Sustainability (STPP) Theory, Practice and Policy
Vol. 5 No. 1
e-ISSN: 2808-4829
DOI: https://doi.org/10.30631/sdgs.v5i1.3166
https://e-journal.lp2m.uinjambi.ac.id/ojp/index.php/SDGs

Measuring Settlement Livability in Dalam Bugis through the Lens of Clean Water and Sanitation Access

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ARTICLE INFO

Keywords: *Settlement; Livability; Clean Water; Sanitation Access*

Received: June 1, 2025
Accepted: June 23, 2025
Published: June 30, 2025

ABSTRACT

This study aims to examine the spatial distribution of residential habitability levels in the Dalam Bugis Subdistrict based on the availability of drinking water and wastewater management aspects. Employing a qualitative descriptive approach, data were collected through observation, interviews, and documentation. The data analysis involved processes of data reduction and presentation. The results indicate that the residential areas within the study region are categorized into two primary groups: habitable (lightly slum) and moderately habitable (moderate slum). The habitable residential area comprises one zone with a total area of 85.02 hectares, accounting for approximately 43% of the subdistrict's total area, encompassing 2,416 housing units. In contrast, the moderately habitable residential areas are dispersed across four distinct zones, covering a total of 112.98 hectares or 57% of the subdistrict, comprising 1,677 housing units. These findings underscore the critical importance of enhancing access to clean water and improving wastewater management as strategic efforts to elevate residential environmental quality and support the development of adequate housing zones.

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Introduction

The quality of human settlements is a critical concern in urban studies, especially in rapidly urbanizing regions of developing countries, where socioeconomic and environmental challenges often compromise residents' well-being. Recent research on human settlements in Beijing has shown a positive trend in improving settlement quality, highlighting significant correlations among medical resources, economic development, public services, governance investment, and infrastructure (Xie et al., 2022). These factors collectively contribute to enhanced living conditions and sustainable urban development. Complementary studies stress the importance of inclusive and sustainable urban planning approaches that balance local

community needs with environmental considerations, thereby promoting equitable development (Ghosh et al., 2025; Jodder et al., 2025). Settlement quality is fundamentally linked to habitability, which integrates environmental, social, and economic dimensions that jointly determine residents' quality of life (Norouzian-Maleki et al., 2015; Pasanen et al., 2024; Skalicky & Čerpes, 2019).

Habitability assessments are essential tools for evaluating whether settlements fulfill minimum environmental and infrastructural standards, commonly encompassing criteria such as building conditions, environmental sustainability, and socioeconomic factors (Firmansyah et al., 2018; Martínez et al., 2019; Qureshi, 2024). In Indonesia, the Ministry of Public Works and Housing has developed a national framework for assessing settlement conditions through the Settlement Location Assessment Formula, as outlined in Ministry Regulation Number 14 of 2018 (2018). This regulation classifies residential habitability into three categories—habitable (light slum settlements), moderately habitable (moderate slum settlements), and uninhabitable (severe slum settlements)—based on specific environmental criteria, particularly access to safe drinking water and wastewater management systems. These criteria are critical, as safe water is defined by quality standards (colorless, odorless, tasteless) and quantity benchmarks, with the World Health Organization recommending a minimum of 60 liters per person per day (WHO, 2022).

Effective wastewater management is assessed through the availability and compliance of sanitation systems, including septic tanks and centralized wastewater treatment facilities, with poor systems directly linked to increased health risks and environmental degradation. Settlements lacking such infrastructure are typically categorized as having low habitability. Despite these comprehensive national guidelines, a notable gap exists in detailed micro-level spatial analyses focusing on key environmental indicators, such as water accessibility and sanitation infrastructure. Previous assessments in Pontianak City, including official designations of slum areas, often rely on generalized classifications without comprehensive field validation of environmental parameters, limiting their precision and utility for targeted intervention.

According to the Pontianak Mayor's Decree (2020), Pontianak City includes 150.16 hectares of slum areas, with the Dalam Bugis Subdistrict classified as moderately habitable. However, this designation lacks a thorough field-based environmental validation. To address this gap, the present study undertakes a focused spatial analysis of settlement habitability in Dalam Bugis Subdistrict, centering on drinking water availability and domestic wastewater management, two fundamental indicators influencing public health and environmental quality. Preliminary observations revealed that residents predominantly rely on rainwater harvesting and packaged drinking water, with economic factors motivating a preference for boiled rainwater, which may impact water quality. Concurrently, inadequate wastewater disposal infrastructure prevails, as many households lack septic tank connections or access to communal sanitation facilities, exacerbating health and ecological risk.

The novelty of this study lies in its explicit spatial evaluation of habitability indicators using nationally recognized standards at the subdistrict scale, a methodological approach infrequently applied in the existing literature. Moreover, this study provides actionable insights for urban planners and public health policymakers by revealing spatial disparities in infrastructure and settlement quality. By focusing on the targeted analysis of water and sanitation indicators, this study advances a data-driven framework for improving informal settlements. Thus, the objective of this study was to identify and map settlement habitability levels in the Dalam Bugis Subdistrict using the national assessment framework, thereby informing evidence-based local government strategies to enhance environmental health and overall settlement quality.

Methodology

Study Area

This study employs a qualitative descriptive approach complemented by spatial analysis using Geographic Information Systems (GIS) to comprehensively assess settlement habitability. The research site is the Dalam Bugis Subdistrict, located within the East Pontianak District of Pontianak City, West Kalimantan. This area is geographically bounded by coordinates 109°20’53” – 109°21’27” E and 0°1’19” – 0°2’10” S. The subdistrict is officially designated as slum area number 1063.1/D-PRKP/Year 2020, indicating recognized socio-environmental challenges that justify its selection for this study. The area’s socioeconomic profile and environmental characteristics are representative of typical urban informal settlements in rapidly developing Indonesian cities.

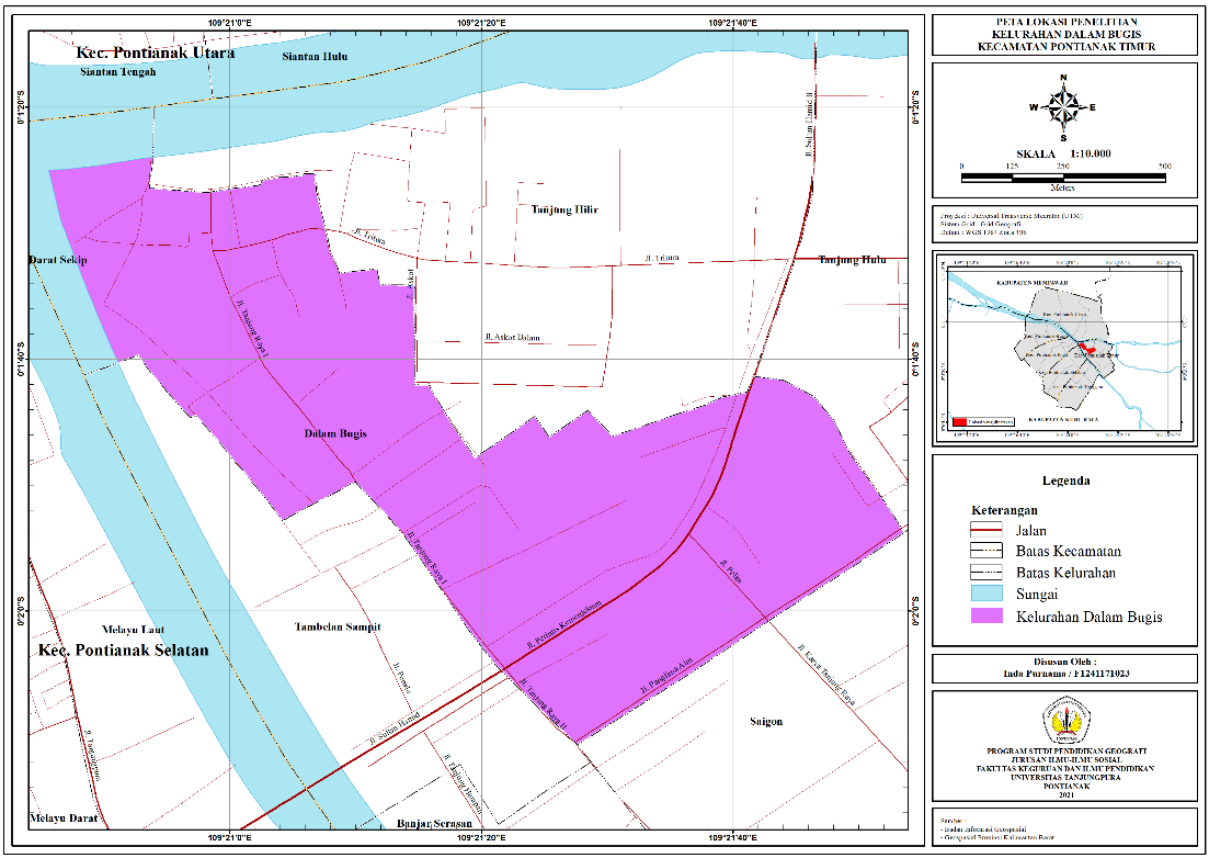

Figure 1. Administrative map of Dalam Bugis Subdistrict

Data Source

Primary data collection involved systematic field observations, structured interviews with a purposive sample of residents and key local officials from the Civil Works Division of the Public Works and Housing Agency, and detailed documentation of the clean water and sanitation infrastructure. Specifically, 30 residents were interviewed over four weeks to capture diverse perspectives on water usage and sanitation practices. Secondary data were gathered from relevant urban planning agencies, official village profiles (Bugis Village Government, 2020), high-resolution satellite imagery, and the Pontianak Mayor’s decree on slum area designations. The currency and reliability of all secondary data were critically assessed prior to their inclusion.

Data Analysis

The habitability assessment was guided by the Settlement Location Assessment Formula, as stipulated in the Ministry of Public Works and Housing Regulation No.

14/PRT/M/2018, focusing on two primary indicators: drinking water availability and the management of wastewater. Each indicator was measured against defined criteria with an assigned scoring system to classify settlements into three habitability categories: habitable, moderately habitable, and uninhabitable. Specific threshold values for water quality, supply adequacy, and sanitation compliance were established in accordance with national standards.

Table 1. Weighting of Residential Habitability Aspects

Aspect	Assessment Criteria	Parameter (%)	Score	Category
Drinking Water Availability	Unsafe access to drinking water	25 - 50	1	Good
		51 – 75	3	Poor
		76 - 100	5	Very poor
	Insufficient minimum drinking water supply	25 - 50	1	Good
		51 – 75	3	Poor
		76 - 100	5	Very poor
Wastewater Management	Non-compliance with technical standards of management systems	25 - 50	1	Good
		51 – 75	3	Poor
		76 - 100	5	Very poor
	Non-compliance with technical standards of facilities & infrastructure	25 - 50	1	Good
		51 – 75	3	Poor
		76 - 100	5	Very poor

Source: Ministry of Public Works and Housing Regulation No. 14 of 2018 (2018)

Spatial analysis was conducted using ArcGIS version 10.4. Advanced GIS techniques, such as overlay, buffering, and clipping, were employed to integrate attribute data compiled from field measurements and interviews with spatial layers that represent settlement boundaries and infrastructure networks. The attribute tables were meticulously validated and cleaned prior to integration to ensure data accuracy.

The total habitability score for each settlement unit was computed by summing the weighted scores from the two indicators, yielding values ranging from 0 to 10. These scores were then categorized as light slum (0–3, habitable), moderate slum (4–7, moderately habitable), and severe slum (8–10, uninhabitable), following the classification criteria validated by Ramadhan, Purnomo, and Summiyatinah (2020).

Table 2. Categories of Residential Habitability Levels

Total Score (0–10)	Slum Category	Habitability Category
0 – 3	Light Slum	Habitable
4 – 7	Moderate Slum	Moderately Habitable
8 – 10	Severe Slum	Uninhabitable

Source: Ministry of Public Works and Housing Regulation No. 14 of 2018 (2018)

To enhance validity and reliability, the findings were cross-validated through triangulation with urban planning documents, direct field verification, and photographic evidence of current settlement conditions. Discrepancies identified during validation were resolved through iterative field visits and consultation with local experts.

Result and Discussion

Spatial Distribution of Residential Habitability Levels Based on Drinking Water Availability and Wastewater Management Conditions in Dalam Bugis Subdistrict, East Pontianak District

The spatial distribution of residential habitability levels in the Dalam Bugis Subdistrict of East Pontianak District, Pontianak City, was assessed using a combined approach involving direct observation, structured interviews, documentation, and geospatial analysis. Habitability classification was based primarily on two critical infrastructure criteria: the

availability of safe drinking water and the adequacy of wastewater management systems. These criteria were operationalized following standards adapted from, with thresholds established to differentiate between the habitability categories.

1. Habitable Settlements (Light Slum)

Settlements classified as habitable—termed here as “light slum” due to moderate deficiencies in infrastructure but overall acceptable living conditions—are spatially distributed within the coordinates 109°21'14.48"E to 109°21'27.49"E and 0°1'34.15"S to 0°2'9.98"S. These areas cover approximately 85.02 hectares, equivalent to 43% of the total land area of the Dalam Bugis Subdistrict, comprising 2,416 housing units. The “light slum” designation reflects moderate but manageable challenges in water supply and wastewater treatment, as per the applied standards (e.g., minimum daily water consumption per capita and the proportion of households connected to septic systems).

To ensure spatial accuracy, geospatial data underwent buffer analysis and spatial validation with an estimated positional uncertainty of ±5 m. Nevertheless, further fine-scale studies are required to confirm these boundaries. It should be noted that this classification does not account for socio-economic factors, which may also influence habitability but were beyond the scope of this study.

2. Moderately Habitable Settlements (Moderate Slum)

The “moderate slum” category denotes areas with significant limitations in drinking water accessibility and inadequate wastewater infrastructure, leading to compromised habitability in these areas. Four discrete spatial clusters were identified within the sub-district:

a. Moderate Slum 1 (109°20'52.91" E to 109°20'54.20" E; 0°1'23.95" S to 0°1'41.43" S)
b. Moderate Slum 2 (109°21'1.92" E to 109°21'20.53" E; 0°1'54.39" S to 0°2'3.81" S)
c. Moderate Slum 3 (109°21'14.85" E to 109°21'14.47" E; 0°1'54.39" S to 0°2'3.19" S)
d. Moderate Slum 4 (109°21'36.74" E to 109°21'34.04" E; 0°2'2.01" S to 0°2'6.17" S)

These combined zones cover approximately 57% of the subdistrict’s land area and contain 1,677 homes. The segmentation reflects the spatial clustering of infrastructural deficiencies, which are likely influenced by historic urban development patterns and varying access to municipal services. However, this study did not extend to detailed socio-economic profiling or temporal analysis of these areas, which warrants further research in this area.

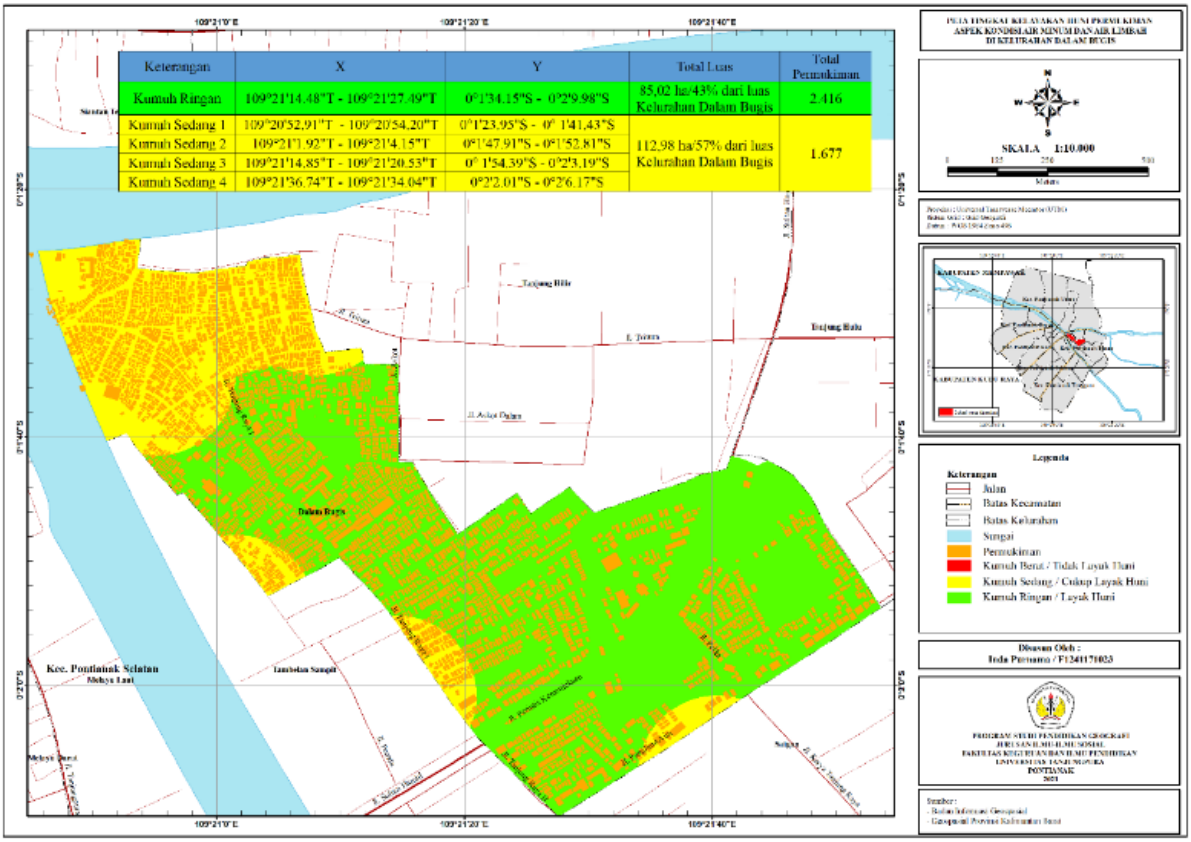

Figure 2. Map of Building Condition Habitability Levels in Dalam Bugis Subdistrict, East Pontianak District, Pontianak City

Distribution of Residential Habitability Levels Based on Drinking Water Availability and Wastewater Management Conditions in Dalam Bugis Subdistrict, East Pontianak District

The assessment of drinking water availability was conducted by evaluating both access to safe drinking water and whether the minimum per capita water needs were met. Safe drinking water was operationally defined not only by sensory characteristics (i.e., colorless, odorless, and tasteless) (Ervina & Kristanael, 2024) but also by adherence to chemical and microbiological safety standards, as outlined by the World Health Organization (2022). Household water needs encompass drinking, cooking, and hygiene purposes, following the WHO-recommended minimum thresholds (Eichelberger et al., 2020; Stoler et al., 2020).

Data collected through structured interviews indicated that residents predominantly rely on boiled rainwater and bottled water for drinking and cooking. Although boiling rainwater reduces microbial risks, potential chemical contaminants inherent in rainwater were not assessed, representing a limitation in water quality evaluation (Mejía-Ferreyra et al., 2024; Salih et al., 2024). For hygiene, residents use a combination of river water and treated water supplied by the Regional Drinking Water Company (Perumda Air Minum). According to Perumda Air Minum Tirta Khatulistiwa Pontianak, 1,368 households in the Dalam Bugis Subdistrict are registered as clean water customers; however, the extent of reliable service coverage and daily water supply volume remains uncertain.

Subjective sensory evaluations from interviews confirmed that the drinking and cooking water sources generally met the basic sensory quality criteria. However, no laboratory testing was conducted to verify the chemical or microbiological safety of either drinking or hygiene water sources, particularly the untreated river water used for hygiene, which presents a potential health risk.

Furthermore, the average per capita water consumption was found to be below the WHO-recommended minimum of 60 (l/c/d), based on interview data. It is important to note that consumption estimates derived from interviews may be affected by recall bias, highlighting the need for complementary quantitative measurements in future studies to address this limitation.

Wastewater management was examined with reference to compliance with technical standards regarding sanitation infrastructure, particularly the connection of latrines to septic tanks, whether individual, communal, or centralized. Interviews and field observations revealed that households situated directly over riverbanks commonly discharged wastewater directly into rivers without septic tank connections, posing significant environmental and health hazards. Conversely, settlements located away from water bodies generally have latrines connected to septic tanks, although the operational status and maintenance of these systems have not been systematically evaluated.

This study further acknowledges the critical role of wastewater treatment infrastructure, such as Wastewater Treatment Plants (IPAL). According to an interview with Edwin Raditya, Head of the Civil Works Division at the Public Works and Housing Office, no communal IPAL facilities exist within the Dalam Bugis Subdistrict. The area's susceptibility to flooding and proximity to rivers have been cited as constraints to IPAL installation, indicating the need for alternative, context-appropriate wastewater management solutions.

Based on these data sources and observations, residential habitability in the Dalam Bugis Subdistrict was initially classified into two categories: habitable settlements with light slum conditions and moderately habitable settlements with moderate slum conditions. These categories were delineated using spatial analysis by integrating georeferenced data guided by the evaluated infrastructure conditions.

The habitable (light slum) settlement area is geographically bounded by coordinates 109°21'14.48" E to 109°21'27.49" E and 0°1'34.15" S to 0°2'9.98" S, covering approximately 85.02 hectares (43% of the subdistrict’s land area) and encompassing 2,416 housing units in the study. Four moderately habitable (moderate slum) areas were identified as follows:

1. Moderate Slum 1: 109°20'52.91" E to 109°20'54.20" E and 0°1'23.95" S to 0°1'41.43" S
2. Moderate Slum 2: 109°21'1.92" E to 109°21'20.53" E and 0°1'54.39" S to 0°2'3.81" S
3. Moderate Slum 3: 109°21'14.85" E to 109°21'14.47" E and 0°1'54.39" S to 0°2'3.19" S
4. Moderate Slum 4: 109°21'36.74" E to 109°21'34.04" E and 0°2'2.01" S to 0°2'6.17" S

Collectively, these moderate slum areas cover 112.98 hectares (57% of the sub-district) and include 1,677 housing units. Spatial delineation was performed using Geographic Information System (GIS) tools with positional accuracy validation to ensure reliability.

This spatial pattern highlights the critical disparities in water and sanitation infrastructure across Dalam Bugis, underscoring areas that require urgent intervention. While this study focuses on drinking water and wastewater management as primary indicators of habitability, future research should integrate broader environmental, socioeconomic, and health data to develop a more comprehensive habitability assessment framework tailored to the urban dynamics of the subdistrict.

Conclusion

Based on the findings of this study conducted in the settlements of Dalam Bugis Subdistrict, it can be concluded that the evaluation of drinking water availability and wastewater management—using established operational criteria—classifies approximately 43% of the residential areas as light slums (habitable settlements), while 57% are categorized as moderate slums (moderately habitable settlements). These classifications are grounded in the specific infrastructural and environmental indicators detailed earlier in this study.The

habitable settlements cover an area of 85.02 ha and comprise 2,416 housing units, whereas the moderately habitable settlements encompass 112.98 ha with 1,677 housing units. These figures highlight spatial disparities in infrastructure quality and imply varying levels of service provision and population density, warranting targeted interventions.

Given the critical importance of safe drinking water in Dalam Bugis, it is recommended that local government authorities promote the adoption of bioceramic septic tanks, a technology that has been shown to be effective in improving sanitation and reducing the direct disposal of wastewater into rivers. However, further assessment of the cost, community acceptance, and technical feasibility of this technology in the local context is necessary to ensure its successful implementation. In addition, while conventional communal or domestic wastewater treatment plants (IPAL) are generally beneficial, their installation in flood-prone areas, such as Dalam Bugis, presents challenges. Therefore, it is advisable to explore adaptive or decentralized wastewater management solutions tailored to the subdistrict's hydrogeographic conditions to ensure sustainable sanitation infrastructure development.

Finally, community awareness campaigns should be developed to emphasize the health benefits of consuming safe water, the importance of proper septic tank usage, and the prohibition of the direct discharge of wastewater into rivers. These educational initiatives should be supported by clear enforcement mechanisms and stakeholder engagement to foster compliance and sustainable behavioral change.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests

The authors declare no competing interests.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available due to ethical reasons related to protecting the privacy and confidentiality of research participants, but are available from the corresponding author upon reasonable request.

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