The application of remote sensing technology for environmental quality analysis of settlement in Bengkulu

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Abstract. Environmental quality research was conducted in Bengkulu City which aims to determine the quality of the residential environment. The method used in this study is a combination of high-resolution image interpretation techniques (Google Earth) assisted by geographic information system technology (GIS). High-resolution images are used to identify objects that function as parameters. Then these parameters are given a rating or scoring to obtain an analysis of the environmental conditions of the settlement, by giving weights we can determine the level of ability based on the level of these parameters. The parameters used in this study were settlement density, settlement layout, and settlement location. Based on the study results, the quality of settlements in Bengkulu City is dominated by good category, especially in Muara Bangkahalu and Selebar subdistrict, these two subdistricts still have a lot of non-developed lands and are close to transportation access in the form of bus terminals and airports so it will attract people to live there. For suggestion, good planning is really needed to build a settlement, thus the settlements and environment quality can also be well preserved.

Keywords: Settlements, quality of settlements, high resolution imagery, GIS

1. Introduction
Rapid population growth can have implications for the greater need for space and as a result, various problems will arise in the procurement and arrangement of space for housing, education, health, trade, recreation, religion, industry, sports, and so on [1]. In urban areas, the population growth rate is usually higher, this happens because cities are relatively large residential centres and are the centres of human activity and provide opportunities for a better life than in rural areas [2]. Bengkulu City is a coastal city located on the western coast of Sumatra Island which faces the Indian Ocean. As the capital city of Bengkulu Province, Bengkulu City is a destination of migration for the population in the province of Bengkulu. Population concentration in Bengkulu City encourages population compaction and results in an increasing need for residential or built land. The large number of settlement developments that have been carried out will prompt the development of the Bengkulu City area [3, 4]. Based on the previous study in [5] and [6], states that the settlement development in Bengkulu City are developing towards the north of the city of Bengkulu, Muara Bangkahalu District and developing towards the east of Bengkulu City, District Selebar. This research focuses on assessing the quality of settlements in Bengkulu City to become a consideration that determines the feasibility of development plans to be prepared for the future.
2. Method
The research method used in this study is a combination of high-resolution image interpretation techniques (Google Earth) assisted by geographic information system technology (GIS). There are three sets needed for object recognition, namely detection, identification, and analysis [7]. Image interpretation is an activity to study aerial photographs or imagery that aims to analyze objects and see these objects [8]. The principle of identifying the identity and type of objects in an image is based on object attributes or object attributes in the image. The categories of objects depicted in the image are identified using 8 (eight) elements of interpretation, namely hue or color, size, shape, texture, pattern, shadow, location or location, and the association of the appearance of the object [9]. So that in this study high-resolution images are used to identify objects that function as parameters. Then these parameters are given a rating or scoring to obtain an analysis of the environmental conditions of the settlement, by giving weights we can determine the level of ability based on the level of these parameters [10] or in other words, data analysis in this study is a form of quantitative analysis. Scoring is giving weight to each parameter to determine the level of ability based on predetermined criteria [11]. The parameters used in this study were the quality of the settlements with visual interpretation, specifically.

2.1. Settlement density
The settlement density of a residential block is calculated based on the total area of the entire roof divided by the area of the settlement block in residential units. The results of these calculations can determine the comparison between residential and non-residential land use in the settlement [12, 13]. From the calculation of settlement density then classified based on table 1.

2.2. Settlement layout
This parameter is assessed based on the regularity of the location, and the size of the building. Buildings that have the same relative size and are located following a certain pattern are grouped under the same mapping unit [12, 13]. The classification of the settlement layout pattern is shown in table 2.

2.3. Settlement location
Settlement location are evaluated from the distance of a residential block to sources of pollution, such as airports, industries, ports, and terminals. This is related to the level of air quality in the settlement.

| Table 1. Settlement density classification |
|-------------------------------------------|
| No | Criteria | Classification | Score |
|----|----------|----------------|-------|
| 1  | The average density of houses in residential blocks considered as spaced (< 40 %) | Good | 3 |
| 2  | The average density of houses in residential blocks considered as moderate (< 40 % – 60 %) | Moderate | 2 |
| 3  | The average density of houses in residential blocks considered as dense (> 60 %) | Poor | 1 |

| Table 2. Settlement layout classification |
|-------------------------------------------|
| No | Criteria | Classification | Score |
|----|----------|----------------|-------|
| 1  | 50 % building in residential blocks arranged orderly | Good | 3 |
| 2  | 25 % – 50 % building in residential blocks arranged orderly | Moderate | 2 |
| 3  | < 25 % building in residential blocks arranged orderly | Poor | 1 |
Table 3. Settlement location classification

| No | Criteria | Classification | Score |
|----|----------|----------------|-------|
| 1  | Settlement location far from sources of pollution (airports, industries, ports, and terminals) | Good | 3 |
| 2  | Settlement location not affected directly with from sources of pollution | Moderate | 2 |
| 3  | Settlement location located near sources of pollution | Poor | 1 |

In the interpretation stage, the assessment of settlement locations through images is assessed qualitatively [12, 13]. The classification of the Settlement location parameters is shown in table 3.

After all the environmental quality parameters have been inputted in the attribute table, the next step is to give weight to each parameter. This weighting is given to each parameter according to the level of influence on the quality of the residential environment. The value of each parameter that determines the quality of the settlement is determined based on weighting with several categories, consisting of good (giving a score of 3), moderate (giving a score of 2), and bad (giving a score of 1). The weight value will be multiplied by the value of each parameter. This classification aims to classify residential blocks into good, medium, or bad classes. Before doing classification, first of all, calculate the class interval (range). The formula used is: Total score = (solid x 3) + (location x 3) + (location x 2). The results of the calculation obtained the highest and lowest scores so that the difference (range) can be found [12, 13].

3. Results and discussion

3.1. Settlement density

The results of the interpretation of high-resolution imagery (Google earth) in Bengkulu City, can be seen that Bengkulu City is dominated by the density of settlements in the good category (The average density of houses in residential blocks considered as spaced (< 40 %)) and Bad category of settlement density is not found.

On the map as shown in figure 1, it can also be seen that the closer to the northwestern part of the city of Bengkulu (sub-district Teluk Segara) the more settlements are found in the moderate category, and the further away from the bay area the density of settlements decreases. This is happened due to Teluk Segara sub-district is the areas of densely populated fishing villages, offices, cultural heritage areas such as Fort Marlborough and Kampung China, and trading areas.

3.2. Settlement layout

The results of the interpretation of high-resolution imagery (Google earth) in Bengkulu City, can be seen that Bengkulu City is dominated by poor category of settlement layout building in residential blocks.

On the map as shown in figure 2, it can also be seen that the closer to the north-western part of the city of Bengkulu (Teluk Segara sub-district) the more settlements layout are found in the poor category, and the further away from the bay area the settlements layout spread with various categories. Poor category of settlement layout in Teluk Segara sub-district occurs because due to high-density settlement and the existence of a fishing village which is dominated by the low-income society. In contrast to what happened in Selebar sub-district, which is located far from the bay and still has a lot of undeveloped lands gives it the opportunity to have a better settlement layout.
Figure 1. Settlement density in Bengkulu City.

Figure 2. Settlement layout in Bengkulu City.
3.3. Settlement location parameters
The results of the interpretation of high-resolution imagery (Google earth) in Bengkulu City, can be seen that Bengkulu City is dominated by the settlement location parameters are evaluated from the distance of a residential block to sources of pollution, such as airports, industries, ports, and terminals (figure 3).

On the map, it can also be seen that there are settlements that are close to sources of pollution, especially industrial pollution sources such as those found in the sub-districts of Kampung Melayu dan Gading Cempaka. An airport that is located in Selebar sub-district and bus terminals that is located in Muara Bangkahalu are two kind of pollution source, but the existence of the airport and terminal does not really affect settlements because of its condition which is a bit far from the settlement.

3.4. Settlement quality in Bengkulu City
The results of the overlay and weighting of the three settlement quality parameters show that Bengkulu City is dominated by good category quality of settlement as shown in figure 4. Bad category is concentrated in Teluk Sagara and Gading Cempaka sub-district. This is because the Teluk Segara sub-district is concentrated by fishing village settlements, offices, cultural heritage areas such as Fort Marlborough and Kampung China, and trading areas. Meanwhile, in Gading Cempaka subdistrict, there is an industry, which makes the quality of settlement worse.

Pratami et al. in Modelling cellular automata for the development of settlement area Bengkulu City said that during the last 15 years (2002–2017) changes in residential land cover have increased in area by 1,919.40 ha, especially in the northern and eastern parts of Bengkulu City [5]. The districts that experienced a fairly rapid increase in residential / built land cover were Muara Bangkahulu District of 465.59 ha and District of Selebar of 912.43 ha. This is of course in line with what is found on the settlement quality map. On the map, it can be seen that two sub-districts (Muara Bangkahulu and Selebar) are dominated by good quality settlements, and still have a lot of non-developed land, and are close to transportation access in the form of bus terminals and airports so that of course it will attract people to live.

Figure 3. Settlement location in Bengkulu City.
4. Conclusion
The quality of settlements in Bengkulu City is dominated by good category, especially in Muara Bangkahalu and Selebar subdistrict, these two subdistricts still have a lot of non-developed lands and are close to transportation access in the form of bus terminals and airports so it will attract people to live there. For suggestion, good planning is really needed to build a settlement, thus the settlements and environment quality can also be well preserved.

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