Potential mapping of limestone using Landsat 8 and Quickbird imagery in Tuban Regency

B M Sukojo and D A Majid

Department of Geomatics Engineering, Faculty of Civil, Environment, and Earth Engineering, Institut Technology of Sepuluh Nopember

Abstract. Indonesia is a country rich in minerals. Limestone is one of the non-metallic mineral industry is very large potential and spread almost throughout the territory of Indonesia. Tuban regency is one of the regencies located on the north coast of Java Island, precisely in East Java. As an area located in the northern part of East Java basin and is possible as a potential area of various mineral resources, one of them is limestone or limestone rock. The potential of limestone in Tuban Regency is very possible to be managed and processed to become an industry. Moreover, there are still many sources of limestone that have not been explored, With technological advances in the field of sensory, calculation of limestone potential estimation can be done by using remote sensing data and geographic information system. Remote sensing data used is Landsat 8 satellite image data reinforced with satellite data of extremely high resolution Quickbird. This study aims to determine the potential of limestone rock in Tuban Regency. Parameters used for the identification of limestone potential in this study were 4, ie land cover, surface temperature, vegetation index, and geological elements. The result of this research is potential map of limestone of Tuban Regency which is divided into 5 classes namely very low potency, low potency, medium potency, high potential, and very high potential. From data processing resulted in Tuban Regency dominated by medium potency level with wide of 56483.70 hectare while for level of potency tinggi and very high have wide 33074.12 hectare and 31336.82 hectare.

1. Introduction
Indonesia is a country rich in minerals, both mineral and metal materials. Various regions in Indonesia have mineral resources in the form of various types of mining materials / excavation. Limestone is one of the non-metallic minerals industry enormous potential and spread to almost all parts of Indonesia (Shubri and Armin, 2014[1]). Most of this rock content in Indonesia is found in West Sumatra, East Java, Central Kalimantan and East Kalimantan. One of the main limestone producing areas in East Java is Tuban Regency.

Tuban regency is one of the regencies located on the north coast of Java Island, in East Java, directly adjacent to Lamongan regency in the east, Bojonegoro regency in the south and Blora regency and Rembang regency, Central Java in the west. As an area located in the northern part of East Java basin and is possible as a potential area of various mineral resources, one of them is limestone or limestone rock. The limestone quarry material in Tuban Regency is spread in several locations such as Kerek, Merakurak, Tambakboyo, Palang, Semanding and Montong. Mine exploitation is an activity to find the location points where an area can be mined and the area is
still economically valuable, to be mined. One of the most important things in mining work is the calculation of the estimated potential of the mine. Estimates of mine potential play an important role in determining the quantity of quality, production work, mining methods undertaken, even estimating the time required for mining operations.

With technological advances in the field of senses, calculations of potential limestone estimates can be made using Landsat 8 satellite imagery data reinforced with Quickbird very high resolution image data and geographic information systems. This research is expected later can be used as spatial data with faster and more efficient method in calculation of potential estimation of lime rock.

2. Methods and data
The research location of this final project is done in Tuban Regency, East Java. Geographically located at coordinates 111 ° 30’ - 112 ° 35 longitude and 6 ° 40’ - 7 ° 18 Latitude.

![Figure. 1. Research site.](image)

The data used in this research include:
- Citra Landsat 8 acquisition date 24 September 2014 path/row 119/065 with resolution 30 m (sumber: [http://earthexplorer.usgs.gov](http://earthexplorer.usgs.gov))
- Quickbird 2013 (source: Bappeda Tuban)
- Digital Elevation Model (DEM) data of Tuban Regency 2015 (source: Bappeda Tuban)
- Geological Map of Tuban Regency in 2008 (source: Bappeda Tuban)
- Administrative Boundary Map (source: RBI Map 1:25000)
- Coordinate Ground Control Point (GCP) (source: GPS Geodetic measurement)

Equipment used in this research include:
- Hardware : GPS Geodetic Hiper Pro dual frequency, GPS handheld, Laptop
- Software : Satellite image processing software, Geospatial data processing software, GPS data processing software, Word processor

This research is done through several step of data processing. The following step of data processing in this study.

a. Landsat 8 Processing : Perform geometric correction for the reinstatement of the position of the pixel to the places that have been deemed correct, then the cutting (cropping) to get the image that only covers an area of research that is Tuban, East Java and radiometric correction for merperbaiki visual imagery.
b. Making Land Cover Map : Map-making is done by using supervised classification: maximum likelihood, and calculates confusion matrix and do pengharkatan..
c. Map Surface Temperature Map : Map-making is done by using an algorithm Land Surface Temperature (LST), and carried out classification and pegharkatan
d. Making Vegetation Index Map: Map making is done by using NDVI algorithm, as well as classification and scoring.

e. Making Geological Map: Geological element data obtained in the format of shapefile then done scoring on available data.

f. Quickbird Processing: Doing manufacture nets design, geometric correction with GCP measurement points, cropping to get the research and do the calculation algorithm to get the NDVI Vegetation index value.

g. Accuracy Test: Ground truth be done with the land cover maps and map surface temperature. The accuracy test is performed to check the results of image processing with measurement data in the field.

h. Correlation Test: A correlation test was performed on NDVI Landsat 8 with NDVI Quickbird. A correlation test is performed to obtain correlations between Landsat 8 and Quickbird and to determine the compatibility between Landsat 8 results with Quickbird.

i. Overlay dan Reklasifikation.: Be overlaid on four questions that have been given the dignity that land cover maps, maps of surface temperature, vegetation index maps and geological maps in order to obtain a map of the potential of limestone. Reclasification is done by dividing into 5 potential classes of limestone.

3. Results and analysis

3.1. Landsat 8 processing

The Landsat 8 satellite image used is the path / row: 119/65 with the date of September 24, 2014. The first step is to make geometric correction by using the Rectification method (image to map) with RBI Map as the reference. In this Records the RMSE obtained is 0.25 with eight control points scattered in the study area.

The next step is to do radiometric correction Radiometric correction of two stages of radiometric calibration and atmospheric correction. Radiometric calibration is done by converting the Digital Number (DN) into radiance and / or reflectance. Atmospheric correction is done using methods FLAASH (Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes), FLAASH can eliminate the influence of atmospheric disturbances to obtain more accurate parameters of reflectivity, emissivity, surface temperature and physical surface [2].

The next stage is cutting the image according to the research area is Tuban Regency by using the administrative boundary data Map RBI.

3.2. Land cover map

Preparation of land cover maps using Landsat 8 satellite image path / row 119/65 the date of 24 September 2014. The acquisition of map-making is done by digital interpretation using Supervised Classification: Maximum Likelihood and confusion matrix values obtained by 88.404%. The classification system in this study is based on ISO 7645: 2010 Land Cover Classification [3].

In the research area found 5 types of land cover that is settlement, rice field, water body, shrubs, open land / moor. The classification of this cover needs to be done in the field accuracy test using 20 point samples and obtained accuracy of 85%. According Daels Antrop stated that the interpretation is quite good if having ≥80% accuracy [4]. Here is the result of land cover map of Tuban Regency.
Here is a table of land cover classification and its extent.

| Class | Land Cover  | Area (ha) |
|-------|-------------|-----------|
| 1     | Water Element | 1574.28   |
| 2     | Resistive Land | 81757.71  |
| 3     | Settlemand   | 36235.89  |
| 4     | Rich Field   | 33305.94  |
| 5     | Shrubs       | 44787.51  |

3.3 Surface temperature map
Preparation of surface temperature map using Landsat 8 path / row 119/65 satellite images with acquisition date 24 September 2014. Map making is done by calculating LST algorithm.
LST algorithm of calculation of the research area obtained the lowest temperature 26 °C and the highest temperature of 51 °C and can be classified into eight as the table below.

### Table 2. Surface temperature classification

| Class | Surface temperature (°C) |
|-------|--------------------------|
| 1     | 26 - 29                  |
| 2     | 29 - 32                  |
| 3     | 32 - 35                  |
| 4     | 35 - 38                  |
| 5     | 38 - 41                  |
| 6     | 41 - 44                  |
| 7     | 44 - 47                  |
| 8     | 47 - 51                  |

Based on the emissivity tables limestone surface temperature should be 38°C[5]. But the image processing temperature on the surface area of limestone at 44° C - 48°C. The results of this surface temperature must be checked in accordance with the surface temperature in the field using 19 sample points. The results obtained are as follows:

### Table 3. Comparison of temperature temperature and field temperature

| Sample | Temperature Landsat 8 (°C) | Field Temperature (°C) |
|--------|----------------------------|-------------------------|
| 1      | 41.20                      | 33.5                    |
| 2      | 45.74                      | 33                      |
| 3      | 36.45                      | 30                      |
| 4      | 40.30                      | 32.5                    |
| 5      | 43.28                      | 30                      |
| 6      | 46.60                      | 37.5                    |
| 7      | 43.70                      | 35                      |
| 8      | 37.91                      | 35                      |
| 9      | 42.52                      | 33.5                    |
| 10     | 37.27                      | 29                      |
| 11     | 42.31                      | 34.5                    |
| 12     | 42.22                      | 32                      |
| 13     | 43.48                      | 33                      |
| 14     | 38.70                      | 32.5                    |
| 15     | 37.59                      | 31.5                    |
| 16     | 39.43                      | 30.5                    |
| 17     | 38.56                      | 31                      |
| 18     | 43.89                      | 35                      |
| 19     | 37.07                      | 31                      |

Field temperature samples were used to test the correlation. This is done to determine the extent to
which the correlation or proximity of the surface temperature of image processing with field results. When tested the correlation between surface temperature in image and field obtained value of 0.64 can be interpreted that the closeness of the relationship between image temperature and temperature in the field is 64%. These results show a strong correlation between temperature imagery and field\cite{6}.

The difference between the temperature on the image and the temperature in the field is caused by several factors, one of which is the difference of data retrieval time, the temperature of the image is taken on September 24, 2014 while the temperature in the field is taken on 6-7 May 2017 where the month of September is dry season while In May is the end of the rainy season. Although the end of the rainy season in the area of research is still often rain.

3.4. Vegetation index map

Mapping the vegetation index using Landsat 8 satellite image path / row 119/65 the date of 24 September 2014. The acquisition of map-making is done by calculating the NDVI algorithms. From the processing of NDVI in the research area obtained the lowest value -0.909 and the highest value 0.921. The lower the value of NDVI, then the area the higher the potential presence of limestone, and vice versa \cite{5}. This is because limestone is often found on the farm / field.

![Figure 4. Vegetation index map](image)

Grading on the vegetation index NDVI algorithms refers Peppermint No: P.12 / Menhut-II / 2012 which divides it into five-grade classification\cite{7}. Here is a table of NDVI classifications and their extents

| Class | NDVI         | Category          | Area(ha)   |
|-------|--------------|-------------------|------------|
| 1     | -0.90 s/d - 0.03 | Land is not vegetated | 630.790    |
| 2     | -0.03 s/d 0.15   | Very Low Greenery | 1948.269   |
| 3     | 0.15 s/d 0.25    | Low Greenness     | 23415.033  |
| 4     | 0.25 s/d 0.35    | Medium Greenness  | 64115.479  |
| 5     | 0.35 s/d 0.92    | High Greenness    | 107538.920 |
3.5. Geological map
Geological data obtained in shapefile format (vectors) that include Tuban.

![Geological map](image)

Figure 5. Geological map.

Determination of classification conducted by Geological map [8]. To obtain the following results.

| Class | Constituent Rocks | Area (ha) |
|-------|-------------------|-----------|
| 1     | Alluvium          | 5253.34   |
| 2     | Batu Lempung Anggota F. Kujung | 2292.74 |
| 3     | Batu gamping Prupu, Anggota F. Kujung | 256.51 |
| 4     | Batulanau Anggota F. Kujung | 710.35 |
| 5     | Formasi Bulu      | 5702.07   |
| 6     | Formasi Ledok     | 8681.16   |
| 7     | Formasi Mundu     | 22819.35  |
| 8     | Formasi Ngrayong  | 27763.94  |
| 9     | Formasi Paciran   | 51092.50  |
| 10    | Formasi Tuban     | 5271.39   |
| 11    | Formasi Wonocolo  | 6939.52   |
| 12    | Formasi Lidah     | 13612.92  |

Limestone in Tuban area abundant in Paciran formation, Kujung, and Tuban [8].

3.6. Processing Quickbird
Quickbird image processing begins with preparing DEM data of Tuban DEM data districts that have been obtained and then combined in a mosaic process using DEM data processing software to produce files with formats .Dem.
The next step is making the design of the net using the ground control point (GCP) and determining the accuracy test point (ICP) in the research area. The choice of location and distribution point GCP and ICP Module Validation refers to the Spatial Plan Map BIG (2016) \(^9\) Where point placement should be clearly identifiable on the image. Most of the objects selected are corner buildings to make it easier when interpreting the imagery. Here's a picture of the net design, GCP and ICP point spread.

There are 8 points GCP and 12 ICP points used in this research area. Calculation of SOF value obtained with the following calculation.

\[
\begin{align*}
\text{Total baseline} & : 20 \\
\text{Number of dot} & : 7 \\
\text{N\_measurement} & : \text{Total baseline} \times 3 = 60 \\
\text{N\_parameter} & : \text{Number of dot} \times 3 = 21 \\
\text{U} & : \text{N\_measurement} - \text{N\_parameter} = 39
\end{align*}
\]

The smaller the value, the stronger the net design configuration. From the SOF calculation above the value <1 is obtained which means that the design can be received strongly \(^{10}\). The coordinates of GCP and ICP data are obtained by measuring the field using dual frequency Geodetic GPS. The method used was static with a measurement duration of 30-40 minutes at each point. Measurement data is processed using GPS processing data that is equipped with a post-processing and network adjustment process. The smaller the value the stronger the design configuration of the nets. SOF from the calculation above obtained value <1, which means the design can be considered strong nets \(^{10}\).

The coordinate data of GCP and ICP were obtained by measuring the field using dual frequency GPS Geodetic. The method used is static with the duration of measurement 30-40 minutes at each point. Measurement data is processed by using GPS data processing software that includes the post-processing and network adjustment. Geometric correction on the image using the coordinates of GCP and ICP has been tied with CORS CTBN Tuban and corrected by SRGI BIG to obtain dy/dx = 4.306 m and RMSE = 0.391 m to obtain the required <1.5 pixels, amounting to 0.65 pixels.
Geometric corrected image is then performed an accuracy test to determine the value of accuracy of the image. According Module Validation Spatial Plan Map BIG map said to meet the standards if the accuracy of the horizontal $<2.5$ m [9]. The accuracy test is performed by calculating the RMSE of all ICP points then calculated by the formula according to the Basic Map Accuracy Technical Guidance.

The results of the test calculation accuracy of $1.0926$ thus obtained in accordance with the standard[11]. Geometric corrected image is then performed NDVI algorithm calculation. Grading on the vegetation index NDVI algorithms refers Peppermint No: P.12 / Menhut-II / 2012 which divides it into five-grade classification[7]. Here's a map of the NDVI classification results.

![Figure 8. Map image vegetation index of Quickbird.](image)

The result of NDVI processing of Landsat 8 image is then tested by correlation with Quickbird image. The correlation test is done with 25 points with the same coordinates on both images Here is a comparison graph of NDVI Landsat 8 value with Quickbird.

![Figure 9. NDVI correlation Landsat 8 and Quickbird](image)

The correlation test result gives correlation value (R) equal to $0.92$. This value indicates the correlation value with Quickbird NDVI Landsat 8 including a very strong category[6] so that we can conclude the processing of NDVI is appropriate.

### 3.7 Map of limestone potential

Map of potential limestone created by overlaying of the four maps that land cover maps, maps of surface temperature, vegetation index maps and geological maps. Classification is divided into five classes so that the interval obtained from the calculation is 3 as shown below.
Figure 10. Potential of limestone rock.

From the classification results obtained area of each potential class of limestone rock as the following table.

| Category             | Area (ha)   | %   |
|----------------------|-------------|-----|
| Potential Very Low   | 20267.90    | 10.29 |
| Potential Low        | 45921.29    | 23.32 |
| Potential Medium     | 64514.36    | 32.76 |
| Potential High       | 33511.54    | 17.02 |
| Potential Very High  | 32709.36    | 16.61 |

4. Conclusion

Based on the research that has been done can be concluded: The potential limestone map in Tuban Regency uses four parameters: land cover, surface temperature, vegetation index, and geological element. There are five potential classes of limestone rock that is very low, low, medium, high, and very high. Tuban Regency is dominated by medium potential level with area of 64514.36 ha, while for very low potency level 20267.90 ha, low potency of 45921.29 ha, high potency 33511.54 and very high 32709.36 ha. The three sub-districts that have the largest area for very high potential are Kerek District, Montong District and Merakurak Sub-district with 7423.00 ha, 5641.67 ha and 5255.72 ha.

5. References

[1] Shubri E and Armin I 2014 Penentuan Kualitas Batu Kapur dari Desa Halaban Kabupaten Lima Puluh Kota di Laboratorium Dinas Energi dan Sumber Daya Mineral Provinsi Sumatera Barat. Universitas Bung Hatta. Padang.
[2] Fibriawati L 2016 Koreksi Atmosfer Citra SPOT-6 Menggunakan Metode MODTRAN4. LAPAN. Jakarta
[3] Badan Standarisasi. Nasional 2010 Klasifikasi Penggunaan Lahan SNI 7645:2010 Jakarta
[4] Gunawan T 1993 Penginderaan Jauh Terapan Studi Pedesaan. (Yogyakarta: Universitas Gadjah Mada)
[5] Nurjannah 2013 Pemodelan Estimasi Potensi Tambang Batu Kapur Dari Hasil Analisa Data Citra Satelit Landsat 7 ETM+ (Studi Kasus : Tambang Batu Kapur PT. Semen Gresik Persero Tbk. Pabrik Tuban.
[6] Jonathan S 2006 Metode Penelitian Kuantitatif dan Kualitatif. Yogyakarta.
[7] Peraturan Menteri Kehutanan Republik Indonesia Nomor : P.12/Menhut-li/2012.
[8] Hartono and Suharsono 1997 *Peta Geologi lembar Tuban, Jawa Timur*. Bandung.
[9] Badan Informasi Geospasial 2016 *Modul Validasi Peta Rencana Tata Ruang*. Jakarta.
[10] Abidin H Z 2002, *Penentuan Posisi Dengan GPS dan Aplikasinya* (Jakarta: PT. Pradnya Paramita).
[11] Peraturan Kepala Badan Informasi Geospasial Nomor 15 2014 Tentang Pedoman Teknis Ketelitian Peta Dasar. (Bogor: Badan Informasi Geospasial)