Identifying the sustainability level of urban slums in the Greater Jakarta, Indonesia using a composite index

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Abstract. The Republic of Indonesia's government aims to alleviate slums to mark the start of smart city development. The goals of KotaKu, a national program established to handle slum issues, are 100% access to sanitation and clean water and the reduction of slum areas to zero, which aligns with the nation's commitment to Sustainable Development Goals to tackle climate change and its impacts. Slum identification and intervention are undertaken through the government's emphasis on the settlement's environment, resulting in the wrongful judgment of an area as a slum or vice versa. This study is conducted in four urban slums or kampungs located in the Greater Jakarta area (i.e. Kampung Cikini, Kampung Gedong Pompa, Kampung Cimone-Cincau, and Kampung Markisa). Each area's sustainability level was calculated using a composite index that used indicators to represent the three pillars of sustainability, i.e., social, economy, and environment. Kampung Cimone-Cincau had the best sustainability (0.75), while Kampung Gedong Pompa had the worst (0.52). Across all the study areas, access to sanitation reached 97% and, access to clean water reached 98%. More thorough indicators to identify slum sustainability can help resolve an area's wrongful judgment, and a more suitable approach for slum intervention can be made.

1. Introduction

Indonesia is one of the countries committed to Sustainable Development Goals (SDGs). These goals have been incorporated into the country’s long-term development plan (Rencana Pembangunan Jangka Panjang 2005-2045), including equitable development. Urbanization in Indonesia is triggered by economic development, wherein urban-centered activities spread out into the suburbs, forming a megacity [1]. In the absence of a housing development plan, the rapid population growth of a city can trigger the emergence of urban slums. To encourage equitable development, the government established a national program named KotaKu to reduce slums to 0 hectares and increase sanitation and clean water accessibility to 100%. Slum identification is conducted to determine an intervention plan (Dirjen Cipta Karya) [2]. However, the identification approach utilized by the government primarily focuses on the surrounding environment of the settlements, while the intervention plan prioritizes in-situ intervention that uses public participation. An intervention plan involving community engagement is considered an approach that can maintain social ties and result in considerably better outcomes [3], [4], [5]. Non-thorough slum identification can lead to an ineffective intervention strategy that may result in a rebound. An effective intervention plan can help improve dwellers’ well-being by promoting health, equitable development, and reduce climate change vulnerabilities.

Several methods have been utilized to conduct a sustainability assessment on several scales, including spatial data analysis, sustainability tools, and the most used method indexing. Composite
indexing is the most frequently used technique owing to its ability to aggregate indicators into a comparable value. Urban slums usually referred to as *kampung kumuh kota*, are viewed negatively because they are overcrowded, unplanned, and lack basic and municipal services, putting the dwellers in a high risk for climate change vulnerabilities. *Kampungs*, or dwellings, are considered the front line of a city’s sustainability [6] and the perfect level to depict relations between individuals, their participation, bonds, and willingness, forming a decision that will affect the living environment [7].

This study aims to (a) assess the sustainability level of urban slums and (b) perform an overview of the intervention plans for urban slums with low results. Data are obtained by conducting a cross-sectional survey on four urban slums in Greater Jakarta Area, *kampung* Cikini, *kampung* Gedong Pompa, *kampung* Cimone-Cincau, and *kampung* Markisa.

2. Methods and materials
Several factors contribute to the formation of the urban slums, including population, land ownership, income, density, building type, infrastructures and services, and dwellers’ mindset [8], [9]. *Kampung kumuh kota* is a term that describes a living environment with a survival concept in the middle of modern culture [9] that is usually formed based on land ownership and a strong bond. The main characteristics of *kampung kumuh kota* are a high population with the bare minimum of basic services and infrastructures [10], [11]. These characteristics and are located in a dangerous/hazardous site make *kampung* dwellers one of the most vulnerable groups to climate change risks. An intervention is done on *kampung kumuh kota* to help build resilience for the dwellers in parallel to achieving SDGs, both of which contribute toward adapting to climate change.

2.1. Study area
The study is conducted in four *kampungs* in the Greater Jakarta Area. Two are located in Jakarta city, *kampung* Cikini and *kampung* Gedong Pompa, and the other two are located in Tangerang city, *kampung* Cimone-Cincau and *kampung* Markisa. All four *kampungs* are densely populated areas with minimum access to basic and municipal services (illustrated on Figure 1).

![Figure 1. Study area of four urban slums in the Greater Jakarta Area, kampung Markisa (A), kampung Cimone-Cincau (B), kampung Gedong Pompa (C), and kampung Cikini (D).](image-url)
2.2. Data collection
Data are collected by questionnaire. The study uses a complex sample design calculation [12] with an estimated conservative coverage of 50%, 8% precision, and 95% level of confidence level. About 150 respondents from each kampung are selected through systematic random sampling.

2.3. Calculation method
As the data collected are in different units, a normalized step is required. A min-max method is chosen for its simplicity in normalizing data. To get the data for minimum and maximum scores, benchmarking is done by gathering data from urban slums located in megacities with similar characteristics as the Greater Jakarta Area. An unweighted composite index method is used to assess the sustainability level for each kampung.

2.3.1. Indicators
A set of indicators (Table 1) is developed by considering adequate housing [13] and previous studies on indicators for sustainability assessments [14], [15], [16]. Indicators are grouped into three parameters: social, economic, and environmental. All three parameters represent the three pillars of sustainability [17, 18].

| Parameters | Indicators                              | Units                              |
|-----------|----------------------------------------|------------------------------------|
| Economic  | House ownership                        | % Dwellers with private ownership  |
|           | Household income                       | USD Monthly household income       |
|           | Saving capability                      | % Monthly household income and expenses |
|           | Clean water expense                    | % Percentage of income allocated for clean water expenses |
| Social    | Education of household head            | % Head of household completed secondary education |
|           | Open space                             | % Open space per population        |
|           | Household density                      | (m²/person) Living space per number of dwellers |
|           | Population density                     | (person/km²) Kampung population per kampung area |
|           | Participation of dwellers in           | % Dwellers actively participating in segregating domestic waste |
|           | waste segregation                      |                                   |
| Environmental | Access to sanitation                  | % Dwellers with non-communal latrine |
|           | Access to clean water                  | % Dwellers with piped water        |
|           | Access to solid waste management       | % Waste transported to waste management facility |
|           | Adequate housing                       | % Settlements built with permanent materials |
|           | Tree coverage                          | % Percentage of tree canopy coverage |

2.3.2. Composite index
Each indicator is then normalized using a min-max method [19] before it is computed into an index score. Using the same method as in the study by Reddy & Balachandra [20], the current work first calculated the indicators into a relative index for each parameter with a root mean square formula. The relative index is then presented as Equation (1), where $v_{ij}$ is indicator $i$ grouped in parameter $j$, and $I$ is the number of indicators in a parameter.

$$\text{Relative parameter index} = \left( \frac{\sum_{i=1}^{I} v_{ij}^2}{I} \right)^{0.5}$$ (1)

The result is a score range of 0-1 that can help describe the kampung’s condition according to each parameter. The relative parameter index score is computed into sustainability composite index using
Equation (2), where $d_j$ denotes the parameters and $J$ is the number of parameters to calculate the sustainability composite index of each kampung,

$$\text{Sustainability composite index} = \left( \frac{\sum_{j=1}^{J} d_j^2}{J} \right)^{0.5}$$

(2)

A final score ranges from 0-1, where 1 implies the best kampung sustainability and 0 implies otherwise.

3. Results and discussion

Kampung Cikini and kampung Gedong Pompa are both located in Jakarta. The existence of kampung Cikini dates back to the colonial era when it served as a settlement area for the indigenous population. Since then, the number of immigrants in the area has ballooned, expanding the kampung and placing it in Governor Ali Sadikin’s Kampung Improvement Program. Now the home of 328,000 people, kampung Cikini is one of Jakarta’s most densely populated urban slums. Dwellers utilize every space available (illustrated on Figure 2). They expand their living space by invading the 2-meter-wide street, making it narrow and difficult to access.

Kampung Gedong Pompa was a fishing village that turned into an urban slum due to immigrants overpopulating the area. Dwellers are in danger of tidal floods as the kampung is close to the sea and has an elevation lower than sea level. Owing to overcrowding, houses are built close to one another. Living space expansion is done vertically and onto the already narrow street (1.5 meters), increasing fire risk and making it a challenge for the rescue teams to do their work (illustrated on Figure 2).

![Figure 2. Illustration of how dwellers utilize the street/alleyway in kampung Cikini (left) and kampung Gedong Pompa (right). Most of the spaces are for (A) transport, (B) service area, (C) extension of living space, and (D) children’s playground.](image)

Kampung Cimone-Cincau and kampung Markisa are both located in Tangerang city. They were utilized as haphazard dumpsters for nearby neighborhoods before participating in Tangerang city’s intervention program “kampung tematik,” wherein the green scapes and aesthetical aspects of kampungs are enhanced. Paving blocks are used for the street cover to aid with water absorption. However, extended service areas and greeneries that invade alleyways can still be found in kampung Markisa (illustrated on Figure 3).

![Figure 3. Illustration on how dwellers utilize the street/alleyway in kampung Cimone-Cincau (left) and kampung Markisa (right). Most of the spaces are for (A) transport and (B) service area or green scapes.](image)
3.1. Kampung’s condition

A kampung’s condition can be seen from the relative index score of each parameter, specifically, the economy relative index score for the economic situation, the social relative index score for the social condition, and the environment relative index score for the environmental condition.

Figure 4. Achievement of the kampungs on indicators that reflect the economic condition: (A) house ownership, (B) household income, (C) saving capability, and (D) clean water expense.

Figure 4 illustrates each kampungs’ achievement on their economic situation, which then translated into an economy relative index score. A high economy relative index score represents the financial capacity of dwellers to help improve their well-being and environmental quality. Cimone-Cincau has the highest score (0.83) with 56% private house ownership, creating a legal stand for its dwellers. By contrast, kampung Cikini has the lowest score (0.47) with only 39% private house ownership, indicating that dwellers have low financial stability and legal standing. Meanwhile, kampung Gedong Pompa, with a score of 0.6, has clean water expenses that take 17% of dwellers’ income. According to the WHO [21], the maximum allowance for clean water expenses is 3%–5% of the household income.

Figure 5. Achievement of the kampungs on indicators that reflect the social condition: (A) education of household head, (B) open space, (C) household density, (D) population density, and (E) participation of dwellers in waste segregation.
Figure 5 illustrates each kampungs’ achievement on their social condition, which then translated into a social relative index score. The social relative index score reflects the bond and willingness of dwellers to improve their settlements’ condition, which plays a part in an in-situ intervention based on public participation. Kampung Cikini with the lowest score (0.48), has the highest population density of 95,000 people/km², whereas kampung Markisa has the lowest social relative index score and the lowest density of 33,000 people/km². A high density may contribute to inadequate living and open space. It can affect the well-being of dwellers by potentially transmitting airborne diseases and pollutants because of the lack of proper air circulation [22]. High density can also lower social bonds as there is no space for dwellers to interact or conduct a counseling session, thereby hampering their participation rate and interfering with the success of the intervention program [23]. The best participation rate (38%) can be found in kampung Cimone-Cincau with a score of 0.59 and kampung Gedong Pompa with a score of 0.48. This result demonstrates the willingness of dwellers to participate while showcasing good waste management practices. The Head of the household plays an important part in helping educate dwellers on sustainability and improve a kampung’s quality [24], [25]. Higher education can also help secure a more formal and stable job.

Figure 6 illustrates each kampungs’ achievement on their environmental condition, which then translated into an environment relative index score. A high environment relative index score reflects a healthy kampung environment that helps mitigate climate change impacts. Kampung Markisa has the highest score with 0.84, whereas kampung Gedong Pompa has the lowest (0.52). A total of 98% of the respondents’ houses in kampung Markisa is built using roofing, flooring, and wall materials that meet the national standard for adequate housing. Meanwhile, only 80% of the respondents’ houses in kampung Gedong Pompa meet the national average for adequate housing, mainly for roofing materials. Good housing materials can help protect inhabitants from disasters and prevent pollutants from polluting the environment [26].

Access to non-communal latrine ranges from 87% (kampung Gedong Pompa) to 97% (kampung Markisa), displaying an action to prevent the disease from spreading. Moreover, 97% of the latrines disposed of end up in a septic tank or treatment plant. However, 20% of the septic tanks are placed less than 20 meters from a groundwater source that could be potentially contaminated as there are still 20% of respondents who use groundwater. Piped water access reaches 98% in kampung Cikini but only 4% in kampung Gedong Pompa, forcing the dwellers to purchase water to meet their consumption needs. An estimated 80%–95% of waste is transported to the final disposal. The rate of waste segregation demonstrates functioning waste management that reduces the potential for
environmental pollution and protects dwellers from human-made disasters due to littering. A high number of tree canopy coverage can be found in kampung Markisa. Tree canopy coverage helps protect dwellers from airborne diseases and sick building syndrome [27] while improving air quality [28] and providing many benefits on mental and physical well-being [29].

3.2. Kampung’ s sustainability

Based on the result shown in Table 2, kampung Cimone-Cincau has the best sustainability with a score of 0.75, followed by kampung Markisa with 0.66, and kampung Cikini with 0.59. The kampung with the lowest sustainability is kampung Gedong Pompa with a score of 0.52.

Table 2. Level of sustainability achieved by each kampung.

| Kampung Study         | Economy Relative Index | Social Relative Index | Environment Relative Index | Sustainability Composite Index |
|-----------------------|------------------------|-----------------------|----------------------------|--------------------------------|
| Kampung Cikini        | 0.39                   | 0.46                  | 0.82                       | 0.59                           |
| Kampung Gedong Pompa  | 0.60                   | 0.48                  | 0.52                       | 0.52                           |
| Kampung Cikini-Cincau | 0.83                   | 0.59                  | 0.81                       | 0.75                           |
| Kampung Markisa       | 0.47                   | 0.63                  | 0.84                       | 0.66                           |

With the lowest sustainability score, Kampung Gedong Pompa has obtained a status of “heavy slum” area from the government. A public-participation-based program called Community Action Plan has been assigned to this kampung to help improve its quality. Thus far, a representative has created a mural describing the kampung’s vision and mission of transforming into a fishing tourism area [30]. The main issue in Kampung Gedong Pompa is its minimum access to clean water. PT PAM Jaya was assigned to help resolve this issue, but due to legal problems, a legal status specified by the kampung’s headman is required for piped water installation to begin [31]. Owing to overcrowding, the legal issues, and the kampung’s vulnerable location, an in-situ intervention plan might not be a good option.

4. Conclusions

Although kampung kumuh kota have a negative image as the cause of human-made disasters, because of their survival needs, some efforts have contributed to their achievement of sustainable goals, such as solid waste management, mainly with segregation at the source. Strong bonds and an active role in the community help create an excellent sustainable kampung such as kampung Cimone-Cincau. Governance and stakeholders play an important role, too, as these aspects cause hindrances for kampung Gedong Pompa. Although it is considered as a good intervention strategy, the community participation-based might not be a fit-for-all approach. For kampungs located in a suitable location with less crowding like kampung Cimone-Cincau and kampung Markisa, an in-situ participation-based intervention can help with dwellers’ overall well-being condition, improving their living condition and chance in adapting to climate change. But for kampung Gedong Pompa that’s located near the sea and below sea level with overcrowding and legal issues, an in-situ participation-based intervention might not help dwellers’ living condition, thus making them prone to climate change risks. The unweighted composite index method cannot be used to prioritize an intervention for a kampung. Moreover, several indicators like governance and stakeholder role are needed to create a thorough assessment and help create a better intervention plan.

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