Advisability Analysis of Gold Exploration Based on Remote Sensing and Geographic Information Systems (Case Study: Banyuwangi Regency)

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Abstract. Economically, gold is a mining material that is widely enjoyed by the community and used as jeweleries, cosmetics, currency blends, and investment media. Banyuwangi Regency is one of the regions in Indonesia which has potential of gold resources by proving that there are several gold mining companies that have been managed since 2004. It is designated as a Metal Mineral Mining Area and a State Reserved Area by the Minister of Energy and Mineral Resources. This study aims to analyze and identify the advisability of gold exploration activities in Banyuwangi Regency. The method used in this study uses scoring and weighting method and combines using overlay method on land cover data and the potential gold mineral distribution data. The results of this study are in form of regional distribution which has the advisability of gold exploration and in accordance with the Mining Area Map by the Department of Energy and Mineral Resources. Areas worthy of being explored in gold and in accordance with maps of mining areas are scattered in the Districts of Pesanggaran, Siliragung, Glenmore, and Kalibaru. The area which has the largest area of exploration advisability results is in Pesanggaran subdistrict, which is an area of 44,894 hectares.

Keyword : Gold, Remote Sensing, Land Cover, GIS

1. Introduction
Gold is a type of mineral which has high economic value for individuals, groups and countries [1]. Economically, gold is a mineral that is much liked by the public. The majority demand that gold is currently used as jewelry, cosmetic ingredients, currency blends, and investment media [2]. Banyuwangi Regency is one of the regions in Indonesia which has the potential of gold resources. While gold mining activities in Banyuwangi began in 2004, which was managed by PT. IMN (Indo Multi Niaga) located in Tumpang Pitu, Pesanggaran District. Tumpang Pitu Mountains is area that contains gold minerals that have been known since the Dutch era [3]. According to Banyuwangi Regent Decree No. 188/555 / KEP / 429.011 / 2012 concerning mining business permits, in 2017 the Tumpang Pitu area, Sumber Agung Village, Pesanggaran subdistrict, controlled by PT Merdeka Copper Gold [4].

Based on the Decree of the Minister of Energy and Mineral Resources Number 3672 K / 30 / MEM / 2017 2017 Banyuwangi Regency is designated as a Metal Mineral Mining Area and the State Reserved Area. The exploration activities in Banyuwangi Regency are required to analyze its suitability with the Mining Area Map based on the ESDM Department and the advisability analysis is needed based on the location of the existing gold mineral potential. By using land cover data and potential gold mineral distribution data, this study aims to analyze and discuss the advisability of gold exploration activities in Banyuwangi Regency and how to spread access.
2. Methods

2.1. Study Area
This study located in Banyuwangi Regency, East Java. Based on the coordinates of the boundary line, the position of Banyuwangi Regency lies between 7°43' - 8°46' South Latitude and 113°53' - 114°38' East Longitude. Administratively, Banyuwangi Regency consists of 25 districts. Banyuwangi Regency is one of the areas which has gold mineral potential in Indonesia, as evidenced by conventional exploration activities and the presence of gold mining companies in Banyuwangi Regency.

![Figure 1. Map of The Research Location, Banyuwangi Regency, East Jawa, Indonesia [7]](image)

2.2. Data
The data used in this study are Sentinel-2 satellite imagery, Banyuwangi Regency Fine Maps, Map of gold mineral distribution in Banyuwangi Regency, Mining Area in Java and Bali Island data based on Minister of Energy and Mineral Resources Decree No. 3672 K / 30 / MEM / 2017 2017.

2.3. Radiometric Correction
In sentinel-2 imagery, no geometric correction is needed so only radiometric correction is required first. Satellite imagery generally contains original Digital Number (DN) values which have not been processed based on actual radial spectral values, which results in inaccurate information. This is caused by differences in recording angle values, solar location, weather conditions and other influencing factors. Therefore it is necessary to do radiometric corrections to improve the pixel value by converting the DN value to the reflectance unit value [5]. In this study, to carry out radiometric corrections on sentinel-2 images using sen2core processors.

2.4. Band Composit and Subsetting Image
Composite bands on Sentinel-2 imagery is needed to facilitate interpretation of satellite images. The image cutting process is based on the area used in this study using administrative boundary data obtained from the digital Earth Map of Banyuwangi Regency.

2.5. Region of Interest (ROI)
Before classifying land cover using the supervised method, the analysis must first determine some training areas or commonly called the Region of Interest area (ROI) on the image as a specific land class. Areas that have similar pixel values will be included in the predetermined land class. So in this supervised methods, it has to fo identify the information class first which is then used to determine the
spectral class that represents the information class [6]. The determination of the Region of Interest (ROI) of land cover class is based on the land cover shapefile data of the Banyuwangi Regency RBI map digital scale of 1: 25,000 and compared with images on Google Earth.

2.6. Land Cover Classification and Accuracy Test
This classification process uses the Supervised Classification: Maximum Likelihood method. Land cover classification accuracy test is based on the value of accuracy and object validation (overall accuracy). The overall accuracy value allowed is above 75%.

2.7. Scoring and Weighting
Scoring and weighting are used to assign values to the parameters of land cover and the parameters of the potential distribution of gold minerals. The scores and weights used are as follows:

| Table 1. Weighting Gold Exploration Advisability Map Classification [8] |
| --- |
| No | Parameter | Class | Value | Weight |
| 1 | Land Cover | Shrubs | 5 | |
| | | Forest and Plantation | 4 | |
| | | Field Rice | 3 | |
| | | Water Body | 2 | |
| | | Settlement | 1 | |
| | | Cloud | 0 | |
| 2 | Potential Level of Gold Distribution | Very High | 5 | 50% |
| | | High | 4 | |
| | | Plenty | 3 | |
| | | Low | 2 | |
| | | Very Low | 1 | |

2.8. Overlay
Overlay conducted to combine the parameters of land cover and the parameters of the potential distribution of gold minerals using the Union method. Overlay in this study will produce 5 classes with the following intervals:

| Table 2. Interval of Advisability Classification of Gold Exploration [8] |
| --- |
| Interval | Advisability Level |
| 0.00 – 1.80 | Very High |
| 1.80 – 2.60 | High |
| 2.60 – 3.40 | Plenty |
| 3.40 – 4.20 | Low |
| 4.20 – 5.00 | Very Low |

2.9. Suitability Analysis of Exploration Results
The results of Gold Exploration Advisability Map is compared with the Mining Area Map data from the ESDM Department of East Java. The overlay process is carried out between the two data using the
intersect method. So that the resulting gold exploration suitability is based on data from mining areas in Banyuwangi Regency.

3. Result and Discussion

3.1. Land Cover Map
The land cover map is produced from the land cover classification process using Sentinel-2 satellite imagery data which has an overall accuracy value of 94.59% and a kappa value of 0.8456. Land cover class consist of six class such as shrubs, forest and plantation, field rice, water body, settlement, and cloud [7]. The result of satellite imagery classification can be seen in figure 2.

![Figure 2. Land Cover Map](image)

Based on the results of land cover classification, classes with forest and plantation categories dominate in these area amount 140,346 hectares with details of the extent of land cover classification classes can be seen in the following table.

| No | Kelas            | Area (Ha) |
|----|------------------|-----------|
| 1  | Shrubs           | 65.311    |
| 2  | Forest and Plantation | 140.346  |
| 3  | Field Rice       | 129.069   |
| 4  | Water Body       | 5.276     |
| 5  | Settlement       | 14.246    |
| 6  | Cloud            | 6.335     |

3.2. Map of Advisability of Gold Exploration
The advisability map is obtained from the process of overlaying the map of the potential distribution of gold with a map of land cover which is then performed the calculation of the attribute scoring on the overlay results. There are 5 (five) classification classes of gold exploration advisability levels, namely very high, high, sufficient, low, and very low. The classification result table for the advisability of gold exploration in Banyuwangi Regency can be seen in the following table.
Table 4. Classification of Advisability of Gold Exploration

| Interval   | Advisability Level | Area (Ha) | Percentage (%) |
|------------|--------------------|-----------|---------------|
| 0.00 – 1.80 | Very High          | 41.104    | 11            |
| 1.80 – 2.60 | High               | 62.348    | 17            |
| 2.60 – 3.40 | Plenty             | 54.596    | 15            |
| 3.40 – 4.20 | Low                | 180.152   | 50            |
| 4.20 – 500  | Very Low           | 22.848    | 6             |

Figure 3. Map of Advisability of Gold Exploration in Banyuwangi Regency

From the processing of the advisability of gold exploration, it can be seen that the level of advisability for gold exploration is very high, having an area of 41,104 hectares or 11% of the total area of Banyuwangi Regency. For the high level of gold exploration advisability has an area of 62,348 hectares or 17% of the total area of Banyuwangi Regency.

3.3. Suitability Analysis Against Mining Area Map

As for regions that have a very high level of gold exploration advisability and high gold exploration advisability, then a suitability analysis is carried out on a advisi map of the Banyuwangi Regency mining area obtained from the East Java ESDM Office using the intersect method. In the mining area map, 3 (three) types of mining areas are obtained, namely non-metal mineral areas and / or rock mining business areas, metal mineral areas, and state reserve areas. The gold exploration includes metal mineral regions and state reserves. The following is a map of the mining area of Banyuwangi Regency as can be seen in the following table.
Figure 4. Mining Area Map in Banyuwangi Regency

From the overlay processing of the gold exploration map of advisability which has a high and very high grade with a map of the Banyuwangi Regency mining area, the results can be seen in Figure 5.

Figure 5. Map of Suitability of Gold Exploration

From these results obtained areas that are worthy of gold exploration and in accordance with the mining area map of Banyuwangi Regency are found in 4 (four) districts, namely Pesanggaran district, Siliragung district, Glenmore district and Kalibaru district. Following is a table of the results of the analysis of the suitability of gold exploration in Banyuwangi Regency:
Table 5. Area of Suitability of Gold Exploration

| No | District   | Area (Ha) |
|----|------------|-----------|
| 1  | Pesanggaran| 44.894    |
| 2  | Siliragung | 20.065    |
| 3  | Glenmore   | 7.960     |
| 4  | Kalibaru   | 5.715     |

4. Conclusions
In this study shows that areas worthy of gold exploration and in accordance with the Mining Area Map based on the Minister of Energy and Mineral Resources Decree No. 3672 K / 30 / MEM / 2017 in 2017 are in Pesanggaran, Siliragung, Glenmore, and Kalibaru Districts. In Pesanggaran District, areas that are worthy of being explored in gold and in accordance with the mining area map have an area of 44,894 hectares. In Siliragung District, an area worthy of being explored in gold and in accordance with a mining area map has an area of 20,065 hectares. In Glenmore District, an area worthy of gold exploration and in accordance with the mining area map has an area of 7,960 hectares. Whereas in the Kalibaru District, areas worthy of gold exploration and in accordance with the mining area map have an area of 5,715 hectares.

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