A Combination of Landsat-8 Satellite Imaging with Geothermal Manifestation Point at Wayratai Geothermal Prospect Area to identify “the zone of interest” on Geo-track and Geo-tourism planning

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Abstract. In this paper, we will identify the zone of interest on Wayratai geothermal prospect area based on the Satellite Imagery Map and Geothermal Manifestation Point to make a geo-track and geo-tourism planning in the future. Based on Satellite Imagery Map, we composite several bands, such as band (6,4,2) to describe an alteration rock and composite band (4,3,2) to describe a vegetation variation. After that, we process several bands to get the land surface temperature in this area, then we correlated the satellite data with surface measurement (with X-Ray Thermogun) on several geothermal manifestations. Based on both correlation, it shows a positive correlation, such as hot spring on the East Area with temperature 70-80ºC is correlated by a high value of LST (indicated by dark-red zone), fumarole with temperature 74-78ºC, and steaming ground on the West Area with temperature 26-59ºC. Based on this data, then we make a geo-tourism planning on this area with make geo-track to connect all of “zone of interest” on satellite imagery with regional geology spot with a circular route, so in the future, Wayratai geothermal prospect area can be one of a geo-tourism spot on Lampung Province.

1. Introduction
Wayratai geothermal prospect area is located in the administrative area of Pesawaran, Lampung Province. It has a huge potential for tourism locations such as mountain, coastal, island, river, and waterfall that have not been explored and managed properly. This potential occurs because the geographical of Wayratai is directly related to Mt. Ratai in the West, Lampung Bay, and Pahawang Island in the East, Betung Mountain in the North, and Shark Teeth Geo-park in the South. Based on the tectonic setting, this area is the result of divergences between the two plates that meet in the southwest, It is the Indo-Australian plate (ocean plate) which has a basaltic composition (base) and Eurasian plate (continental plate) which has a granitic (acid) composition. The divergences of two plates and volcanic activities[3] in the past made this area have complex geology, it is dominated by lava, breccia and tuff rocks from young volcanic sediments, and we can found an alluvial composition such as cobble, pebble, sand, clays, and peat. Based on a previous preliminary survey and research result[6][12], we obtained several geothermal manifestations in the Wayratai area such as hot spring, solfatara, and the steaming ground that did not utilize and developed immediately. Then, in this research, we try to extract and calculate the land surface temperature from Satellite Imagery Landsat-8 data that combined with geothermal manifestation point from previous research[6][12] to get
“the zone of interest” or we call it “spot with many geological or geothermal studies”. After that, we made geo-tracking to connect all “the zones” on a circular route, and in the future, Wayratai can become one of geo-tourism place on Lampung.

2. Theory
In this research, we used two methods to collect data and analyze the data:

2.1. Collect Information from Regional Geology Map
Way Ratai geological map has a complex several formation. The first formation is dominated by young volcanic sediment from the eruption of complex Ratai volcano (Qhv-R) containing andesite basalt lava, breccia, and tuff. Then Menanga Formation (Km) contains alternating shale and claystone with basalt, intercalations of chert, and lenses of limestone. Then Alluvium contains a cobble, pebble, sand, clay, and peats. Then Hulusimpang Formation (Tomh) contains andesite basalt lava, tuff, and volcanic breccia with lenses of limestone. Then Sabu Formation (Tpos) contains alternating conglomerate breccia with sandstone. Then Dacite Piabung (Tmda) contains dacite and last is Tarahan Formation (Tpot) contain welded tuff, breccia with intercalations of chert[8]

Figure 1. Geological Map of Wayratai Geothermal Prospect Area (Modified from Mangga, 1993).

2.2. Collect Information from using Landsat-8: Composite Band
Satellite Imagery Landsat-8 has several combinations to describe a variation on the surface such as vegetation, alteration of rock, hot spot, etc. In this case, we will use three Combination of Band (Composite Band), there are Natural View (Band 4,3,2), Atmospheric Penetration (Band 7,5,3), and Alteration Rock (Band 6,4,2). The First is Natural Band (Band 4,3,2), which is a typical combination of false color[5] cables as in aerial photographs. Channel 4 is to detect a part of vegetation and differentiates of vegetation, apart from separating the soil and conservation. This combination displays red, bright red vegetation indicating larger vegetation. Soil with less or zero vegetation between white (sand or salt) to green or brown depending on moisture and organic content. Waters is appeared a blue color, at clearwater will look dark blue or black, while on shallow water or high sediment concentration water will appear a light blue. And look a brown-blue style in a settlement.
Second is the Atmospheric Penetration^{9} (Bands 7,5,3) give colors like a natural and also give a penetration ability of atmospheric particles, smoke, and fog. Vegetation looks blackish and light green when growing season. A settlement has appeared in white, gray, cyan, or purple. Sand, soil, and minerals show in a variety of colors. Almost all absorption in the middle of the infrared (IR) is in water, ice, and snow giving us a clear boundary of coastlines and sea. Snow and ice look dark blue, and water shows a black or dark blue. Hot surfaces such as forest fires and volcanic caldera absorb medium infrared (IR) and show in red or yellow. The application for this combination is forest fire monitoring.

Third, is Alteration Rock (Bands 6,4,2) will show like a "natural-like" as well as combinations of 4-3-2 but the difference is Band 6,4,2 can be used to detect a difference of vegetation and containing rock at this case is alteration rock for geothermal manifestation. Where the vegetation will appear dark red (because of IR penetration), the ground will appear brown-red, the water will appear blue, and last the alteration can show green. This combination is very useful in geology, agriculture, and wetlands.

2.3. Processing and analysis of Land Surface Temperature Map using Landsat-8

Land Surface Temperature is obtained by using satellite imagery map from Landsat-8 especially using Band 3,4,10 and 11. First step is radiometric calibration^{1}[2], is to process or convert a satellite imagery data with Digital Number (DN) format to radiance or reflectance format, as well as to brightness temperature (for Infra-Red Thermal Channels). For this case, note to attention a radiometric resolution which shows how many bits are used in a single pixel. In this research we will used gain offset to process satellite imagery map, with using radiance or reflectance multiple rescale factor (Gain) and additive rescale factor (Offset) with equation:

\[
L_\lambda = M_L Q_{cat} + A_L
\]  

Where:
- \( L_\lambda \): TOA spectral radiance (Watts/(m^2 * srad * μm))
- \( Q_{cat} \): Quantized and calibrated standard product pixel values (DN)
- \( M_L \): Band-specific multiplicative rescaling factor from the metadata
- \( A_L \): Band-specific additive rescaling factor from the metadata

Then we do the At-Satellite Brightness Temperature^{10} with equation:

\[
T = \frac{K_2}{ln\left(\frac{K_1}{T_\lambda + 1}\right)}
\]  

Where:
- \( T \): At-satellite brightness temperature (K)
- \( T_\lambda \): ToA Spectral radiance (Watts/(m^2 * srad * μm))
- \( K_1 \): Band-specific thermal conversion constant from the metadata
- \( K_2 \): Band-specific thermal conversion constant from the metadata
Brightness Temperature (T) is not a surface temperature on the earth, so to obtain a real temperature, Satellite Brightness Temperature must be changed to Surface Temperature by utilizing Emmissivity data (derived from NDVI data) by the formula:\[4\]:

\[
NDVI = \frac{(NIR - VIS)}{(NIR + VIS)}
\]  

After get NDVI value, we continue to find LSE value to get Land Surface Temperature with equation:

\[
LSE = NDVI - \left(\frac{NDVI_{\text{min}}}{NDVI_{\text{max}} + NDVI_{\text{min}}}\right)
\]

\[
LST = \frac{T_B}{\left[1 + \left(\frac{\lambda}{C_2}\right) + ln(e)\right]}
\]

Where:
- LST : Land Surface Temperature (°K)
- \(\lambda\) : Wavelength of Emitted Radiance
- \(C_2\) : 14388 µm.K
- \(T_B\) : Band-specific brightness temperature conversion from the metadata
- \(e\) : LSE value

3. Result and Discussion

Wayratai geothermal prospect area has a huge potential of tourism location such as mountain, coastal, island, river, and waterfall that have not been explored and managed properly. In this research, we will use the satellite imagery map using Landsat-8 to know and correlate the geothermal manifestation with a land surface temperature that made a geo-track for geo-tourism.

Based on Satellite Imagery Map, we used a composite band or combination band with the band (4,3,2) to know the area as a natural like\[5,7\] (see Figure 2). On the composite map, we will look at the penetration of forest or trees vegetation with black-green color, then the soil, land, and flow of sediment river can be seen in brown color, and last the water or sea shows with dark-blue color. This view of the composite band can be used to track the flow of the sediment river from west to east the research location, so we can know the heat-flow water from Mt. Ratai as a source (in the West direction).

Second composite map, combined (band 7,5,3) (see Figure 3) as an Atmospheric Penetration\[9\], we will look the penetration of forest or trees vegetation with green color, then the soil or land is indicated with brown color, and river or water object can be seen in blue until dark-blue color. This view of the composite band can be used to track vegetation, soil, and stagnant water and flow of water indicated from the area. So based on this data, we can know the vegetation and water content of Wayratai area.

Third composite map using (band 6,4,2) (see Figure 4) as an Alteration Rock Penetration, we will look the penetration of forest or trees vegetation with dark-red color, then the soil, land, and river are indicated with brown-red color, and alteration rock object can be seen in dark-green color. This view of the composite band can be used to track vegetation, a soil, and an alteration rock caused by geothermal manifestation on these locations. So based on this data, we can know the alteration of rock in Wayratai.

Then we used Band 10 and Band 11 to process Land Surface Temperature Map\[11\] (see Figure 5), after the process, we can look at the difference of temperature (Figure 5 on the right side), on this map, temperature move from low until high temperature. The low temperature indicated by green
until yellow color (cloud effect value) and high temperature indicated by orange to red color. Based on this map, we obtained the red zone is indicated by hot spot or geothermal manifestation because the red zone has a high temperature, is equal to 20-30 °C on the rescaling of satellite imagery.

![Figure 2](image-url) Composite Band (using band 4,3,2) as a Natural View

![Figure 3](image-url) Composite Band (using band 7,5,3) as an Atmospheric Penetration

![Figure 4](image-url) Composite Band (using band 6,4,2) as an Alteration of Rock Penetration

![Figure 5](image-url) The result of Landsat-8 process to get Land Surface Temperature Map

| Geothermal Manifestation Point | Temperature  |
|------------------------------|-------------|
| Area 1 (Steaming Ground )    | 26-59 °C    |
| Area 1 (Hot Spring)          | 70-80 °C    |
Area 1 (Fumarol) 74-78 °C
Area 2 (Solfatara) 78-81 °C

Based on Satellite Imagery Map especially Land Surface Temperature, then we do the tracking on geothermal manifestation in this area based on previous results [6][12]. First, we track on near settlement at the east and then we follow the sedimentation from the river, trace the manifestation and heat from the hotspot at this map, then we get a geothermal manifestation on this area such as solfatara, hot spring, mud pool, and steaming ground. After that, we used X-Ray Temperature Detector to measure surface temperature on the geothermal manifestation (see Table 1).

After we plot a manifestation point on the top of Land Surface Temperature Map (Figure 6), we look a positive correlation between the high temperature on LST Map and Geothermal Manifestation on the red-box (Figure 6). This result can be plan to make a geo-tracking in the next research. Geo-tracking is a geo-travel journey that follows a trail that have been designed to be tracked either by foot or by vehicle, this method is combined with satellite imagery model to facilitate geo-tourism travel in the area of Wayratai. Therefore, the challenges is not unavailability track to the surface manifestation, second is geothermal manifestation is located on the slopes of Mt. Ratai, and last is the geothermal manifestation have a steaming ground as a weak ground so we will carefully to step in this area.

From Figure 6. Many areas have not been roammed directly due to limited access to the location, but from the land surface temperature map, we can track the area in knowing the existence of the hotspot zones to make Wayratai become geo-tourism area. To develop geo-tourism on the geothermal manifestation of Wayratai area, we studied in two aspects that is destination and market, but the concept of geo-tourism can not be separated from the conservation area hence in the form of a group driving nature tour which is managed by the local population. In the aspect of the destination, we can utilize the surface manifestation to be studied and developed as a hot pool or bathpool area. Wheres in market aspect we can utilize yields like coffee, cocoa, some type of fruit and handicrafts typical Wayratai, as self-managed to advance BUMDES (Business owned by the village) at Wayratai area so from that to be used for the management of geo-tourism area of the sight further.
5. Conclusion

The conclusions derived from this paper are:
1. Based on Geological Map, we conclude the Wayratai area is dominated by young volcanic sediment from the eruption of Ratai volcano (Qhv-R) containing andesite-basalt lava, breccia, and tuff.
2. Based on Composite Band, we conclude the alteration rock can be described with a band (6,4,2) that shows the dark-green color and the vegetation can be described with the band (4,3,2) as a green form.
3. Based on Land Surface Temperature Map, the high temperature is indicated by dark-red color with value is 20-30 °C.
4. Based on X-Ray Temperature Measurement from Geothermal Manifestation, we obtained the area 1 (east) have a steaming ground with values 26-59 °C, Hot spring with values 70-80 °C, and Sulfatara with values 74-78 °C on Area 1 and 74-78 °C on Area 2.
5. Based on the land surface temperature map and geothermal manifestation point, we can correlate the temperature and the geothermal manifestation point in the next research as a geo-tracking circular on the Wayratai geothermal prospect area.

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