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ASSESING GEOTHERMAL INFLUENCE ON VEGETATION HEALTH THROUGH TIME SERIES ANALYSIS

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INTRODUCTION

Geothermal systems influence surface environments by altering soil temperature, gas emissions, and geochemical conditions, which can affect vegetation health. In tropical regions, identifying geothermal activity using satellite thermal data is challenging due to dense vegetation, cloud cover, and limited surface manifestations.

Vegetation responds to geothermal stress through changes in chlorophyll, moisture, and reflectance, which can be detected using vegetation indices. Previous studies often used single-date imagery, limiting the ability to observe long-term vegetation response.

This study uses Sentinel-2 time-series (2019–2025) and four vegetation indices (NDVI, EVI, SAVI, REP) to monitor vegetation dynamics in the Papandayan geothermal field, Indonesia (Figure 1). Field datasets such as radon, mercury soil gas, and geological structures, are integrated to evaluate relationships between vegetation health and geothermal activity.

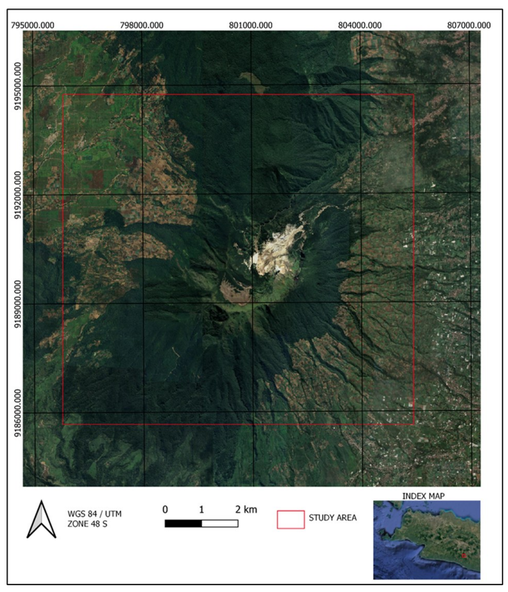


Figure 1. Study Area in the Mount Papandayan geothermal field, West Java, Indonesia

METHODS

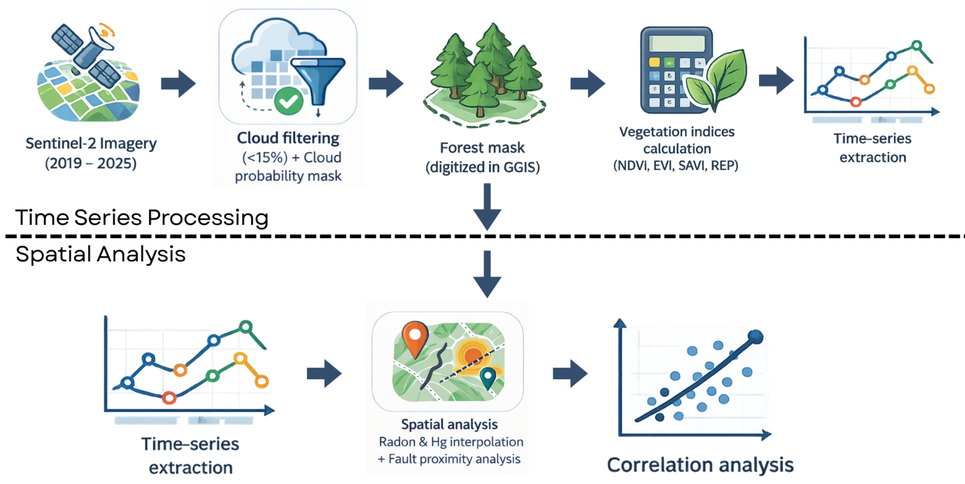


Figure 2. Vegetation time series workflow

RESULTS

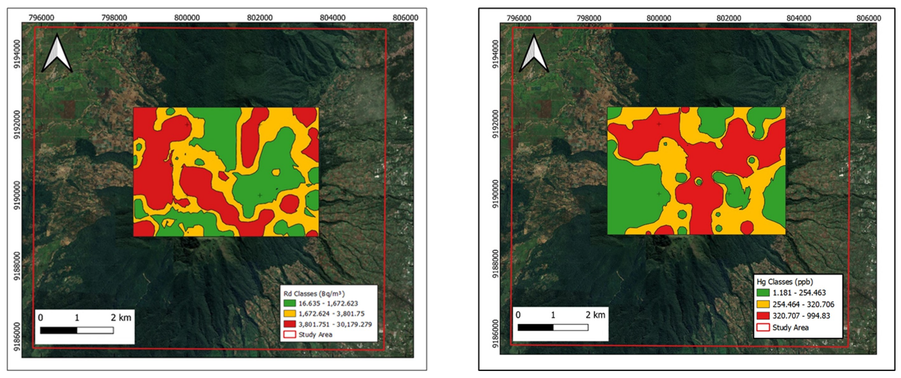


Figure 3. Spatial distribution of interpolated Hg (ppb) and Radon (Rn) soil gas concentrations in the Papandayan geothermal area.

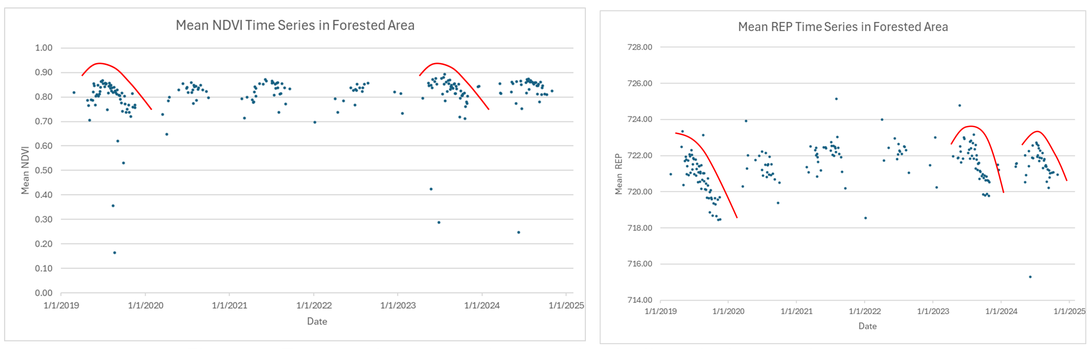


Figure 4. Temporal pattern of vegetation indices in forested area



Figure 5. Temporal pattern of vegetation indices in forested area

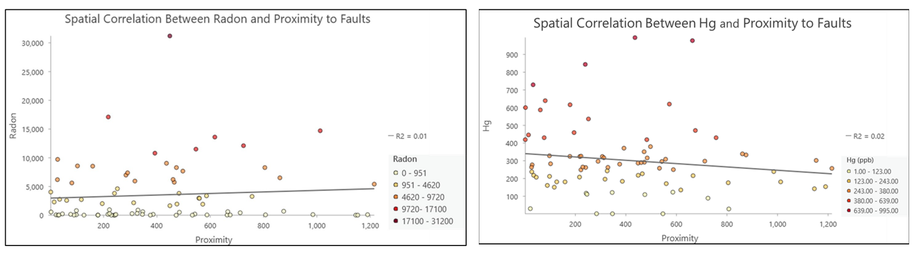


Figure 6. Soil gas concentration and fault proximity correlation

DISCUSSION

The vegetation time-series analysis indicates that forest conditions in the Papandayan geothermal field remain largely healthy, with only small localized reductions in vegetation indices. The weak and inconsistent relationships between vegetation indices, soil-gas concentrations, and fault proximity suggest that geothermal influence on vegetation is limited and easily masked by dense tropical canopy conditions. Spatial statistics confirm the absence of meaningful clustering, reinforcing that optical vegetation indices alone cannot reliably map geothermal activity in this environment. Overall, the study concludes that while Sentinel-2 time-series provide valuable insights into seasonal vegetation dynamics, identifying geothermal signals requires integrating satellite data with soil-gas measurements and structural information to improve detection in tropical forest settings.

CONCLUSION

This study investigated vegetation responses to geothermal activity in the Papandayan geothermal field using Sentinel-2 time-series data (2019–2025) and soil-gas measurements. NDVI, EVI, SAVI, and REP showed consistently healthy forest conditions with seasonal peaks mid-year and slight declines toward year-end. Localized reductions in NDVI and REP occurred in areas with higher radon levels, but overall vegetation patterns showed weak spatial relationships with soil-gas concentrations or fault proximity. Despite cloud-related limitations, the findings demonstrate that multi-temporal vegetation indices can reveal subtle geothermal signals. Future work should incorporate higher-resolution imagery, improved atmospheric correction, and additional environmental parameters to enhance geothermal monitoring.

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