Evaluation of the Categorization of a Slum Environmental Condition using Geospatial and Statistical Analysis: Case Study of Pipa Reja Village in Palembang City

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Abstract

Informal settlements or slums have become an integral condition in an urban area. Economic growth in the city attracted rural people to migrate to the city. There are more than 50% of the world population living in the urban area since 2007. Indonesia experienced the same trend, with 21.8% of the population are still living in the slum area. Actions have been made by the government to identify area, which is indicated as a slum area for further rejuvenating and improvements. This paper presents the spatial analysis on the infrastructure parameters and indicators which defined the slum category of Pipa Reja Village. The indicators and parameters which defined the slum category are set in the Minister of PUPR Regulation No. 2 of 2016. This study used secondary data from KOTAKU programme on baseline data of the slum parameters. The statistical analysis and geospatial analysis were conducted to evaluate the contribution of each indicator to the local slum value. The result was compared with the score value used in the Minister of PUPR Regulation No. 14 of 2018. It is found that condition of the building, condition of drainage system, waste management system, and fire protection conditions were driven the severity condition of the slum in Pipa Reja Village. There was a slightly different category of slum determined by using
the percentage value approach and the scoring value approaches. Furthermore, the geospatial analysis using geographical information system can give better insight into distinguishing the critical indicators for further targeting action.

**Key words:** Slum category; spatial analysis; urban growth; Pipa Reja Village; KOTAKU Programme

1 **Introduction**

The development of residential areas in urban areas is inseparable from the rapid rate of urban population growth. Both increases due to the factors of population growth of the city itself and due to urbanisation factors [1]. The negative impact of urbanisation that has been going on so far is more due to the imbalance of opportunities to make a living in rural areas and urban areas [2], [3]. Figure 1 shows the increase of population in the urban area of the world and Indonesia. The trend almost the same as the percentage of the population of the world living in the urban area. Indonesia experienced more than 54% of the population living in the urban area in 2018 and projected to reach 68% by 2025 [4], [5].

In Indonesia, the implementation of SDGs is stated in Presidential Regulation No. 59 of 2017, that reflected in RPJMN 2015-2019 (National Mid-term Development Plan). In Indonesia, The goal of SDGs 11 makes cities and human settlements inclusive, safe, resilient and sustainable. In 2019, there is access to 3.7 million households for decent and affordable housing, realised city service standards for 12 metropolitan urban areas, 20 medium cities and 10 new cities.

**Figure 1:** Percentage of population living in the urban and rural area for Indonesia and the world [4]
Regarding the human development process of a Nation, poverty is an avoidable phenomenon. Poverty is always throughout human existence worldwide. Efforts have been made to solve and reduce poverty by identifying the indicators contributing to or related to poverty. Nevertheless, the poverty alleviation programme has criticised due to the inefficiency of implementation of the poverty reduction and inaccuracy of poverty targeting which attracting the inequality in the economic growth of a region [6], [7]. Alkire mentioned in [8] that poverty is a multidimensional index that categorised in persistence across time.

Poverty becomes one of the factors people unable to establish a habitable settlement. Other than that, accelerating urbanisation and population growth is partially contributing to the increase of the urban resident living in the slum area [9]. There are more than 1 billion people live in slums, that is about 29% of the total world population [4]. The number is predicted to rise by more than 2 billion by 2030 [10], [11]. Figure 2 shows the percentage of the population for the region of South Asia and East Asia & Pacific under lower-middle-income group countries living in slums.

Along with population growth in urban areas, the need for housing infrastructure and facilities will also increase. Indonesia faced housing backlog by ownership, which reached 13.5 million in 2014 and slightly reduced to 11.4 million in 2017 [12], [13]. Data from the Directorate General of Housing Provision at the Ministry of Public Works and Public Housing (PUPR) said that of the 11.4 million backlog numbers, the 20% belong to the lower group that needs government social assistance because they still cannot afford to purchase a home even though they have been given the facility of loan services.
Furthermore, the fulfilment of the obligations of infrastructure and housing facilities that are affordable and habitable cannot be adequately provided either by the community itself or by the government. So, the capacity to support the existing infrastructure and facilities of settlements starts to be unbalanced with needs, which in turn contribute to the occurrence of slums.

UN-Habitat developed a definition to determine a slum household for census and survey purposes [14]. The slum households are a group of individuals living under one roof in an urban area that does not have one of the following indicators: (1) a sturdy house; (2) enough living space; (3) easy access to safe water in sufficient quantities and at affordable prices; (4) access to adequate sanitation; (5) certainty or security of residence (secure tenure).

According to clause 1 (13) of National Law of Indonesia No. 1 of 2011 concerning housing and area of settlements, slum settlements are defined as uninhabitable settlements because of irregularities in buildings, high levels of building density, and the quality of buildings and infrastructure and facilities that do not meet the requirements [15]. Implementation of the law is contained in Minister Regulation of Public Work of Housing and Settlement (PUPR) No. 2 of 2016. Based on the Minister Regulation, the indicators to measure the slum are (1) condition of building; (2) condition of local road; (3) condition of drinking water supply; (4) conditions for local drainage system; (5) wastewater management conditions; (6) waste management conditions; (7) fire protection conditions [16].

This study is aimed to evaluate the finding on determining slum area in Pipa Reja Villages at Palembang City. The work has been conducted by Kota Tanpa Kumuh (KOTAKU) programme which was started since 2010 and continue for the implementation of the action plan until 2020.

2 Material and Method

Palembang City is the capital of South Sumatera Province. In 2017, the projected population of Palembang City was 1.62 million, with 1.01% of population growth rate [17]. Urban growth in Palembang city is expanding to the North West follow the inland paved road. In the past, the urban growth spread alongside the riverbank of the Musi River and its tributaries. The primary transport modality at that time depended on water transport along the watercourses. This type of urban growth transformed the physical urban environment to the irregular pattern [18]. Figure 3 shows the urban footprint growth from 1990 to 2013 [19].
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Overlaid on the urban footprint growth, as in Figure 3, is the spatial data of the slum area in Palembang City [20]. Most of the slum area located at the high-density residential area along the Musi River. The existence of the bridge across the Musi River in the 1960s has changed the urban growth pattern. Palembang City consists of more than 52% wetland, and about 32% of the area is the built-up area as per 2013 [5], [21]. Palembang City has conserved swamp area in the city which is regulated in the Map of Palembang City Regulation No. 15 of 2012 concerning the Palembang City spatial plan for the year 2012-2032.

Figure 3: The urban footprint of Palembang City in 1990, 2001 and 2013 [16]

Figure 4: Slum area within the administrative area of Palembang City.
The Pipa Reja Village is located in Kemuning Subdistrict. It covers an area of 1.73 km² and lays on a low area with an elevation ranged from 0 m to 5 m above Mean Sea Level (MSL). Figure 4 shows the overlay of the village on the digital elevation model (DEM) of the DEMNAS. The spatial resolution of the DEMNAS is 0.27 arc-second that is equivalent to 8.1 m per pixel. The DEMNAS data was developed and published by the Department of Information and Geospatial of Indonesia.

**Figure 5:** Study area of Pipa Reja Village overlaid on DEM

Slum area in Pipa Reja Village is unique compared to the other slums which were located along the Musi River and near the swamp conservation area. It formed due to sporadic growth of settlements where located near to the business centre of the city. The land use of Pipa Reja Village is dominated with 79.77% settlements area and 9.08% green open space. Based on the characteristic settlements type, the housing is built by their own, developer and illegal housing on Bendung River banks. Waste is the second biggest problem in Pipa Reja Village. There are only a few neighbourhoods which have waste disposal management system. The domestic waste is collected from houses by motorcycles that pick the garbage upon schedule. Many people still throw their garbage at several points near their houses, throwing garbage into the drainage and even do open burning. Other than causing environmental problems, the waste caused clogging in the drainage and reduce the capacity of drainage or rivers. Most of the sanitation and wastewater facilities condition was drained directly to Bendung River, but the drainage and sewage networks are not separated. The drainage system types are an open and closed channel with minimum quality. The drainage is flowing to the retention pond and into Bendung River. The local road condition is accessible to the main road but needs some fixing. The pavement of local roads are dirt roads and macadam, that can be only accessed by two-wheeled vehicle. Figure 5 shows the condition of the local roads and drainage system in the neighbourhood of RT009 and RT017.
There are seven indicators to measure slum. Each indicator has parameters dictating the value as stated in the Minister Regulation of Public Work of Housing and Settlement (PUPR) No. 2 of 2016. Table 1 list the indicators and parameters used to determine the infrastructure condition of a settlement area.

**Table 1: The Parameters And Indicators To Measure The Slum**

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition of building</td>
<td>Building regularity</td>
</tr>
<tr>
<td></td>
<td>Building density</td>
</tr>
<tr>
<td></td>
<td>Building complied Technical Requirements</td>
</tr>
<tr>
<td>Condition of local road</td>
<td>Accessibility to local road</td>
</tr>
<tr>
<td></td>
<td>Road complied technical requirements</td>
</tr>
<tr>
<td>Condition of drinking water supply</td>
<td>Decent complied technical requirements</td>
</tr>
<tr>
<td></td>
<td>Water needs are met</td>
</tr>
<tr>
<td>Conditions for the local drainage system</td>
<td>No inundated or flooded</td>
</tr>
<tr>
<td></td>
<td>Need for a new drainage system</td>
</tr>
<tr>
<td></td>
<td>Drainage with minimum quality</td>
</tr>
<tr>
<td>Wastewater management conditions</td>
<td>Toilet complied technical requirements</td>
</tr>
<tr>
<td></td>
<td>Separate drainage and sewerage network</td>
</tr>
<tr>
<td>Waste management conditions</td>
<td>Domestic</td>
</tr>
<tr>
<td></td>
<td>waste facilities complied technical requirements</td>
</tr>
<tr>
<td></td>
<td>Domestic waste management system</td>
</tr>
<tr>
<td>Fire protection conditions</td>
<td>Availability of fire protection infrastructure</td>
</tr>
<tr>
<td></td>
<td>Availability of fire protection facilities</td>
</tr>
</tbody>
</table>
This study used secondary information from the OC 4 South Sumatra’s team of Kota Tanpa Kumuh (KOTAKU). The information is on the village and neighbourhood level of slum parameters baseline data for physical and non-physical aspects. Interviews were performed to assess the infrastructure parameters, measure the infrastructure dimension and observe the drainage and household waste facilities status. Geospatial modelling was created to map the distribution of the slum indicators in Pipa Reja Village based on that information. This study processed spatially based data in the geographical information system (GIS). Each indicator was delineated on the spatial map and merged as new attributes. Other related spatial data was gathered from Palembang Geoportal [20].

3 Result and Discussion

Pipa Reja Village locates at subdistrict population centre where the population density ranged from medium to high density (i.e. 102 – 241 person/Ha and 242 – 261 person/Ha). There are 38 neighbourhoods inside the village. In appendix 2 of the Minister of Public Works and Housing (PUPR) Act 2018 No. 4 as in [22], assessment of the level of slums of an area is based on the unavailability of infrastructures and facilities supporting the system in a settlement area. The score of each parameter of the slum is categorised into three nominal values (i.e. 1, 3 and 5). If the unavailability ranged between 25% – 50%, the score is 1. Score 3 and 5 are given if the unavailability is 50% – 75% and 75% – 95% respectively. The baseline data used in the assessment of the Pipa Reja Village measuring the physical and non-physical aspect of the infrastructure. This paper discusses only the physical aspect of the infrastructure that derived the slum condition determination. The slum value is a product of summation of the indicators. Figure 6 shows the comparison between slum category for each neighbourhood in Pipa Reja Village using the percentage value and the scoring value.

Figure 7: Comparison of local slump category between percentage value and scoring value
It was found that the scoring value approach used in the PUPR for each indicator have shared a generalised nominal score to represent the specific unavailability infrastructure condition. It has caused inaccuracy in identifying the real slum condition. The use of raw baseline data for each neighbourhood gave more decent insight into the condition of the site. Based on the score value approach, the slum condition is ranged between 19 – 44. It gives the slum condition of the neighbourhoods to a fair slum. The slum category which is given in Figure 7 is generated based on the local neighbourhoods in the village’s slum score by grouping the score into three groups (i.e. between the standard deviation, below and above standard deviation range).

Figure 8: Significant correlation for each indicator to the slum value

Statistically, the significant correlation for each slum’s indicator to the slum value can be determined. The building regularity, drainage conditions, waste management and fire protection conditions were the indicators significantly contributed to the slum condition in Pipa Reja Village. Figure 8 maps the significant correlation for each indicator of the slum value.

Figure 9: Ternary plot of the most significant indicator of the slum value
An equation based on statistical multilinear regression to determine the slum category as a function of the seven indicators is developed. The baseline information (i.e. neighbourhood level) of physical criteria of the slum from other villages were combined to increase the number of cases. Equation (1) shows the prediction of the slum category to be mapped with the category as stated in Minister of PUPR Regulation No. 4 of 2018. It gives a value of multiple $R = 0.91$, the value of multiple $R^2 = 0.84$ and the standard error of estimation of 4.09.

$$SC=72.94-0.44Bu+0.35Ro-0.21W-0.12Ds-0.46Sw-0.45Ws-0.27Fs$$ (1)

Where SC is the slum condition, Bu is the building condition, Ro is the Road, W is the water supply, Ds is the drainage system, Sw is the sewerage system, Ws is the waste management system and Fs is the fire protection system.

The GIS of the local slum category as in Figure 9 gives a categorised indicator on each spatial data of the neighbourhoods. The local slum category determined five poor slum area on the neighbourhoods (i.e. RT001, RT005, RT018, RT019 and RT021). This local slum condition agreed with the percentage value approach calculation of the slum value. Figure 10 shows the spatial information for each indicator on the neighbourhoods. Most of the neighbourhood with local slum category had indicators ranged from moderate to poor. Those neighbourhoods located in the area where it has the lowest elevation, as shown in Figure 11. It reflects the fact that possible inundation and flood during rainfall could worsen the slum condition of the neighbourhoods.

![Figure 10: The spatial representation of the local slum category](image)
Furthermore, Pipa Reja Village locates at the upstream of Bendung sub-river system (SRS), which is an urban drainage system with 8.9 km length. Based on the morphometric characteristic, the slope of this area is 0 – 3%, the circulation ratio (Rc) < 0.33 and the streamflow frequency (Fs) was 2.55. This Fs value is influenced by the non-permeable subsurface materials, vegetation, surface relief and low infiltration rate. The drainage density (Dd) that reflects potential runoff, infiltration capacity, climatological condition and land cover on the Bendung SRS is 1.15 km/km², and this value indicates that the drainage system is inadequate and most of the times will be inundated by heavy rainfall. The higher relief of the sub river system basin relief (Bh) is 24.5 that indicates the gravity flow condition of the area, the low infiltration and the higher surface runoff. The runoff coefficient (C) is 0.71, which is a ratio between peak runoff to rainfall intensity. It was influenced by the major factors such as infiltration rate, land slope, land cover, and soil characteristics. The distribution of inundation that occurs on the riverbank, along the river, was up to 100 m from the riverbank of the Pipa Reja Village. The depth of the inundated area ranges from 0.20 – 1.0 m, the high inundation up to 1 m when rains more than 3 hours. The influence of Musi River tides in Pipa Reja Village is more than 0.50 m [22]. Figure 11 shows the delineation of the inundated area within Bendung SRS. The high tide of Musi River blocked the streamflow pattern of the Bendung SRS. It reflects the fact that possible inundation and flood during rainfall have worsened the slum condition of the neighbourhoods.

Figure 11: The neighbourhoods with poor slum category on the lowest elevation
4 Conclusions

This paper presents the spatial analysis on the infrastructure parameters and indicators which defined the slum condition of Pipa Reja Village. The Pipa Reja Village is in Palembang City which laid on medium density urban area. The indicators on building condition, condition of drainage system, waste management system, and fire protection conditions have driven the severity condition of the slum in Pipa Reja Village. There was a different category of slum delineated found on the two different approaches used (i.e. the score value approach and the percentage value approach). The classification strategy used in the PUPR for each slum's parameter distributed a generalised nominal rating to reflect the particular situation of unavailability of the infrastructure. It has created inaccuracy in defining the actual situation of the slum. The geospatial analysis using geographical information system can give better insight into distinguishing the critical indicators for further actions of improvement. Based on the hydraulic and hydrological modelling on the Bendung SRS, the neighbourhoods in the Pipa Reja Village are vulnerable to flood and inundation when the rain poured for more than 3 hours. This information will target appropriate actions to rejuvenate and improve the slum condition.

Figure 12: Pipa Reja Village slum category on the delineation of the inundated area on Bendung SRS
The rejuvenating of slum can be done physically and non-physically. In handling slum areas, the results of the analysis that has been done not only create the beautification of a location but also need to achieve the changes in the structure of the village (village rejuvenation) with land consolidation to organize the density and structuring the regularity of buildings. The pattern of physical handling of infrastructure can be in the form of restoration, rejuvenation and resettlement. Restoration is more on the rehabilitation of seven indicators, rejuvenation is in the form of the changes in function, and capacity improvement of seven indicators, while resettlement is more on development in new locations in accordance with the spatial plan and master plan per sector indicators.

In appendix 4 of the Minister of Public Works and Housing (PUPR) Act 2018 No. 4 [23], The non-physical strategy and recommendation can be done in Pipa Reja Village for the building and environment aspect are building regulation, control of building permits and fostering building maintenance and repair of buildings. The waste management regulation 3R programme, improvement in a clean and healthy lifestyle, and fostering community-based waste management need to be improved. The recommendation for the local drainage is to make the regulation of drainage system, the guidance of providing land infiltration and fostering drainage maintenance and repair. Besides that to realise the handling community participation with program socialisation and action plan for handling the slum area and fostering community self-reliance.

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