IDENTIFICATION OF GEOTHERMAL PROSPECT AREAS USING REMOTE SENSING TECHNIQUES IN THE MOUNT GALUNGGUNG REGION

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ABSTRACT

Geothermal energy sources are economical and have significant potential because Indonesia is located in the Ring of Fire area, which results in numerous tectonic processes that play a role in the emergence of geothermal resource potential. Among Indonesia's many geothermal energy potentials, one is the geothermal resource found in Tasikmalaya Regency, particularly in Mount Galunggung, an area with a geothermal system, as evidenced by geothermal manifestations. This research aims to determine the location of geothermal prospect areas using remote sensing techniques before conducting further research on the reservoir characteristics in a geothermal system in a given area. The study was conducted by analyzing surface temperature, structures in linear features, and field surveys to confirm the location of geothermal manifestations. The research results indicate geothermal prospect areas in the Mount Galunggung region in Sukaratu District, with surface temperature results ranging between 13-29°C.

Keywords: Geothermal, Galunggung, Manifestation, Remote Sensing, Surface Temperature

INTRODUCTION

Indonesia has significant potential of geothermal with volcanic activity spanning from Sabang to Merauke. (Ramadhan et al., 2021). Geothermal energy sources are economical and have significant potential because Indonesia is located in the Ring of Fire area, which results in numerous tectonic processes that play a role in the emergence of geothermal resource potential. Among Indonesia's many geothermal energy potentials, one is the geothermal resource found in Tasikmalaya Regency, particularly in Mount Galunggung, an area with a geothermal system, as evidenced by the manifestations of geothermal. Mount Galunggung is also on the same ridge as Talaga Bodas and Karaha Bodas, where both locations, especially Karaha Bodas, have proven geothermal systems with an installed capacity of 30 MW by Pertamina Geothermal Energy. This Geothermal system is characterized by a thick cap rock, steep temperature gradients, and low permeability, with steam-dominated regions reaching below sea level and fluid zones with temperatures as high as 350°C. (Allis, R., Moore, J., McCulloch, J., Petty & DeRocher, 2000).

Mount Galunggung has geothermal manifestations in hot springs, thus characterizing an area with a geothermal system. The surrounding community also utilizes hot springs as geotourism in the form of hot springs directly from the source. Therefore, the study focused on the correlation between surface temperature and hot springs in the Mount Galunggung area to determine where the geothermal prospects are located. As an area that has excellent geothermal energy potential, the study is expected to be able to provide analysis results that can be a reference for further research on the characterization of geothermal systems in the Mount Galunggung area.

This research aims to determine the location of geothermal prospect areas using remote sensing techniques before conducting further research on the reservoir characteristics in a geothermal system in a given area. Remote sensing methods serve as an alternative to simplify exploration challenges regarding time effectiveness, cost-efficiency, and accessibility to exploration locations. (Ramadhan et al., 2021).

Remote sensing is highly effective in identifying geothermal features, particularly given the large size of the study area. By processing the thermal band of Landsat imagery, hot spots are detected that could indicate geothermal activity, though not all detected hot spots represent actual geothermal manifestations. Therefore, the hot spots need to be separated into geothermal manifestations and not manifestations of geothermal. (Saragih et al., 2015).

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RESEARCH METHOD

The research method is conducted by processing surface temperature calculations, delineating lineaments and geothermal manifestations, delineating geological structures, spatial modeling, and analyzing buffer and intersect data to determine prospective areas. The manifestation of geothermal heat is usually evident from the heat it emits. If this area is recorded using Landsat satellite imagery in the thermal channel, it will appear to have a higher brightness temperature anomaly than the surrounding temperature. (Nugroho & Fadhilah, 2019).

The research focused on spatial objects in the Galunggung area from remote sensing data. Secondary data required includes Landsat 8 satellite image data, DEM data, regional geological maps, Indonesian landform maps (RBI), and data on the distribution of surface manifestations, with the software used ArcGIS, Global Mapper, Google Earth Engine, and Dips (Mahira, 2021).

Data processing is carried out using Land Surface Temperature (LST) method to obtain the allocation values of surface temperature. The brightness temperature is calculated using the thermal channel, utilizing the single window algorithm with band 10. This is due to the stray light effect caused by light entering the optical path of the TIRS telescope. Therefore, the USGS recommends not using band 11 (USGS, 2016).

Correction of Landsat 8 images is performed to eliminate atmospheric disturbances during recording. The reflectance values recorded in each band on the Landsat image are expressed in digital numbers (DN). The satellite image data obtained cannot be directly processed with digital numbers; they must undergo several conversion steps first to get the actual surface temperature values. The equation used in this conversion is as follows (USGS, 2016):

$$L_\lambda = \frac{L_{MAX} - L_{MIN}}{Q_{calmax} - Q_{calmin}}(TIRS - 1) + Lmin$$

L_λ: Spectral Radiance

Lmax(λ) : Maximum spectral radiance = 22.00180

Lmin(λ) : Minimum spectral radiance = 0.10033

Qcalmax : Quantitize calmax = 65535

Qcalmin: Quantitize calmin = 1

After converting to spectral radiance values, a spectral ratio correction is performed to convert them to Kelvin using the following equation:

$$TS = \frac{K2}{\ln\left(\frac{K2}{L\lambda} + 1\right)} \quad , \; TB = \mathcal{E}^{-\frac{1}{4}} * Ts$$

TS = Saturation Temperature

TB = Surface Temperature

Then, the temperature values in Kelvin are converted to Celsius using the following equation:

$$Tsp = TB - 273$$

Tsp = Convert temperature in Kelvin to Celsius

RESULT AND DISCUSSION

Surface Temperature Calculation

The search for land surface temperature (LST) is closely related because the LST value is influenced by the most sensitive wavelength, thermal infrared. (Farhan, Audi; Didit Haryanto & Hutabarat, Johanes;Ronggour, 2021). Surface temperature refers to how hot the Earth's surface feels at a specific location (from the satellite's viewpoint, the surface is whatever it sees when looking through the atmosphere to the ground, such as grass on a lawn, the roof of a building, or the leaves of a forest canopy) (Clarissa et al., 2020). Information on the distribution of surface temperature values was obtained from processing brightness temperature data, which was classified into eight classes. The lowest temperature recorded was 13°C, and the highest was 29°C. Generally, the higher the elevation of an area, the lower the brightness temperature tends to be.

Temperature anomalies are visible in high-elevation areas on the surface temperature map resulting from data processing. This is illustrated in Figure 1, where in areas with low temperatures (indicated in green), there is a region where the temperature suddenly increases (shown in yellow and red). This occurs because these high-temperature areas are located in geothermal manifestation areas.

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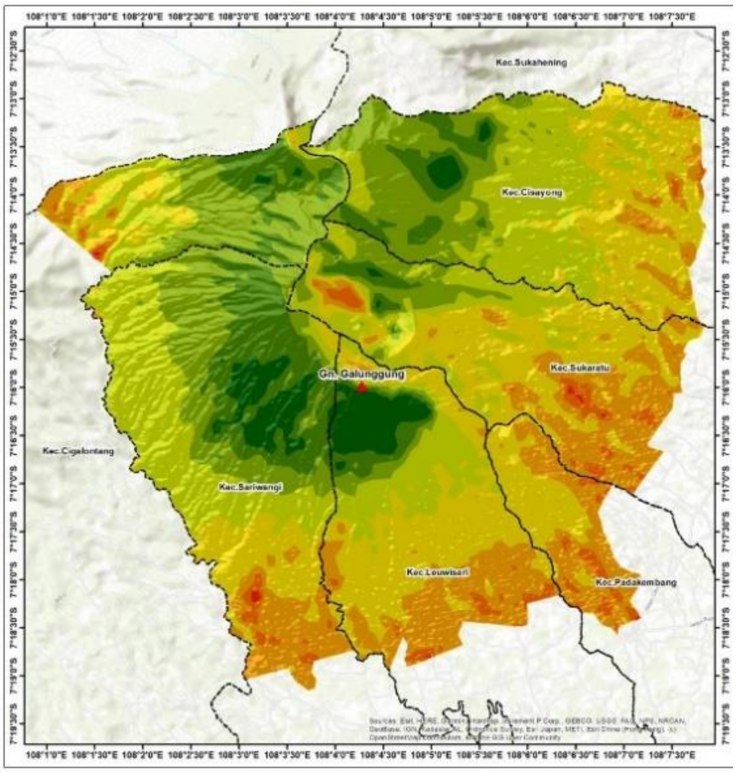

Figure 1. Surface Temperature Map (LST) of Mount Galunggung

Lineament and Geological Structure Delineation

Lineaments and geological structures were delineated to identify the locations of geological structures. Lineaments are morphological expressions of geological structures modified from DEM imagery using ArcGIS by drawing straight lines along ridges and valleys. Geological structures have the potential to act as permeable zones that serve as pathways for geothermal fluids (steam and water) to flow to the surface. Based on the analysis of SRTM-DEM imagery and Tasikmalaya Geological Map of the research area, the structural analysis indicates that the area's structures are oriented in a northwest-southeast direction. Other structures, such as normal faults and fractures, are also identified. These linear features suggest that the hot springs in the Galunggung area surface due to these fractures. The findings in the field indicate that the hot springs' location is associated with the presence of morphological lineaments.

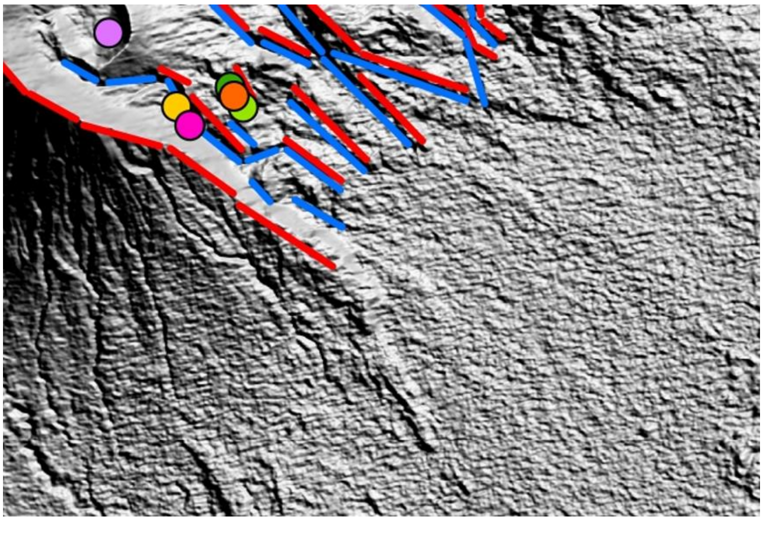

Figure 2. Linear Features Map of Mount Galunggung

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Geothermal Manifestation Delineation

Manifestation is a primary component that indicates the existence of a geothermal energy source, specifically geothermal manifestations. The presence of geothermal manifestations signifies the potential for a geothermal reservoir, such as hot springs, fumaroles, solfataras, geysers, steaming ground, and others.

Delineating geothermal manifestations is crucial for determining geothermal prospect areas. This process involves field verification to confirm whether the results from the visual interpretation align with the actual conditions on the ground. Geothermal manifestation points, such as hot springs, were identified. through field surveys and are located at specific coordinates 7°15'24,68"S 108°4'39,77" E, 7°15'58,15" S 108°5'40,14" E, 7°15'49,20" S 108°5'34,37" E, 7°15'53,18" S 108°5'36,13"E, 7°15'57,86" S 108°5'10,30" E dan 7°16'6,3" S 108°5'16,14" E.

The research area's hot springs have water temperatures ranging from 38.7°C to 68.1°C with a pH of 6.4 to 6.8. The physical condition of the water is clear, tasteless, and odorless. At the bottom of each hot spring are typically silica sinter deposits.

Figure 3. Geothermal Manifestations in Mount Galunggung

Geothermal Prospect

The surface temperature map shows several subdistricts with warm areas, namely Leuwisari, Padakembang, and Sukaratu. However, these warm areas could be caused by human activities, such as markets that increase the temperature. In contrast, the Sukaratu subdistrict has natural geothermal manifestations in the form of hot springs, as observed in the fieldzone.

The brightness temperature in the circled area is around 21°C-29°C. This location is in a Mountainous region, where geothermal manifestations around linear features and geological structures can serve as permeable zones for geothermal fluids to flow to the surface. The manifestations in this area are described by the presence of hot springs, indicating that this region can be considered a geothermal prospect area due to its geothermal characteristics.

The characteristics of the hot springs are dilute-chloride bicarbonate type, namely chloride water mixed with meteoric water.

The Cl (chloride) content tends to be low, indicating that the springs around Mount Galunggung are far from the reservoir. So, it is possible that mixing meteoric water can also greatly influence the fluid that comes to the surface. Moreover, high Mg content may indicate that there has been leaching of Mg from the surrounding rocks or dissolution with groundwater with a relatively high Mg concentration (Nicholson, 1993).

The isotope results plot of the hot spring shows that most of the springs are plotted near the Indonesian Meteoric Water Line, so the image above suggests that, in general, most of the springs come from meteoric water.

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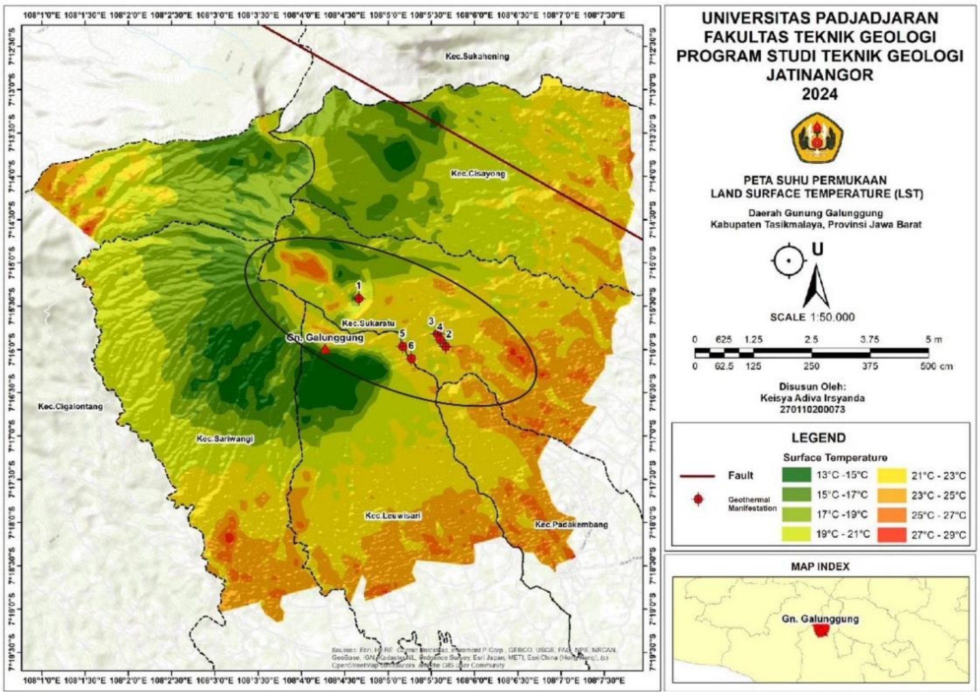

Figure 4 Geothermal Prospect Area Map of Mount Galunggung.

CONCLUSION

Remote sensing techniques, mainly Landsat eight thermal imagery, provide valuable data for identifying geothermal prospect areas. In the Mount Galunggung region, this approach has successfully identified potential geothermal areas by analyzing surface temperature anomalies and integrating geological data. In the study area, the lowest temperature reached 13°C, and the highest temperature reached 29°C. By combining this data with lineament, geological structure, and geothermal manifestation data, supported by field surveys, it can be concluded that the geothermal prospect area is located in Gunung Galunggung region, Sukaratu Subdistrict.

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