Evaluation of urban settlement sustainability in an inland municipality in Central Java, Indonesia

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Abstract. A sustainable human settlement and the environment are one of the SDGs 2030 programs to realize Sustainable Cities and Communities, which also one of Purwokerto municipality's planning goals. Purwokerto is in the progress of the KOTAKU (City Without Slum) program to ensure a sustainable settlement for all. To help the program in the future, sustainable evaluation of the present settlement area based on physical, social, and economic parameters is required. The physical parameter was assessed using a combination of field observations and analysis of remote sensing images (Sentinel 2-A and Worldview). In contrast, the social and economic parameters were evaluated using secondary datasets and interviews. The urban settlement sustainability was determined by the scoring method using geographic information systems and spatial analysis. This study showed that 22.22% of the current total urban settlement area in Purwokerto had a good level of sustainability, while the rest, 48.15% and 29.63%, fell into the medium and poor category. The result indicates that most of the settlement area in Purwokerto municipality still needs to be improved in the future. Thus, urban settlement sustainability can be guaranteed through local government development programs along with local community participation.

1. Introduction
The quality of settlement has always been a concern in development issues. Become one of the 2030 sustainable development goals (SDGs) to be precise in the 11th goal, namely regarding Sustainable Cities and Communities whose first target is 2030, ensuring access to all decent, safe, affordable housing, including slum management, as well as access to essential services. This goal is fundamental, considering that by 2030, more than 60% of Indonesia's population will live in urban areas [1]. Leaves urban areas with many challenges in planning and management, one of them are urban settlement quality, which can be useful for knowing the level of community welfare. Indonesia's government has prepared to deal with this challenge with the KOTAKU program, with the main goal is to eliminate slum areas to create a better human settlement in cities.

The city of Purwokerto as the capital of Banyumas Regency, in the 2000's Purwokerto began to develop rapidly, with the emergence of several existing facilities in the city including shopping centers, culinary centers, sports facilities, universities, international class hotels, health service centers, and government agencies [2]. As a rapidly growing area, several districts in Purwokerto will be a new administrative area [3]. To ensure that plans with the Sustainable Development Goals, an urban settlement quality assessment is needed. As mentioned before, this study aims to determine the quality of the human settlement and environment in Purwokerto, which is currently running the KOTAKU (City without Slum) program. With good planning and risk management, cities can be incubators for innovation, growth, and sustainable development drivers.
This research aimed to analyze the urban settlement sustainability of Purwokerto city using the remote sensing and GIS technology approach. Remote sensing is defined as collecting and interpreting information about a target without being in physical contact with the object [4]. Since the 1990s, the development of high-resolution remote sensing technology provides a powerful tool for environmental assessment, and some of these technologies are used for assessing human settlement either in quantity or quality [5, 6]. Remote sensing data has a wide scope so that it is possible to see the overall environmental conditions [7]. By using remote sensing data the physical conditions of the Purwokerto settlement can be identified effectively.

Purwokerto City is consists of 27 sub-districts and part of the regional plan to be expanded from Banyumas Regency to become a new administrative city. Currently, Purwokerto is still four sub-districts, namely Purwokerto Utara, Purwokerto Timur, Purwokerto Selatan, and Purwokerto Barat, which are still in the planning stage to become a new administrative city. The establishment of Purwokerto City geographically attempted to spur economic growth in South-Central Java. Purwokerto city serves as the hub of the southern central Java archipelago fan area, Cilacap, with the capital of Central Java province, Semarang [3]. The emergence of a new city will bring about new problems that are already inherent in the city. There are social ineligible and criminality, rising unemployment, city poverty problems, informal activities, and urban activities problems in general.

2. Methods

Human Settlement is a product of multiple social, economic, and physical processes that involve issues of location, construction quality, durability, cost, long-term financing, land tenure, turnover, accessibility, household preferences, and neighborhood externalities [8]. So, in this study, we are using three variables to measure urban settlement quality. There are physical variables, social variables, and economic variables. The following indicators are used on each variable [8-10]:

| Indicators                                    | Physical variables | Social variables            | Economy variable |
|----------------------------------------------|--------------------|-----------------------------|------------------|
|                                              | Road accessibility | Education                  | Dependency ratio |
|                                              | Occupancy density  | Security                   | GDP              |
|                                              | Settlement patterns| Waste management           | home ownership   |
|                                              | Green area         | Sanitation (accessibility   |                  |
|                                              | Green public space | for drinking water)        |                  |
|                                              | exposure and       | Exposure and disaster      |                  |
|                                              | mitigation of      | mitigation                 |                  |
|                                              | natural disasters  | Public transportation      |                  |
|                                              |                    | access                     |                  |

The collection of physical variable data are from high-resolution image processing socio-economic data from related incision and interviews of related parties in each village. High-resolution imagery and socio-economic data interpret to obtain variable information. This study uses quantitative and qualitative scoring methods. The scoring results will be analyzed descriptively and spatially.

Each indicator has its score. The scoring is made based on the consideration of how much it affects the quality of the settlement. The weighted tiered scoring method used in scoring, where each parameter of settlement quality is assigned a rating for each determining parameter then multiplied by the factor. It weighs factor functions to assess the size of the parameters' influence on the assessment of settlement quality, where the value is between one and three. The greater the influence of each parameter, the greater the value of the weighting factor.

Parameters that influence the residential environment's quality give a high score for good classification. In contrast, those with a small influence give a low value for bad classification. The amount of each weighting factor settlement quality parameters are as follows:
Table 2. Variable weighting factors.

| No | Variable            | Indicator                        | Weighting Factor |
|----|---------------------|----------------------------------|------------------|
| 1  | 1                   | Road accessibility               | 3                |
| 2  | Physical variable  | Occupancy density                | 3                |
| 3  | Settlement patterns| 1                                | 1                |
| 4  | Green public space | 3                                | 3                |
| 5  | Education           | 3                                | 3                |
| 6  | Security            | 2                                | 2                |
| 7  | Social variable     | Waste management                 | 3                |
| 8  | Sanitation          | 3                                | 3                |
| 9  | Exposure and disaster mitigation | 3 | 3                |
| 10 | Public transportation access | 1 | 1                |
| 11 | Economic variable   | Dependency ratio                 | 1                |

Each variable in physical, social, and economic aspects evaluate by multiplying the weighting factors for the variables with each variable's size. The determination of the environmental quality class is based on the total score of the sum and multiplication of each determining parameter's dignity by a weighting factor.

Total score = (road accessibility*3) + (occupancy density*3) + (settlement patterns*1) + (green public space*3) + (education*3) + (security*2) + (waste management*3) + (sanitation*3) + (exposure and disaster mitigation*3) + (public transportation access*1) + (dependency ratio*1).

Based on this approach, the classification of the settlements' quality is built with the following formula: (Ci = R: K) where Ci = class interval, R = range (the difference between the highest total score and the lowest total score, K = the number of classes. Determining the class of settlement quality is done by calculating:
1) The highest value of the total score is 75
2) The lowest score of the total score is 55
3) The number of classes specified is 3 classes, with class interval: (75-55) / 3 = 6.67
Dignity classes for settlement quality classes are presented in table 15 below:

| Total score      | Criteria         | Class |
|------------------|------------------|-------|
| 55,00 – 61,67    | Poor quality     | III   |
| 61,67 – 68,33    | Medium quality   | II    |
| 68,33 – 75,00    | Good quality     | I     |

3. Results and discussion
3.1. Physical variables
Physical variables use to analyze settlements' quality according to their physical appearance and tangible form of settlements. Pattern, density, accessibility, and green public area are the assessment we use to calculate the specific criteria. Slum settlement can be seen directly by sight. Physical variables assess the condition of roads, buildings, and green open spaces. We know that Purwokerto has a good quality of road accessibility, medium quality of occupancy density, good quality of settlements pattern, and fewer green public spaces.
The physical variable map above has four sub-maps according to 4 indicators. The first one at the top-left of the layout is road accessibility. There are three types of colors according to their classification. Overall, Purwokerto city dominates by good and medium quality road accessibility. The second one at the top-right of the layout is a built-up index, indicating occupancy density—high density of settlements symbolized with red color and low density of settlements symbolized with green color. Spatially we can see the density of occupancy in the city of Purwokerto based on the color classification used. The third one at the bottom-left of the layout is the settlement pattern—the quality of the settlement pattern is denoted by the color we use. The southern region is dominated by green, which means it has good settlement pattern quality. The middle region is red, which means it has a low settlement pattern quality. The last fourth one at the bottom-right of the layout is green public space. The map informs us where are green public spaces and built-up areas spatially.

Figure 2. Correlation diagram between NDBI and number of buildings.
3.2. **Social-economy variables**

Social variables are used to analyze settlements' quality according to the level of social welfare. Society's welfare can affect the quality of their settlements because it relates to making settlements more feasible. From the data result, we know several facts about social variables for settlement quality at Purwokerto. Purwokerto has a good system for waste management. They collect household waste from house to house and take it to the final waste processing site. Purwokerto also has a good social security system.

![Map of social-economy variable](image)

**Figure 3.** Map of social-economy variable.

There are security posts for each region, a security team, a good security system for reporting staying guests, and police stations for each sub-district. For housing and living environment aspects, each sub-district at Purwokerto has good accessibility for public transportation access and sanitation like drinking water. Talk about security from disasters, three sub-districts have early warning systems, and each sub-district has creation, maintenance, or normalization for rivers, canals, embankments, others. On another side, the percentage of high-school graduation is not too high. It will affect other aspects like employment, regional income, and dependency ratio. For the dependency ratio, Purwokerto has a high dependency rate.

3.3. **Urban settlement quality**

The level of settlement quality is a condition that provides an overview of the quality of the settlement environment as a place to live. In evaluating the urban settlement sustainability, it is necessary to consider the settlement’s qualitative and quantitative characteristics. In this research, the data related to urban settlement quality investigates physical, social, and economic parameters summarized in table 1. The results of data processing give us information about urban settlement quality spatially at Purwokerto. It is the combined result of the three variables mentioned. The final result shows that eight sub-districts concentrated in the middle of the research area have poor quality, which covers 29.63% of the area. Thirteen sub-districts spread over four districts have the medium quality equal to 48.15% of Purwokerto, and 22.22% of Purwokerto area that include in 6 sub-districts in the west and north area have good quality.
Figure 4. Map evaluation of urban settlement sustainability.

The most exciting outcome from this research is that urban settlement quality as an interaction between physical, social, and economic factors showed a complicated relationship. As shown in figure 1, the good physical parameter conditions cluster away from the center. Otherwise, the good social, economic parameter is clustered in the center of Purwokerto. This inverse relationship between the physical and social-economy parameters indicates that the physical factors are superior in influencing the settlement quality sustainability in Purwokerto.

4. Conclusion
The final result shows that 22.22% of the current total urban settlement area in Purwokerto, located at six sub-districts, had a good level of sustainability. The rest, 48.15% area in 13 sub-districts that spread over four districts have medium quality, and 29.63% of the area inside eight sub-district categories as the poor category. Evaluation of urban settlements' sustainability is related to the KOTAKU Program. One of Purwokerto municipality planning goals is still in progress for the sustainable goal of improving its people's welfare. The efforts to improve community welfare need to consider from several aspects. In this research, we expect that improving people's welfare can improve their physical, social, and economic quality.

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