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Research Paper

Identification of Potentially Viable Zones, in A Terrain of Geothermal Energy, Using RS and GIS Tools

GeoEngineering

KEYWORDS : Landsat ETM+, Remote Sensing, Land Surface Temperature and ERDAS

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ABSTRACT

Geothermal energy resources are important renewable energy resources, which can be an alternative to the increasingly scarcer fossil fuels. Surajkund, which is located at the terrain of hot water springs , has an abundant potential for geothermal energy. India has a large potential of geothermal energy, which can be gainfully utilized for power generation and fuel production, Jharkhand possesses a good share of these. The total recorded sites numbering 340 in India, around 60 sites are in Jharkhand. Surajkund is among the most prospective sites which is situated in Hazaribagh district, besides this in Surajkund, some other prospective sites in Jharkhand are: Tantolaya / Tantlol, in Santhal Paragana division, and Thatha / Konraha and Jarom in Palamu district. The existence of geothermal energy in this area manifests its power as hot water and it contains sulfur which is believed to have healing medicinal property. Surajkund's hot spring region is claimed to be the hottest spring in India. Surajkund hot spring has a surface temperature of 87 °C (189 °F) and an average subsurface temperature of 165 °C (329 °F). In the field of energy resources, Remote sensing has played an important role, it can be used to find energy resources not only on the surface of the earth but also under the surface like geothermal energy by means of measuring land surface temperature. The focus of this study is to record energy radiated by an object at different wavelengths and acquire land surface temperature. Landsat ETM+ and TM were used to measure land surface temperature.Interpretation of land surface temperature is also expressed by the tone of thermal infrared imagery. It can be identified from thermal manifestations and other geological structure around the area of study which showshigh heat flow is in general. In this present study the land surface temperatures will be integrated with other data sets and maps that are related to the area of study. The final results show the information about the surface, geological analysis, and volcanic phenomenon and potential areas of the energy resources.

INTRODUCTION:

Remote Sensing technique and GIS tools are specifically of importance for exploration and exploitation of natural resources. GIS technology has become very affordable and easy to use tool for mapping the energy resources, where in the same case Remote Sensing Images are very helpful for finding the energy resources with the help of thermal infrared images.

The requirement of energy is increasing day by day because of population growth. There has been an increase of 50% energy consumption during the period 1980-200.. It is estimated that the demand for energy will increase to 57% by 2025 (Siahaan,,2011).

STUDY AREA:

The study relates to the plateau area located in Hazaribagh district and Jharkhand state. Surajkund is located at 24°**08'58"North latitude and 85°38'44" East longitudes**. This study area of a surface of 130 km ^{2} (Fig.1). The average elevation the study area is approximately 364 km. The monthly average temperature is 87°c and the surface temperature is 165 ° c. Soil type of the study area is red and sandy loamy soil and minerals availability of the ground is sulfur.

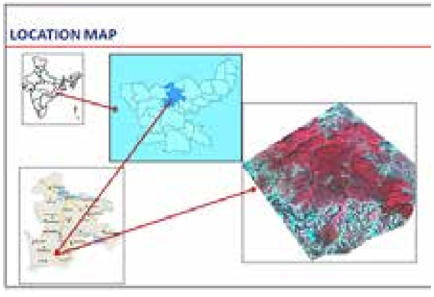


Figure 1: Location Map of Study Area

Methodology:

Methodology involves both remote sensing analysis and GIS techniques. The main and first role is the remote sensing analysis using ERDAS imagine software. Firstly, we have download the LANDSAT satellite imagery using GLCF website and extracted the each band in zip file and Layerstack the all single layer and prepared the MSS image. The MSS images geometrically corrected using SOI reference maps 1:50,000 scale Images and fitted to the ground. At the same time we have used the secondary data like SOI reference maps, SOIL maps, SRTM maps, and Geologic maps to study the ground geomorphological and geological conditions.

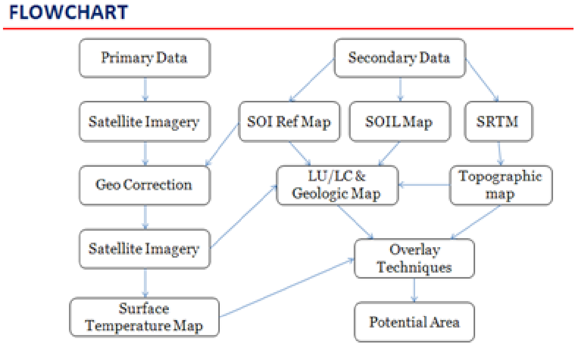
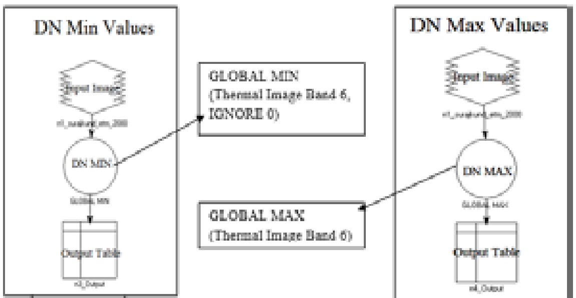


Figure 2: Flow Chart

Using Landsat satellite Imagery we have, prepared the surface temperature maps and land use/land cover maps of the Surajkund area. For the preparation of Surface temperature map we have to extract the minimum and maximum DN values of the Thermal band and extract the LMin and LMax values of the Landsat Image. For the DN Minimum value and DN Maximum value extraction case we have used the Global Minimum Value and Global Maximum Value. (Equation 1 & 2, Model 1 & 2). The details of calculation are given below.

GLOBAL MIN (Thermal Image Band 6, IGNORE 0) ----------------------------------- **Equation (1)**

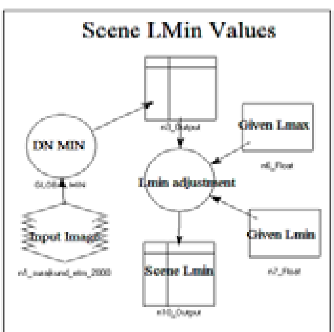
GLOBAL MAX (Thermal Image Band 6) -- **Equation (2)**



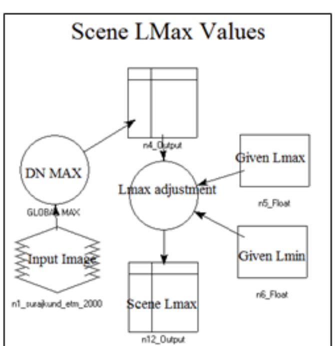
Model -1

Model - 2

For Scene LMin value and Scene LMax value extraction case we are using the Given L Minimum & Maximum values and DN Minimum and DN Maximum values. (Equation 3 & 4, Model 3 & 4).



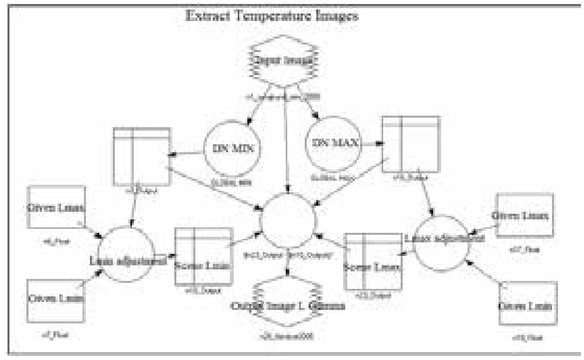
Model - 3



Model - 4

((Lmin - Lmax) / 255) * DN Min) + Lmin) --- **Equation (3)**

(((Lmax - Lmin) / 255) * DN Max) + Lmin) --- **Equation (4)**



Model - 5

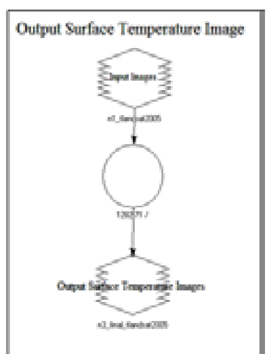
$$L_{\lambda} = \left(\frac{L_{MAX\lambda} - L_{MIN\lambda}}{DN_{MAX} - DN_{MIN}}\right) * (DN - DN_{MIN}) + L_{MIN\lambda} \quad \text{-------------------- Equation (5)}$$

Where,

Lλ Spectral radiance watts/(m*m * ster * μm)
DN Digital Number
LMINλ Spectral radiance which is correlate with DNMIN watts/(m*m * ster * μm)
LMAXλ Spectral radiance which is correlate with DNMAX watts/(m*m * ster * μm)
DNMIN Minimum value of DN (1 (LPGS Product) or 0 (NLAPS Product)
DNMAX Maximum value of DN = 255

After extracting the Lλ value we can use this value to calculate the effective temperature of Landsat Images. For the calculation of surface temperature, we can use the spectral radiance of the images and also K1 and K2 calibration constants emissivity. For the calculation of effective temperature purpose using the following equation (Equation 6 and Model 6).

$$T_{Landsat} = \frac{K_2}{ln\left(\frac{K_1 * \varepsilon}{L_\lambda} + 1\right)} - 273 \quad \text{-------------------- Equation (6)}$$



Model - 6

Where:
TLandsat Effective temperature (Celsius)
Lλ Spectral radiance watts/m*m * ster * μm
K1, K2 calibration constants
(on the Landsat ETM +;
K1 = 666.09,
K2 = 1282.71) emissivity

After extracting, the temperature values base on that models we could produce the temperature maps once we prepared the temperature maps using the GIS overlaying technique potential sites could be finalized.

Results & Discussions:
The Landsat Images of the two years 14/10/2000 and 05/11/2005 (Figure 3) have been used to visualize the surface reflectance

values of each wave length of each band of the both FCC Images, which can represent the 3D graphs (Figure 4 & 5). We have also used the Landsat ETM image and using some SOI references maps the ground land use/land cover map was prepared. For this purpose, the image interpretation keys like shape, size, tone, texture, pattern, location, association, and shadow have been used. For the land use/land cover map preparation, we have applied the supervised classification techniques in ERDAS Imagine. For Supervised classification the signatures have been extracted, with the basis of interpretation keys and using, ERDAS Imagine supervised technique. The NDVI indices was performed to derive the class in the forest area and water-bodies. An Alarm Masking technique is applied to find the signature of each class and supervised classification technique was adopted with maximum likelihood algorithm. The final classified output image was assigned 10 classes i.e. Degraded Forest, Dense Forest, Mixed Forest, Lakes & Water bodies, River, Scrub land, Waste land, Agriculture Crop land, Settlement and Rills & Gullies (Figure 6).

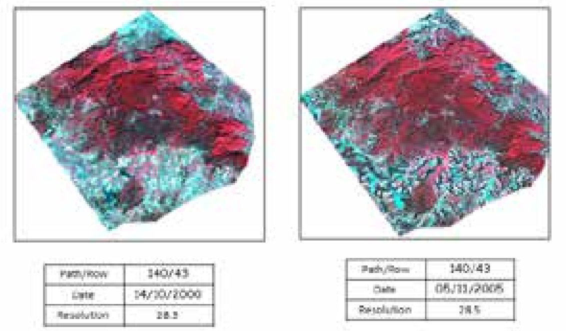


Figure 3: FCC Image of Study Area

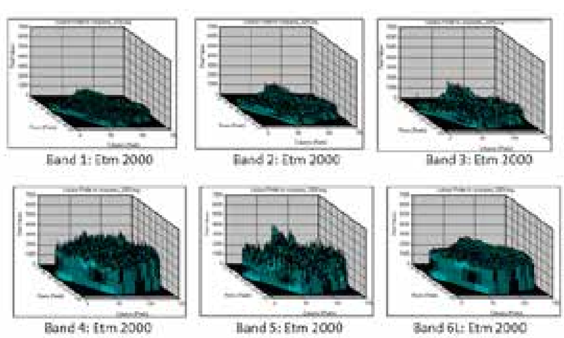


Figure 4: Spectral Radiance Graph of Study Area

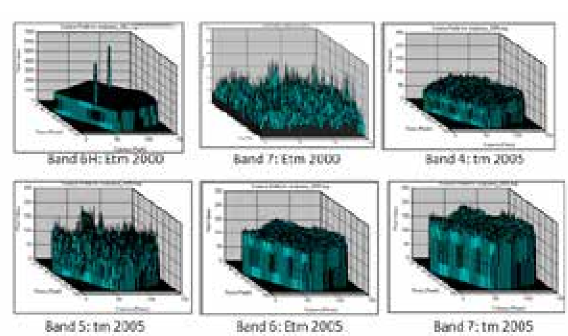


Figure 5: Spectral Radiance Graph of Study Area

Slope can be classified a few categories by using guidelines of All India Soil and Land Use Survey the Slope is categories seven types nearly level to very steep sloping based on the steepness of slope. Study area slope covers the gently level to steep sloping. Surajkund covers terrain undulating so slope of this area is 2 to 70.58%, Slope was further into classified into four groups i.e. Nearly level, Very Gently Sloping, Gently Sloping and Moderate Sloping. For the visualization of 3D view to prepare the DEM using SRTM data in ArcGIS software (Figure 8).

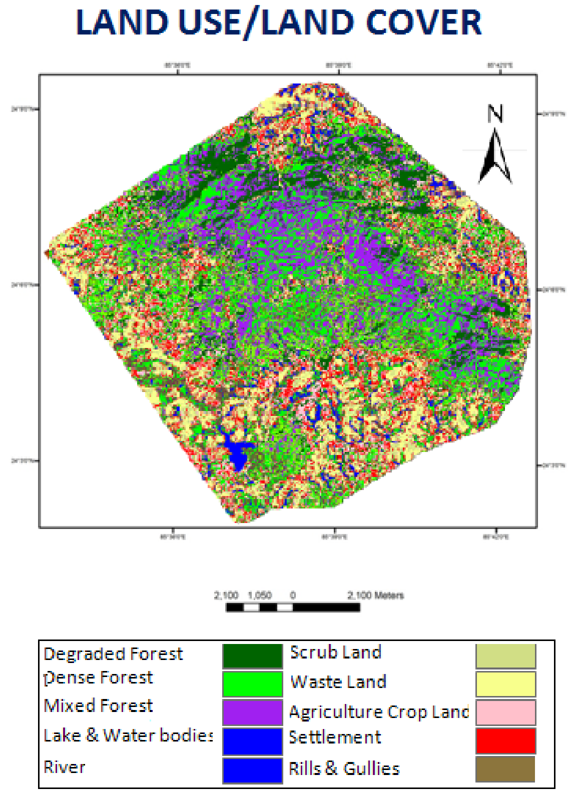


Figure 6: Land Use/Land Cover Map of Study Area

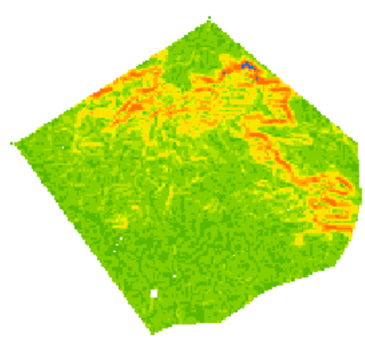


Figure 7: Slope of Study Area

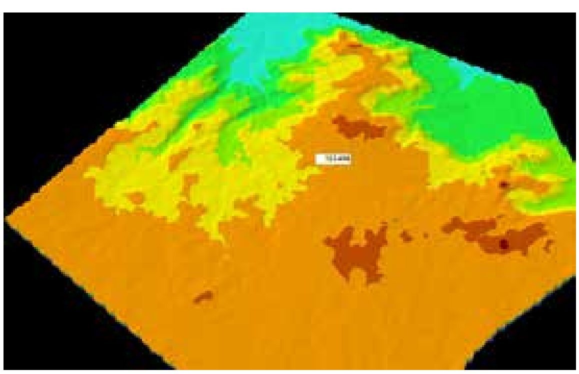


Figure 8: Digital Elevation Module of Study

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For temperature study, we can see the differentiation of the year from 2000 to 2005 with the base of prepared model 5. The spectral radiance of the study area is calculated and prepared the output in imagery format to extract the each pixel value. The output generated spectral radiance images are getting gray values because the output-generated maps are based in single band i.e. Panchromatic view (Figure 9).

After calculating the spectral radiance Lλ using this value and the ETM constant Emissivity value to apply the equation six and model six and generated the effective temperature image of the year of 2000 and 2005 (Figure 10). For the better interpretation of pixel, values of the temperature we have generated the surface reflectance of 3D graph (Figure 11). The generated temperature images are classified into sub category based on pixel values and each pixel is have one temperature values which is assign based on model 6. The classified images of 2000 and 2005 are shown in the figure (Figure 12).

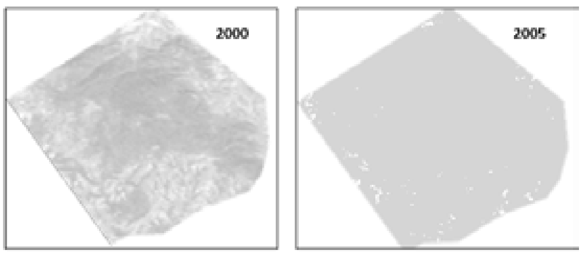

Figure 9: Spectral Radiance Images of Study Area

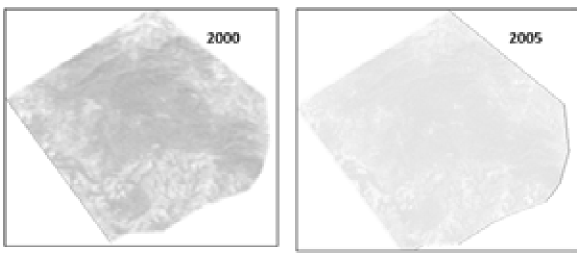

Figure 10: Effective Temperature Images of Study Area

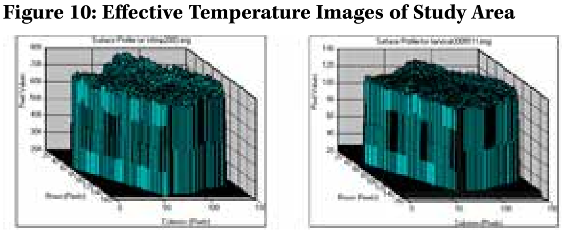

Figure 11: Surface Reflectance of Effective Temperature Images of Study Area

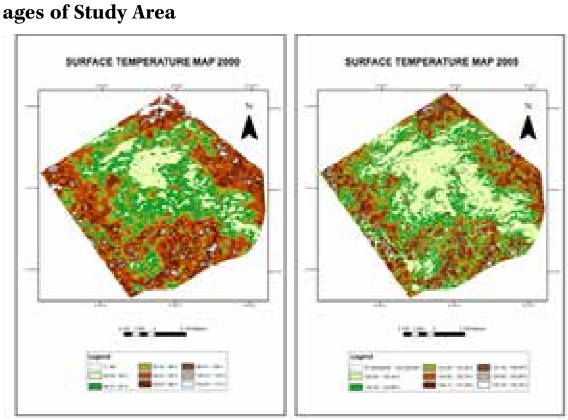

Figure 12: Surface Temperature Map of Study Area

Conclusion:

Temperature anomaly, a manifestation of heat on the surdace, suggests the possibility of hot spot regions potential in the area Surajkund based on the analysis of differentiation of the surface temperature in between years of 2000 to 2005. The difference variation is clearly shown is map with pie chart and bar graph (Figure 13). The similarity of rock type on the research areas with different temperatures. With the availability of an infrared image of Landsat ETM + surface temperature can be obtained and Thermal image in Landsat ETM+ can be used to detect the surface temperature which in turn can be indicators to the availability of natural energy resources base on continuously increasing surface temperatures, which proof the figure 13. For the finding, the priority places of potential energy sites we are analysis the overlaying techniques of all generated output images and resulting the final values based on the slope, geology, geomorphology, lulc and temperatures (Figure 14). In addition, by comparing to Geologic maps, SRTM, Land Use/Land Cover and Geomorphology maps we can conclude that Surajkund Region has Hot spot spring potential sites from the northwestern to the east and southeastern areas, which shows the final priority results (Figure 15).

The study could establish that using the surface temperature data obtained from RS images can be successfully utilized to identify the potential zones of geothermal energy. The Government should take necessary steps to use this preliminary work substantiated by geology and geomorphological data more such zones can be identified. Moreover, 15 years of continuous satellite data are more helpful to extract even the minor surface temperature variations.

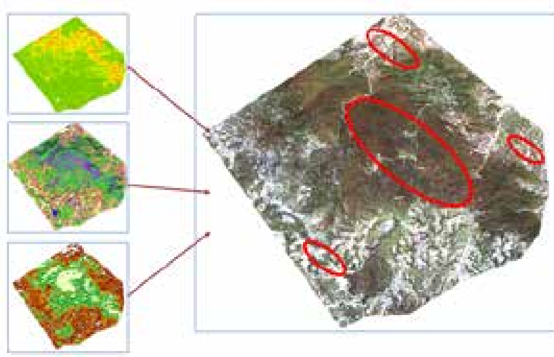

Figure 13: Overlaid map to find the potential map of Study Area

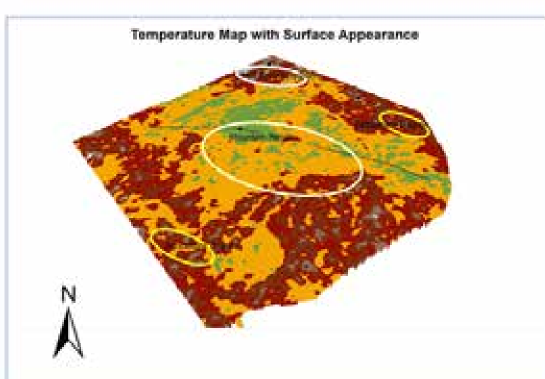

Figure 14: Final Priority Results

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