

Environmental Quality Analysis of Settlement Around the Electric Steam Power Plant (PLTU) Palabuhanratu, Sukabumi, West Java

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ABSTRAK

Menurut Badan Pusat Statistik, laju pertumbuhan penduduk Indonesia mencapai 1,17% pada tahun 2022 dan terus meningkat secara eksponensial setiap tahunnya. Selain itu, pertumbuhan jumlah penduduk yang semakin meningkat menyebabkan beberapa permasalahan, diantaranya adalah penurunan kualitas lingkungan permukiman. Studi ini mengkaji kualitas lingkungan permukiman di sekitar Pembangkit Listrik Tenaga Uap (PLTU) Palabuhanratu. Data yang digunakan dalam penelitian ini merupakan kombinasi data *open source* dan data survei lapangan. Metode yang digunakan adalah teknik interpretasi citra satelit menggunakan teknologi sistem informasi geografis (SIG) dengan 6 parameter yaitu kepadatan permukiman, tata letak permukiman, lokasi permukiman, kondisi jalan, kondisi bangunan dan ketersediaan fasilitas kesehatan. Hasil dari penelitian ini adalah informasi terkait kualitas lingkungan permukiman di sekitar PLTU Palabuhanratu yang dapat dijadikan masukan dalam penataan ruang di kawasan Palabuhanratu untuk pengembangan wilayah yang berkelanjutan. Secara keseluruhan penelitian ini menunjukkan bahwa kualitas lingkungan permukiman di sekitar PLTU Palabuhanratu didominasi dengan kategori baik. Namun, tidak menutup kemungkinan kualitas permukiman di kemudian hari akan semakin buruk karena persentase kepadatan penduduk yang hampir mendekati 40%.

Kata Kunci: Palabuhanratu, Permukiman, Kualitas, Lingkungan, SIG

ABSTRACT

According to the Central Statistics Agency, Indonesia's population growth rate will reach 1.17% in 2022 and will continue to increase exponentially annually. Moreover, the increasing number of population growth leads to several issues, including environmental quality of settlement. This study examined the quality of the environmental settlement around the Electric Steam Power Plant (PLTU) Palabuhanratu. The data used in this study is a combination of open-source data and field survey data. The method used is an interpretation technique (satellite imagery) assisted by geographic information system (GIS) technology with six-parameters, there are settlement density, settlement layout, settlement location, road conditions, building conditions and availability of health facilities. The results of this study are information including settlement quality and recommendations related to the quality of the environmental settlement around the PLTU Palabuhanratu which can be used as input in spatial planning in the Palabuhanratu area for sustainable regional development. Overall, this research shows that the environmental quality of settlements around PLTU Palabuhanratu is dominated by good category. However, it is possible that the quality of settlements will deteriorate in the future because the percentage of population density which almost close to 40%.

Keywords: Palabuhanratu, Settlement, Quality, Environment, GIS

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1. Introduction

According to the Central Statistics Agency (BPS) Indonesia's population growth rate will reach 1.17% in 2022. This significant population increase rate in Indonesia certainly has implications for greater space requirements. As a result, many problems arise in procurement and spatial planning for housing, education, health, trade, recreation, religion, industry, sports and so on (Legowo et al., 2021). Regarding

spatial planning, the more people there are, the more the desire to turn non-residential land into residential land. Settlements are not only to fulfill the basic needs of human life and shelter, but also to build a harmonious relationship with the ecosystem (Tang et al., 2017). The suitability of settlements with nature/ecosystems will directly affect human health and quality of life as well as determine the size of the population and the regional economy (W. Li et al.,

2022). Settlement problems are closely related to poor environmental quality (Rakhmatika et al., 2021). Irregular settlement development with land use can trigger problems such as ecosystem imbalances which lead to potential hazards that result in disasters. Therefore, there is a need for a development strategy in special protection to protect the ecosystem balance (Cao et al., 2022). One of them is the development of sustainable settlement areas.

According to Indonesian Law No. 1 of 2011 concerning Housing and Residential Areas (Undang-Undang Nomor 1 Tahun 2011 Tentang Perumahan Dan Kawasan Permukiman, 2011), regional development is an activity of planning, development, utilization, and control to maintain harmony, harmony, balance, and integration between regions which can direct population distribution and reduce development imbalances between regions and unsustainable spatial use. Thus, to develop settlement areas, it is necessary to look at the potential and capabilities of an area which can be seen from the quality of the environment.

The quality of the environmental settlement is closely related to cleanliness and comfort. A clean and comfortable settlement can determine the quality of human life. A high quality of life can also affect the economic level in a settlement (Taçoral et al., 2017). In quality evaluation of regional types of rural human settlements (Hu & Wang, 2020) also stated that one way to measure quality of life is the availability of transportation facilities and the existence of public services such as the availability of health facilities. The Directorate General of Human Settlements, Department of Public Works (2006) in (Rakhmatika et al., 2021) assesses the quality of settlements with parameters of settlement density, building layout patterns, settlement shade trees, width of settlement entrances, road surface conditions, and location of settlements. On the other hand, the quality of the settlement environment is closely related to the level of slum settlements. Regarding settlement slums according to Law Number 1 of 2011 concerning Housing and Residential Areas (Undang-Undang Nomor 1 Tahun 2011 Tentang Perumahan Dan Kawasan Permukiman, 2011), slums are settlements that are unfit for habitation because of the irregularity of the buildings, the high level of building density, and the quality of the buildings and facilities and infrastructure that do not adequate the requirements. Environmental settlement quality can be identified spatially with a geographic information system (GIS) by analyzing parameters resulting from satellite imagery interpretation such as settlement density, building arrangement, road width, road condition, green/vegetation area, and settlement location (Putra & Pigawati, 2021).

Currently, the government is trying to deal with the demand for electricity in Indonesia, especially in Java, which has the highest density compared to other major islands in Indonesia. One of the things the government is doing is relying on kinetic energy from

steam to produce electricity by building a Steam Power Plant (PLTU). The power plants are scattered in several areas, such as PLTU Suralaya, Cirebon, and PLTU Palabuhanratu. Palabuhanratu itself is a tourist location. The construction of the PLTU certainly results in the opening of jobs which encourages population movement to the PLTU location. This adds to the complexity of settlement problems in the PLTU area.

PLTU Palabuhanratu was founded in 2012 in Jayanti Village. Jayanti Village itself is administratively located in Palabuhanratu District, Sukabumi Regency, West Java Province. The location is close to the tourist area. Meanwhile there are several settlements in Jayanti Village and Palabuhanratu Village and its surroundings. There are many studies on air quality and its relationship to health. One of them is research (X. Li et al., 2018) which says that protecting air quality needs to be considered by various factors to improve the quality of settlements and is also one of the goals of building better livable cities. Air pollution negatively affects residents of settlements (Zhang et al., 2022). Considering that the PLTU has negative impacts such as air pollution and coal waste remaining as the main fuel for the PLTU engine which can affect the quality of the settlement, it is necessary to carry out an analysis of the physical quality of the environmental settlement around the PLTU Palabuhanratu.

The environmental quality of settlements has been researched several times in Indonesia. Prasetyo & Rahayu (2013) conducted research related to the quality of settlements in Serenan District, Surakarta City. Farizki & Anurogo (2017) conducted research on the quality of the residential environment in Batam City District. Rakhmatika et al., (2021) conducted research in Sorosutan Village, Yogyakarta City. The three studies used 6 parameters to analyze the quality of the settlement environment, namely building density, building layout, shade trees, width of the entrance, condition of the access road, and location. Meanwhile, Rahman & Putro (2022) conducted research related to the quality of the residential environment in Miroto Subdistrict, Semarang City using 10 parameters, namely building density, building order, effects of pollution, road width, road conditions, availability of clean water, sewerage, availability of toilets, drainage channels and places waste disposal.

This study identified environmental quality by combining settlement quality calculation parameters from the Directorate General of Human Settlements, Department of Public Works (2006) with slum settlement quality calculation parameters in the PLTU Palabuhanratu area. The parameters that will be used in this study are the layout patterns of settlement buildings, settlement density, quality of buildings, infrastructure, and location of settlements. This research analysis can be used to determine the level of comfort and feasibility of a settlement to live in as well

as input for spatial planning in the Palabuhanratu area.

2. Methodology

This research was conducted using a combination method, the image interpretation method with GIS technology and the field survey method. Image interpretation is a technique for identifying objects on the surface of the earth. Meanwhile, field surveys were carried out to validate the results of image interpretation and to collect data that cannot be seen through images. The data used in this study are road data from OpenStreetMap, building data from Microsoft, satellite imagery data from Google Satellite, building and road condition data from field survey results and other data from the Indonesian Topographical Map such as coastlines and administrative area boundaries. The research location is divided into 12 settlement blocks. The distribution of settlement blocks can be seen in Figure 1.

This study uses six-parameters to calculate the quality of the settlement environment. The six parameters are settlement density, settlement layout, settlement location, settlement health facilities, settlement building conditions and settlement road surface conditions. The criteria for classifying each parameter are as follows:

2.1. Settlement Density

Settlement density is defined as the total area of buildings in a settlement area. The calculation method is to add up the entire area of the building block and then divide it by the area of the settlement area. In determining the classification of settlement density, this study refers to the assessment of settlement quality according to the Directorate General of Human Settlements, Department of Public Works (2006).

2.2. Settlement Layout

The pattern of building layout can be seen from the regularity between buildings in settlement blocks.

The indicator is regularity so that buildings of the same size and with a certain pattern are grouped into the same settlement blocks. In determining the classification of building layout patterns, this study refers to the Assessment of settlement quality according to the Directorate General of Human Settlements, Department of Public Works (2006).

Table 1. Settlement Density Classification

Criteria	Classification	Score
Settlement density in a settlement block is rare <40%	Good	3
Settlement density in a settlement block is medium 40% - 60%	Moderate	2
Settlement density in a settlement block is dense >60%	Poor	1

source: Directorate General of Human Settlements, Department of Public Works (2006) in (Rakhmatika et al., 2021)

Table 2. Settlement Layout Classification

Criteria	Classification	Score
50% of the existing buildings in a settlement block are orderly arranged	Good	3
25% - 50% of the existing buildings in a settlement block are orderly arranged	Moderate	2
<25% of the existing buildings in a settlement block are orderly arranged	Poor	1

source: Directorate General of Human Settlements, Department of Public Works (2006) in (Rakhmatika et al., 2021)

2.3. Settlement Location

The parameter of settlement location is determined by looking at the proximity of the settlement to the source of pollution. Sources of pollution in the study, for example, are companies and power plants. In determining the classification of building locations, this study refers to the Assessment of settlement quality in accordance with the Directorate General of Human Settlements, Department of Public Works (2006) and added explanations from (Farizki & Anurogo, 2017).

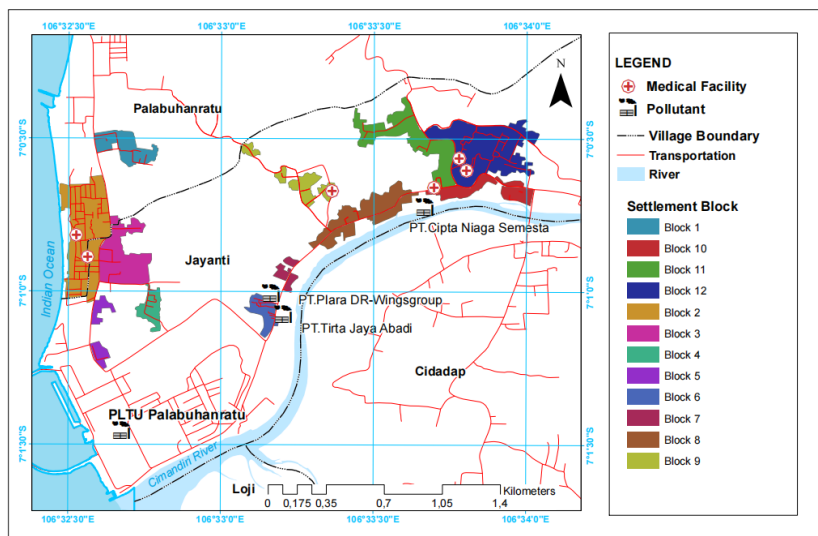


Figure 1. Research Location

Table 3. Settlement Location Classification

Criteria	Classification	Score
The distance between settlement location and pollution sources is ± 5 km	Good	3
The distance between settlement location and pollution sources is ± 3 km	Moderate	2
The distance between settlement location and pollution sources is ± 1 km	Poor	1

source: *Settlement Location Classification in (Farizki & Anurogo, 2017)*

2.4. Settlement Health Facilities

Parameters of health facilities are determined by looking at the proximity of settlements to health facilities. Health facilities in this study, for example, are midwives and posyandu. In determining the classification of health facilities, this study uses analysis with reference to the modified Indonesian National Standard 03-1733-2004 Concerning Procedures for Planning Residential Environments in Urban Areas (Standar Nasional Indonesia 03-1733-2004 Tentang Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan, 2004).

Table 4. Settlement Health Facilities Classification

Criteria	Classification	Score
Distance from settlement location to health facilities < 1000 m	Good	3
Distance from settlement location to health facilities 1000 m - 3 km	Moderate	2
Distance from settlement location to health facilities > 3 km	Poor	1

Source: *Modified from (Standar Nasional Indonesia 03-1733-2004 Tentang Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan, 2004)*

2.5. Settlement Buildings Condition

Building quality is the condition of buildings in housing or settlements that comply with technical requirements. Technical requirements related to building reliability. In this study, building quality is focused on building reliability in terms of comfort, health, and safety. Buildings that have comfort, health and safety equipment are permanent buildings. Permanent buildings have good health facilities and protect the safety of residents. Therefore, this study focuses on the permanence of building construction to determine building quality. As for the permanent criteria for a building, it refers to the Government Regulation of the Republic of Indonesia Number 49 of 1963 concerning Housing Lease Relations (Peraturan Pemerintah Republik Indonesia Nomor 49 Tahun 1963 Tentang Hubungan Sewa Menyewa Perumahan, 1963) which was later modified. The calculation of building quality is by adding up the permanent buildings and then dividing by the number of existing buildings in the settlement.

Table 5. Settlement Buildings Condition Classification

Criteria	Classification	Score
>50% of existing buildings in a block settlement is permanent (brick wall or block wall construction)	Good	3
25% - 50% of existing buildings in a block settlement is permanent (brick wall or block wall construction)	Moderate	2
<25% of existing buildings in a block settlement is permanent (brick wall or block wall construction)	Poor	1

source: *Modified from (Peraturan Pemerintah Republik Indonesia Nomor 49 Tahun 1963 Tentang Hubungan Sewa Menyewa Perumahan, 1963)*

2.6. Settlement Roads Condition

The classification of road surface conditions is determined based on the assessment of the quality of settlements in accordance with the Directorate General of Human Settlements, Department of Public Works (2006). This classification can be calculated by adding the length of the paved road divided by the total length of the road.

Table 6. Settlement Roads Condition Classification

Criteria	Classification	Score
50% of the length of the existing road in the settlement block is hardened with asphalt/cement	Good	3
25% - 50% of the length of the existing road in the settlement block is hardened with asphalt/cement	Moderate	2
<25% of the length of the existing road in the settlement block is hardened with asphalt/cement	Poor	1

source: *Directorate General of Human Settlements, Department of Public Works (2006) in (Rakhmatika et al., 2021)*

The six parameters are scored to determine the class of each parameter. Furthermore, each parameter is given a weight according to the level of its influence on the quality of the settlement environment.

$$\text{Settlement Quality} = \sum_{i=1}^n (P_i \times B_i) \quad (1)$$

where P is a parameter of environmental quality and B is the weight of each parameter.

Determination of the weight is given according to the magnitude of the influence on the quality of the settlement environment. The weighting for settlement density, building layout patterns, road conditions and settlement locations is based on the Assessment of settlement quality in accordance with the Directorate General of Human Settlements, Department of Public Works (2006), while the quality of buildings and health facilities are given weight based on the author's considerations. The total score for settlement quality is = (density x 3) + (layout x 1) + (location x 2) + (health facilities x 2) + (building condition x 2) + (road surface condition x 2). After that, the class interval was determined.

$$\text{Class Interval} = \frac{(\text{Highest Score} - \text{Lowest Score})}{\text{Number of Classes}} \quad (2)$$

In this study, the desired number of classes is 3. The highest score after multiplied by the weight is 36, while the lowest score after multiplied by the weight is 12. Then the class interval is 8. Therefore, the classification of environmental settlement quality can be calculated by classification as shown in table 7.

3. Result and Discussion

3.1. Settlement Density

From the results of data processing, the density of settlements around PLTU Palabuhanratu is in the good category (the average settlement density is less than 40%). Settlement density in the good category means that in the settlement there is still ample space for movement and air circulation is still relatively good (Rakhmatika et al., 2021). The highest density of settlements is in block 2 in 37.39% (see figure 2a), this is because the location of block 2 is very strategic because it is close to the beach, the Indonesian National Army Navy post and close to the PLTU. With these 3 criteria, migrants, especially employees of the PLTU and the Indonesian Navy, will choose block 2 as their home. The second highest settlement is block 6 in 35.57% where the Jayanti Village office is located and is located close to the main road intersection. This means that the density of settlements will be higher if they are in central locations of activities such as tourist sites, offices, and government. The results of settlement density can be seen in Figure 2a.

3.2. Settlement Layout

By image interpretation, the majority of settlements around PLTU Palabuhanratu have layouts in the poor category. The bad category means that a settlement has a high level of irregularity in building layout (<25% of the existing buildings in a settlement block are orderly arranged) (Prasetyo & Rahayu, 2013). Block 2 has a moderate category layout. This is because block 2 is the most strategic location compared to the others, there is a beach, it is close to the PLTU and there is a TNI AL post. The settlements are also dominated by the housing category, not villages. The results of the settlement layout can be seen in Figure 2b.

3.3. Settlement Location

The location of settlements within the data processing shows the criteria of distance from settlements to sources of pollution can be seen that the settlements around PLTU Palabuhanratu are dominated by poor category. It means that settlements can be affected by pollution, including air, noise and also the environment (Rahman & Putro, 2022). This condition is influenced by the existence of companies around the PLTU Palabuhanratu. There are 3 companies around the settlement, there are PT. Cipta Niaga Semesta, PT. Plara DR Wingsgroup and PT. Tirta Jaya Abadi. Locations of settlements in the moderate category are in block 1 and part of block 2 because they are located at 1-3 km from pollution

sources. The results of settlement locations can be seen in Figure 3a.

3.4. Settlement Health Facilities

From the results of the field survey, there are 6 health facilities scattered in settlement areas. The health facilities are in the form of BIDAN (midwives) (BIDAN) and POSYANDU (the government's efforts to facilitate the Indonesian people in obtaining maternal and child health services). These two health facilities are considered as small scale type of health facilities. After analyzing the data, the settlements around PLTU Palabuhanratu are dominated good category for the availability of health facilities. There is no poor category in this case. Good category means the distance from settlement location to health facilities less than 1 km based on modified Indonesian National Standard 03-1733-2004 Concerning Procedures for Planning Residential Environments in Urban Areas (Standar Nasional Indonesia 03-1733-2004 Tentang Tata Cara Perencanaan Lingkungan Perumahan Di Perkotaan, 2004). However, this area needs higher level of health facilities types such as PUSKESMAS. PUSKESMAS is more capable because it has complete health facilities for instance ambulance, 24-hours doctors and complete medical drugs. The results of settlement health facilities can be seen in Figure 3b.

3.5. Settlement Buildings Condition

By combining the survey and data processing it can be seen that the housing conditions around PLTU Palabuhanratu are dominated by good category. Good category means less than 50% of existing buildings in a block settlement is permanent (brick wall or block wall construction) based on modified the Government Regulation of the Republic of Indonesia Number 49 of 1963 concerning Housing Lease Relations (Peraturan Pemerintah Republik Indonesia Nomor 49 Tahun 1963 Tentang Hubungan Sewa Menyewa Perumahan, 1963). Most of the buildings in the area are permanent buildings. The condition of permanent buildings is at least in block 6. Block 6 is a settlement in the form of a village. The area is far from strategic locations, even including settlements closest to pollution sources. There are 2 companies in the area, there are PT. Plara DR Wingsgroup and PT. Tirta Jaya Abadi. The condition of the highest permanent buildings is in blocks 5, 7, 10 and 11. Part of block 5 is housing owned by PLTU Palabuhanratu, while block 7 has high permanent building conditions because it is located on the main road and the settlements are not too large. Blocks 10 and 11 are near the main road and administrative center of Desa Jayanti. The results of the condition of settlement buildings can be seen in Figure 4a.

3.6. Settlement Roads Condition

The roads condition in settlement can be seen from the combination of field survey data and the result of data processing. This research shows that the most of roads condition are hardened, although some of them

are damaged but are still in decent condition (Good category). It means 50% of the length of the existing road in the settlement block is hardened with asphalt/cement based on Directorate General of Human Settlements, Department of Public Works (2006). The lowest condition of the road surface is in block 6. This is because block 6 is a settlement in the village category where some of the roads are still dirt or not paved. The results of the road surface conditions can be seen in Figure 4b.

3.7. Settlement Quality

Overall, the final result of previous six parameters mentioned in section 3.1 until 3.6, the environmental quality of settlements around PLTU Palabuhanratu is dominated by good category. However, there are several settlements that are in the moderate category. This is due to the proximity of these locations to sources of pollution (blocks 5, 4, 6 and 7) and some are due to the factor of being far from health facilities (block 9). The results of settlement quality can be seen in Figure 5.

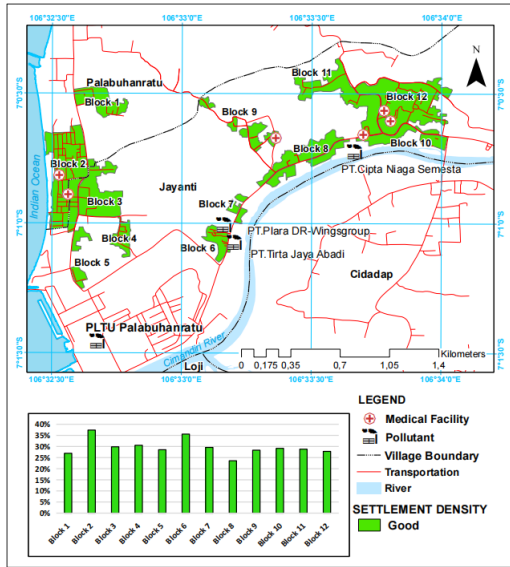


Figure 2a. Settlement Density

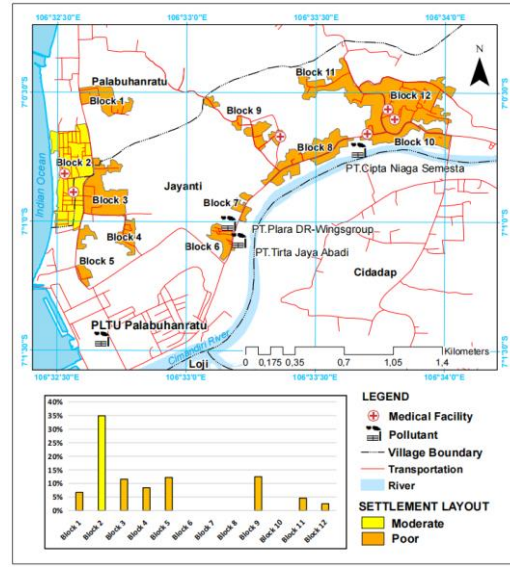


Figure 2b. Settlement Layout

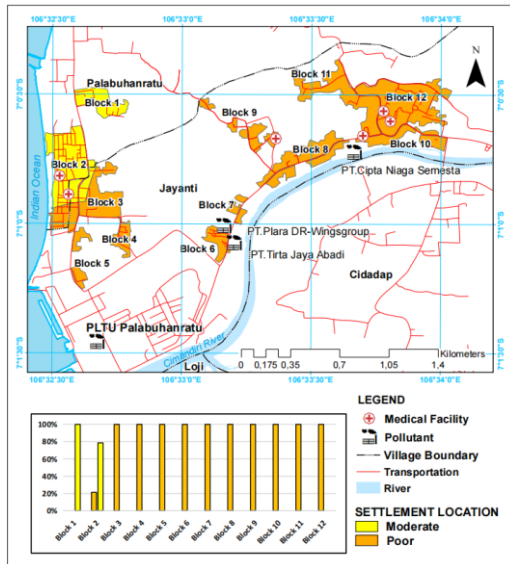


Figure 3a. Settlement Location

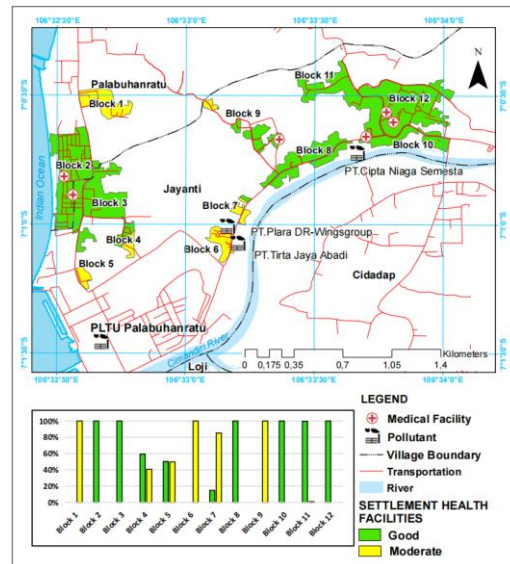


Figure 3b. Settlement Health Facilities

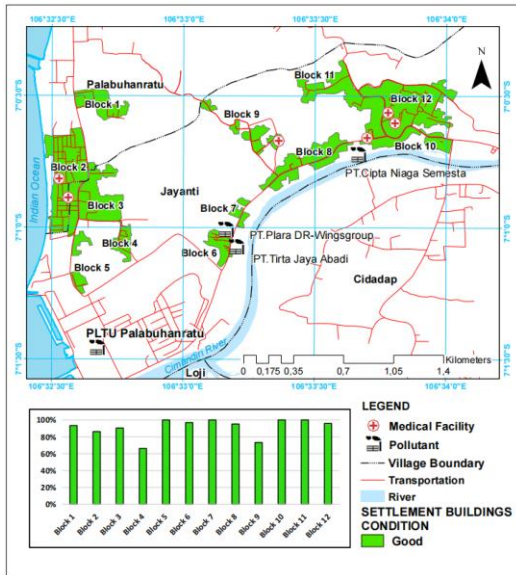


Figure 4a. Settlement Buildings Condition

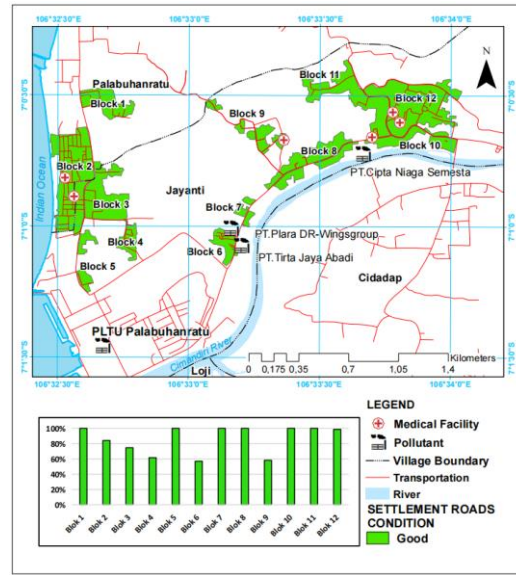


Figure 4b. Settlement Roads Condition

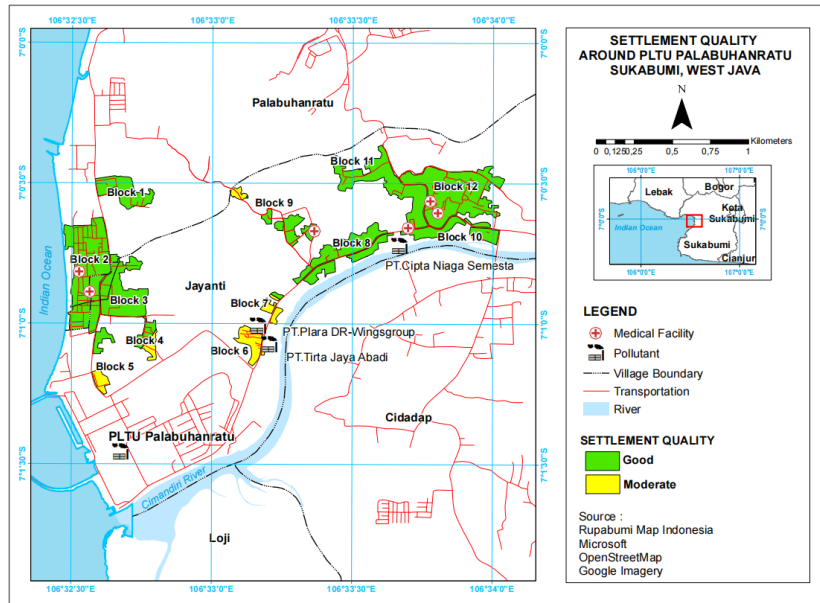


Figure 5. Settlement Quality around PLTU Palabuhanratu

4. Conclusion and Recommendation

Finally, this research shows that the environmental quality of settlements around PLTU Palabuhanratu is dominated by good category. However, it is possible that the quality of settlements will deteriorate in the future. This can be seen from the percentage of population density which almost close to 40%, the layout of settlements which are dominated by poor category, the location of settlements which are poor because they are close to sources of pollution, and the absence of middle type health facility (PUSKESMAS) around the settlements.

PLTU Palabuhanratu is a very strategic location Besides having PLTU, it is also close to tourism sites. For the development of the area around the PLTU Palabuhanratu, there are several things that must be considered in the future, there are:

- a) Limit the growth of settlements around PLTU Palabuhanratu;

- b) Developed more Green Open Spaces in settlement areas;
- c) Add more middle type of health facilities in the form of PUSKESMAS.
- d) Restrict building permits to companies causing pollution.

These four points mentioned above are expected to have a significant impact on the quality of settlements around PLTU Palabuhanratu in the future. Moreover, the role of government in creating policies that are based on sustainable environment is needed in establish and improve the quality of a settlement in the area.

However, this research still has limitations. First limitation is the width of road is not included as an essential parameter. Therefore, it is recommended to assess a well defined road parameter. Second limitation is, the criteria of permanent buildings condition based on wall structure. This research

recommend to add more than one-criteria of permanent buildings condition. The third limitation is the temporal data limited to one-year time. Therefore, it is recommended to have a periodic research in this area to obtain modelling data for long-term regional development.

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