CHAPTER 1 INTRODUCTION

1.1 Research Background

Geothermal energy is a renewable resource with significant development potential. Indonesia alone holds an estimated 29.5 gigawatts (GW) of geothermal capacity—about 40% of the world's total (Khasmadin and Harmoko, 2021). Much of this potential lies along the volcanic belt, including West Sumatra, which has a total capacity of around 1,196 megawatt equivalents (MWe). In Solok Regency, particularly the Surian area, signs point to promising geothermal resources. The site's speculative capacity is estimated at 75 MWe—a notable figure given its location within an active tectonic zone that facilitates the migration of hot fluids to the surface (EBTKE, 2019). Early exploration data indicate that Surian hosts hot spring manifestations with temperatures reaching 40.8°C, as well as a geothermal anomaly zone identified through temperature gradient measurements, heat flow analysis, and an anomaly area covering roughly 3.25 km² (Purwoto, 2017). Despite these findings, exploration in the area remains limited due to the high cost and complexity of conventional methods. For instance, while hot springs have been recorded, detailed mapping of other surface heat anomalies has yet to be conducted. Traditional geological, geochemical, and geophysical surveys require considerable investment of money, time, and energy, and field sampling is often hindered by difficult-to-access terrain (Isa et al., 2020). This makes remote sensing-based studies especially valuable for early-stage geothermal exploration. Such approaches provide effective tools for spatial mapping and prioritizing potential zones, helping guide and optimize costly, logistically challenging exploration drilling efforts.

Remote sensing offers a clear advantage over traditional methods by allowing large areas to be analyzed in a much shorter time (Isa et al., 2020). Satellite imagery, including Landsat 8 TIRS, Sentinel-2, and DEM SRTM, is used to identify areas with geothermal potential by detecting thermal anomalies, changes in vegetation, and geological structures that influence hydrothermal systems. By integrating data on land surface temperature (LST), vegetation health (NDVI), and geological structures (DEM SRTM), researchers can gain an initial geospatial understanding of a region's geothermal potential.

Land Surface Temperature (LST) analysis using Landsat 8 TIRS helps detect thermal anomalies that may indicate geothermal activity. Elevated surface temperatures compared to surrounding areas can signal the presence of a subsurface geothermal system (Putri et al., 2021; Chao et al., 2023; Dong et al., 2022; Utama et al., 2024; Syawalina et al., 2022). To address the limitations of Landsat 8 in detecting alteration minerals in densely vegetated regions, the Normalized Difference Vegetation Index (NDVI) from Sentinel-2A is employed with multitemporal acquisition. This approach offers higher resolution for environmental monitoring and land change detection (Hu et al., 2018; Sentinel-2, 2015). Sentinel-2A imagery is particularly useful for identifying vegetation stress potentially caused by geothermal processes, such as hydrothermal gas emissions or changes in soil mineralogy due to hydrothermal alteration (Haeruddin et al., 2023). Geological structure analysis using SRTM DEM data is applied to detect faults, fractures, and topographic patterns that serve as pathways for geothermal fluid migration. The data is processed through hillshade, slope analysis, and edge detection techniques to map structural patterns associated with geothermal systems (Mahfud et al., 2024). These three key parameters—LST (surface temperature anomalies), NDVI (vegetation stress), and geological structure (faults and fractures from DEM SRTM)—are then integrated using the Analytical Hierarchy Process (AHP). AHP provides a multi-criteria analysis framework for spatial data-based decision-making (Niken, 2023; Teknik et al., 2024).

Each parameter is assigned a weight according to its significance in the occurrence of a geothermal system. Using the AHP method, these weighted parameters are integrated within a GIS environment to produce a spatially prioritized map of geothermal zones (Elbarbary et al., 2022). This process allows for a more focused and efficient exploration strategy by narrowing down target areas before employing resource-intensive field methods. Considering the high costs, limited accessibility, and time constraints of conventional exploration, this study provides a geospatial, multi-criteria framework to optimize early-stage geothermal exploration—particularly in data-scarce or remote areas like Surian.

1.2 Research Purpose

This research aims to conduct an initial study in determining the geothermal potential in Surian area, Solok Regency, West Sumatra, using remote sensing technology with the integration of satellite images and the Analytical Hierarchy Process (AHP) method. More specifically, the objectives of this research include:

1. Identify surface temperature anomalies in the Surian area using Land Surface Temperature (LST) analysis based on Landsat 8 TIRS imagery, in order to detect the possibility of geothermal activity.
2. Analyzing vegetation conditions using Normalized Difference Vegetation Index (NDVI) using Sentinel-2 to identify potential vegetation stress that could be caused by geothermal activities, such as hydrothermal gas emissions or changes in soil characteristics due to mineral alteration.
3. Identifying geological structure patterns using DEM SRTM to determine the presence of faults and fractures that have the potential as geothermal fluid migration pathways, so that they can be associated with the detected thermal anomalies.
4. Integrate the results of LST, NDVI, and geological structure analysis using the Analytical Hierarchy Process (AHP) method to determine the weight of importance of each parameter in geothermal exploration and produce a prioritized map of potential areas.

1.3 Research Benefit

This study is expected to support the identification and prioritization of potential geothermal zones for further exploration in Surian area of Solok Regency. By integrating land surface temperature (LST), vegetation condition, and geological structure data derived from SRTM DEM using the AHP method, the study offers a preliminary yet informative spatial analysis. The resulting geothermal potential map may serve as a reference for local government, researchers, and investors in planning more focused and cost-effective geothermal exploration activities, especially in areas with limited baseline data. This approach provides a faster, more efficient, and economical alternative to conventional early-stage geothermal surveys.

1.4 Research Scope and Limitations

This research covers aspects of location, data, analysis methods, and research limitations to ensure results are fit for purpose. The following is the scope of this research:

1. Location: Located in Surian, Solok Regency, West Sumatra, focusing on the initial identification of geothermal potential areas based on geological and tectonic conditions.
2. Data: Using Landsat 8 TIRS imagery (LST), Sentinel-2 (NDVI), SRTM DEM (geological structure), and regional geological map.
3. Methods:
   a. LST analysis to detect thermal anomalies.
   b. NDVI to identify vegetation stress.
   c. SRTM DEM for geological structure analysis.
   d. AHP to assess parameter weights and GIS-based geothermal potential mapping.
4. Limitations: Secondary data-based without field surveys, preliminary assessment results, and limited to satellite data resolution.

With this scope, the research can be systematically focused on producing an effective and efficient initial mapping of geothermal potential areas using remote sensing technology and the AHP method.