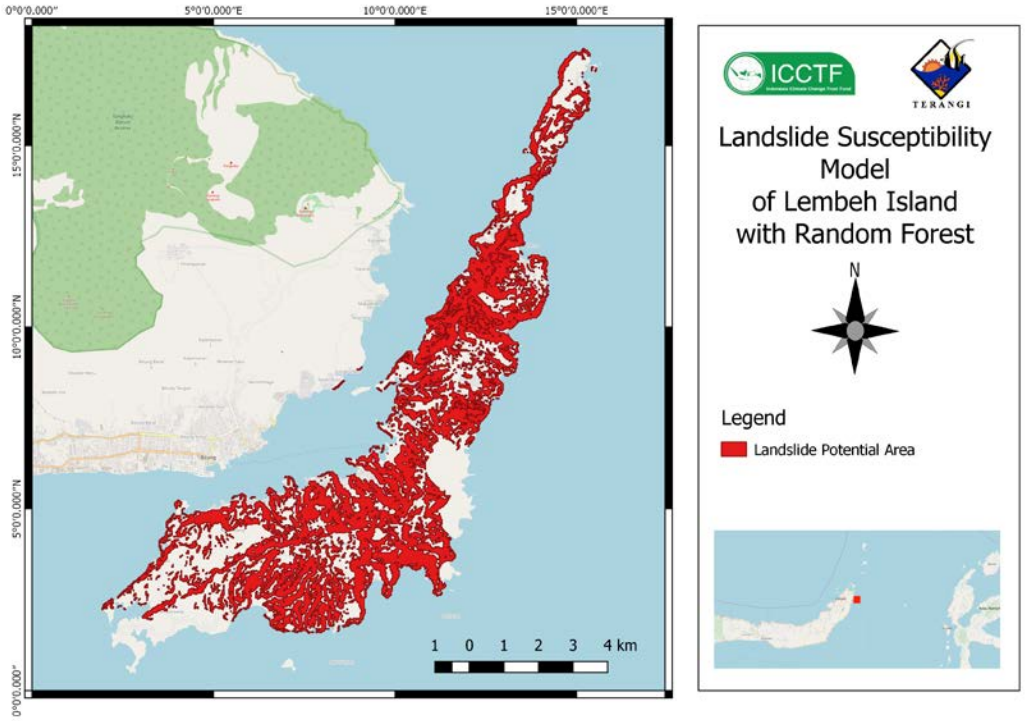
Landslide Susceptibility Models



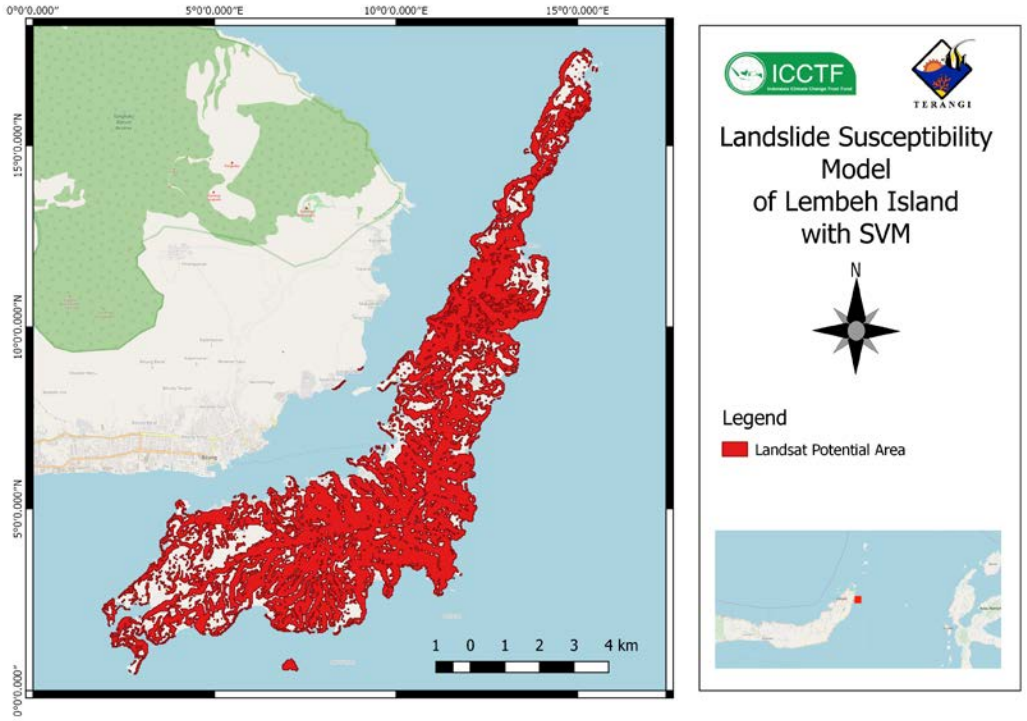


Landslide Susceptibility Models





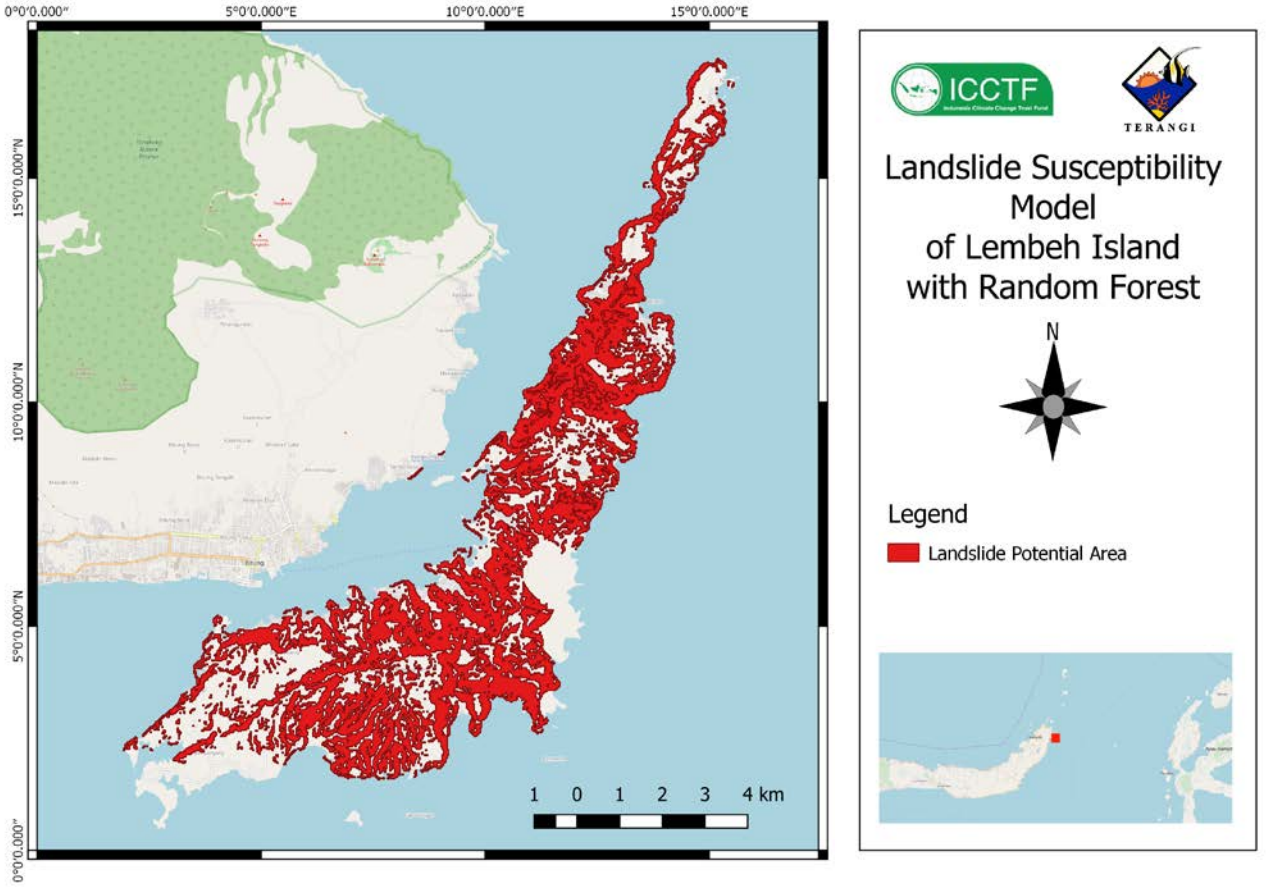
Landslide Susceptibility Models



No	Algorithm	Training accuracy	Testing accuracy
1	Random Forest	0.976	0.981
2	Support Vector Machine	0.970	0.981
3	CART	1.000	0.981
4	GMO Maxent	0.964	0.981
5	Naïve Bayes	0.893	0.904

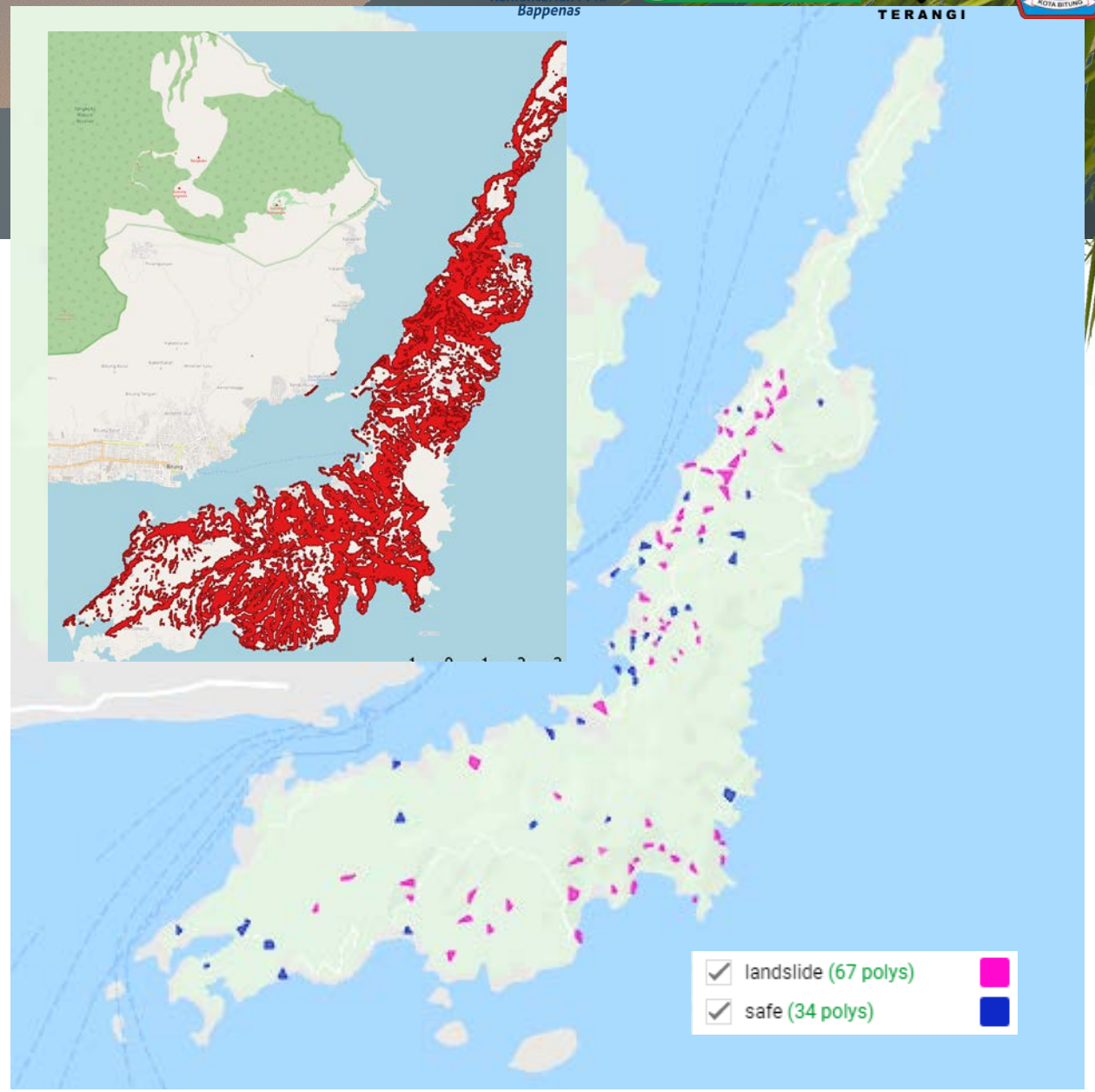
Discussions

- **Most landslide susceptible area are situated at the center of Lembeh Island, where the slope are 30° or higher.**
- **Noorollahi (2018), slope is the parameter with the highest weight for determining landslide susceptibility.**
- **Most of settlement are surrounded by high slope areas, thus, making these settlements prone to landslide impact.**



Discussions

- High altitude area is more prone to landslide than lower altitude area
- While most landslide report collected are situated in the lower altitude due to the proximity to the settlements, the model successfully identify landslide risk in high altitude area.
- This shows that the models don't experience overfitting



Discussions

- Variation in one year mean and maximum precipitation gave insignificant contribution toward classification
- This can be attributed to two factors, which are insufficient time scale and there was no significant difference of precipitation between areas.
- Computation timed out error when calculating 30 years climate normal, thus needed a workaround.
- GEE doesn’t support Area Under the Curve (AUC) of the Receiver Operating Characteristic (ROC) directly
- Accuracy assessment only using Confusion Matrices
- Need to code the AUC and ROC by hand

Conclusions

- Most area in Lembeh Island is prone to landslide, and the settlements are surrounded by it
- Therefore, the residents must be aware, mitigate, and adapt to the hazard
- GEE can be used can be used to model landslides in areas where environmental data required for spatial analysis is not complete
- Care must be taken due to evaluation of modelling accuracy can only use confusion matrices

Thank you

Kementerian PPN/ Bappenas

ICCTF
Indonesia Climate Change Trust Fund

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