Landslide Potential Detection Model Using rdNDVI and the GEE Platform in Leuwiliang District, Bogor

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Abstract. Landslide is among the most frequent natural disasters in Indonesia, especially in regions characterized by steep slopes and high rainfall. This study analyzes the potential for landslides in Leuwiliang District, Bogor Regency, using the Relative Difference Normalized Difference Vegetation Index (rdNDVI) and the Google Earth Engine (GEE) platform. Sentinel-2A imagery with a 10-meter spatial resolution was used to calculate rdNDVI values from pre- and post-event periods (2020–2023). Slope data derived from Digital Elevation Models (DEM) were integrated to identify areas exceeding a 10% slope threshold, categorized as high-risk zones. The rdNDVI analysis revealed that Karehkel Village had the largest landslide-prone area (40.06 ha), while Leuwiliang Village had the smallest (20.88 ha). Validation using field survey data in 2025 showed an accuracy of 78% for a slope threshold of 10%. The resulting WebGIS system provides interactive visualization for disaster risk mapping and supports decision-making for local mitigation planning. The combination of rdNDVI and GEE demonstrates the potential of cloud-based remote sensing for rapid and scalable landslide detection. Future work should include additional parameters such as rainfall intensity and soil moisture to enhance prediction accuracy.

Keywords: Google Earth Engine; rdNDVI; Sentinel-2A; Landslide; Leuwiliang.

I. INTRODUCTION

Indonesia is highly prone to landslides due to its complex topography and heavy rainfall patterns. In Bogor Regency alone, more than 1,500 natural disasters occurred between 2022 and 2024, with over 600 cases of landslides. Leuwiliang District, characterized by steep slopes and dense vegetation, is one of the most vulnerable regions. The application of remote sensing technologies has opened new opportunities to assess environmental conditions efficiently.

Based on data from the Bogor District Disaster Management Agency (BPBD) for the years 2022-2024, a total of 1,585 natural disaster events were recorded, spread across 40 sub-districts. Of these, 627 events were landslides. Of these, 46 occurred in Leuwiliang Sub-district, which is one of the 40 sub-districts in Bogor District [1].

Previous research in Sukajaya District, Bogor Regency, showed that the rdNDVI (Relative Difference Normalized Difference Vegetation Index) method is effective in detecting landslides, with an accuracy rate reaching 90%, especially in areas with a slope gradient of 10% to 15% [2].

Google Earth Engine (GEE) offers cloud-based geospatial processing capabilities that enable large-scale satellite analysis. The rdNDVI method, derived from NDVI changes between pre- and post-event imagery, provides a quantitative measure of vegetation disturbance that correlates with landslide occurrences. [3] This research integrates GEE analysis with spatial modeling to identify and map landslide-prone zones in Leuwiliang District.

II. METHODOLOGY

2.1 Model Design

a) Time and Location

The research period was from January to June 2025. The research location is in Leuwiliang District, Bogor Regency.

b) Materials and Tools

The research materials used several spatial datasets (Leuwliang District Administrative Map 2023 at a scale of 1:25,000 sourced from the Geospatial Information Agency 2023 and Sentinel-2A Multispectral 10-meter resolution imagery sourced from Google Earth Engine 2024) and non-spatial data (Landslide Disaster Reports from 2011 – 2024 sourced from the Bogor Regency Disaster Management Agency 2024 and field validation from the 2025 Survey).

c) Equation

This research employs Sentinel-2A imagery (10 m resolution) for the years 2020–2023, focusing on pre-event (Fig. 1) and post-event (Fig. 2) vegetation indices. The rdNDVI is computed using Eq. (1), comparing NDVI before and after the event to detect significant changes in vegetation cover [4].

$$rdNDVI = \left((NDVIpost - NDVIpre) / \sqrt{NDVIpost^2 + NDVIpre^2} \right) * 100. \quad (1)$$

Where, rdNDVI is Relative Difference NDVI; NDVIpre is maximum NDVI in Pre Event (2020 - 2021); and NDVIpost is maximum NDVI in Post Event (2022 - 2023). Digital Elevation Model (DEM) data were used to derive slope maps, where slopes exceeding 10% were classified as high-risk zones [5] .

The analysis was performed on GEE using JavaScript and later visualized in GIS software for spatial representation. Field validation was conducted in 2025 to assess the accuracy of detected landslide areas.

2.2 Model Visualization

After obtaining the results from data processing and analysis, the next step is to create Unified Modeling Language (UML) diagrams and design the Graphical User Interface (GUI) to model how the system will be designed according to the predetermined requirements, resulting in a structured and reliable system[6].

During the construction phase, the system was designed using Visual Studio Code software. The main programming language used was Typescript (TS). After the system is designed overall, testing is conducted to evaluate the system's feasibility using blackbox testing.

III. RESULT AND DISCUSSION

The results of the landslide potential analysis in Leuwiliang District using the rdNDVI method show that Karehkel Village has the highest average area, which is 40.06 hectares (Fig. 3). This indicates that Karehkel Village is the area most prone to landslides compared to other villages in Leuwiliang District. Conversely, Leuwiliang Village has the lowest average area, which is 20.88 hectares, indicating that the landslide potential in this village is relatively small. Therefore, Karehkel Village needs to be prioritized in the planning of landslide disaster risk mitigation (Fig. 4).

The landslide detection results indicate variation in affected areas across villages within Leuwiliang District. Karehkel Village recorded the largest detected landslide area at 40.06 hectares, followed by Village A with 33.12 hectares, and Village B with 28.45 hectares. Village D showed a detected area of 22.75 hectares, while Leuwiliang Village had a slightly smaller extent of 20.88 hectares. The smallest detected area was found in Village C, with 15.30 hectares, as presented in Table 1.

TABLE 1 LANDSLIDE DETECTION AREA PER VILLAGE

No	Village	Area (ha)
1	Karehkel	40.06
2	Leuwiliang	20.88
3	Village A	33.12
4	Village B	28.45
5	Village D	22.75
6	Village C	15.3
Total		160.56

The results of the landslide detection accuracy test using the Relative Difference Normalized Difference Vegetation Index (NDVI) method, [7] with the best accuracy obtained using a Threshold slope of 10 percent, yielding a value of 78%, while the lowest accuracy was obtained using a Threshold slope of 25 percent, yielding a value of 52%, as presented in Table 2.

TABLE 2 ACCURACY FOR VARIOUS THRESHOLD LEVELS

Threshold Slope	Accuracy (%)	TP	FP	FN	TN
5%	72	40	18	10	32
10%	78	45	12	10	33
15%	70	42	22	8	28
20%	60	35	30	10	25
25%	52	30	36	12	22

WebGIS integration allowed interactive visualization of landslide potential zones (Fig. 5), aiding local authorities in risk management and decision-making. The WebGIS platform provides a critical interface for the presentation of geospatial information, specifically encompassing layers for the reduced normalized difference vegetation index (rdNDVI), topographical slope, landslide susceptibility, and administrative area metrics at the village scale. The synthesis of these data layers is instrumental in improving agency monitoring protocols and informing the strategic prioritization of high-risk zones.

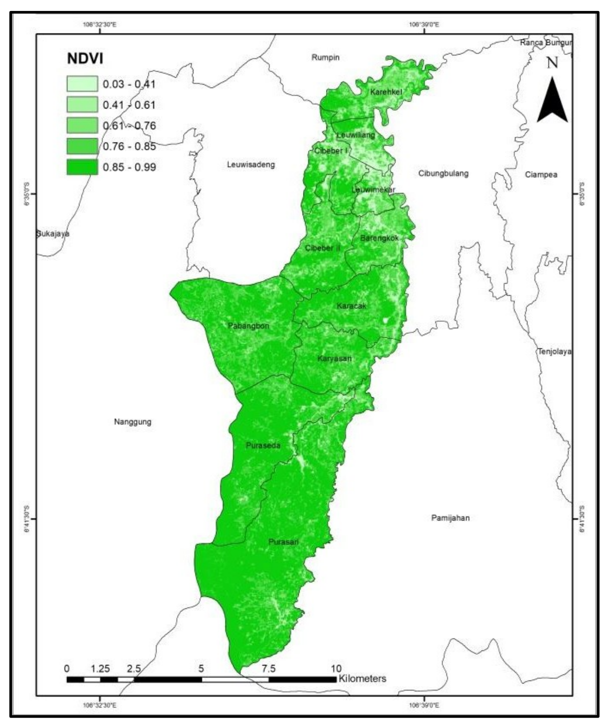

Fig. 1. rdNDVI pre-event visualization in Leuwiliang District.

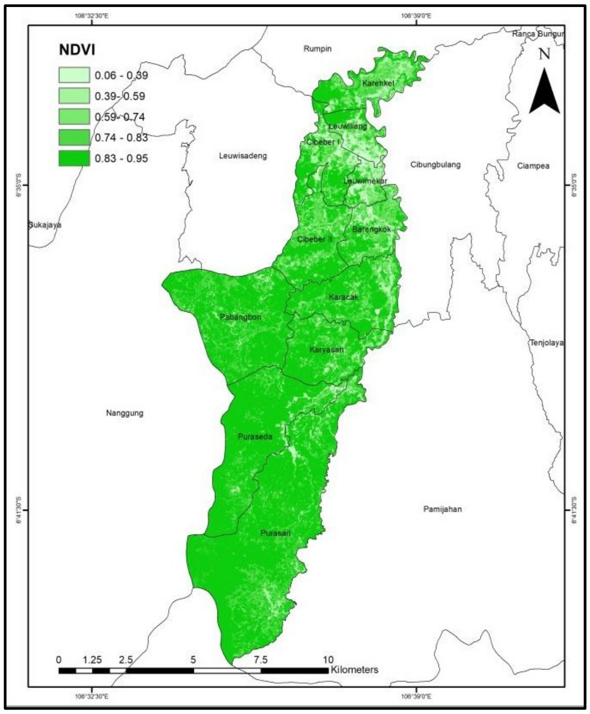

Fig. 2. rdNDVI post-event visualization in Leuwiliang District.

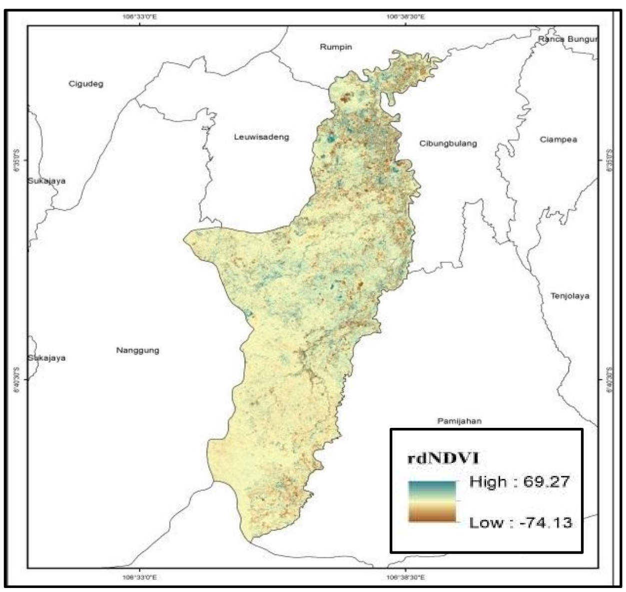

Fig. 3. rdNDVI visualization in Leuwiliang District

Fig. 4. Landslide survey location

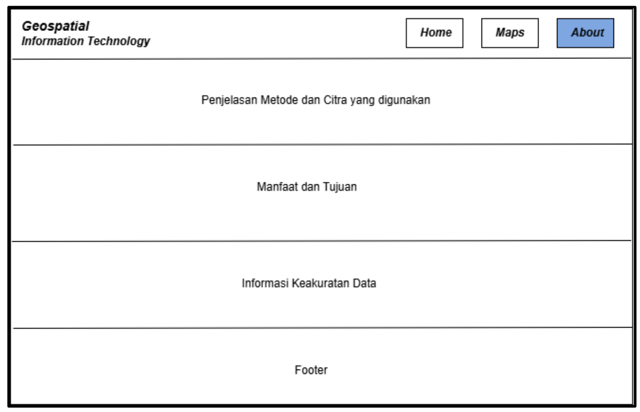

Fig. 5. WebGIS interface of landslide risk mapping

IV. CONCLUSION

The rdNDVI method integrated with Google Earth Engine proved effective for detecting landslide-prone areas in Leuwiliang District. By combining Sentinel-2A imagery and slope analysis, the model achieved an accuracy of 78%. This study demonstrates the potential of cloud-based remote sensing for real-time disaster mitigation planning. Future research is encouraged to incorporate rainfall and soil moisture parameters for improved predictive capability.

The WebGIS-based information system developed in this study successfully presents an interactive map of landslide-prone areas in Leuwiliang District. This system utilizes the results of the Relative Difference NDVI (rdNDVI) method analysis and slope classification to provide a visualization of areas potentially experiencing landslides. This WebGIS allows users to easily access information on landslide-prone areas, supporting decision-making in planning landslide disaster risk mitigation.

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