Eduvest – Journal of Universal Studies
Volume 5 Number 5, May, 2025
p- ISSN 2775-3735- e-ISSN 2775-3727

INVENTORY OF SLUMS WITH REMOTE SENSING METHODOLOGY AS A STEP TO EDUCATE A SUSTAINABLE CITY (CASE STUDY OF MAPPING SLUMS IN THE CITY OF BANDUNG)

Krisna Ramita Sijabat[1*], Irwan Ary Dharmawan[2], Mochamad Candra Wirawan Arief[3]
Dinas Perumahan dan Kawasan Permukiman Kota Bandung, Indonesia[1]
Universitas Padjajaran, Indonesia[2,3]
Email: kr.sijabat@gmail.com[1], iad@geophys.unpad.ac.id[2]

ABSTRACT

Urban slums remain a significant challenge in Indonesia, exacerbated by rapid population growth and inadequate local government intervention. Remote sensing technologies offer high accuracy in mapping these areas, yet a lack of community engagement and knowledge hinders their effective application. This study aims to explore the integration of remote sensing applications with community engagement strategies to enhance urban planning and development in densely populated slum areas. The research employs case studies across various urban areas in Indonesia, complemented by participatory workshops with community members and local officials to gather insights and develop a participatory framework. The study identifies barriers to stakeholder engagement and highlights the potential of combining remote sensing data with local knowledge to create actionable urban development plans. The findings contribute to sustainable urban development discourse by providing guidelines for local governments on leveraging remote sensing data while actively involving communities, ultimately improving urban planning outcomes in Indonesia.

KEYWORDS *Slum Settlement, Remote Sensing, Smart City*

Article Info:
Submitted: 05-05-2025 Final Revised: 14-05-2025 Accepted: 16-05-2025 Published: 23-05-2025

INTRODUCTION

Slums are uninhabitable settlements because they have irregular buildings, building density, and the quality of infrastructure facilities that are not qualified to be used as residences (Nchor, 2022; Uddin, 2018). This settlement can also be dangerous because it is close to vehicular or transportation access, along river

How to cite:	Sijabat, K. R., Dharmawan, I. A., & Arief, M. C. W. (2025). Inventory of Slums with Remote Sensing Methodology as A Step to Educate A Sustainable City (Case Study of Mapping Slums in The City of Bandung). Journal Eduvest. *5*(5): 5334-5342.
E-ISSN:	2775-3727
Published by:	https://greenpublisher.id/

flows, river dumps, or on the outskirts of markets and industries (Gunn, 2013; Onokala, 2015). This settlement can have caused bad environmental problems, so the government needs to act optimally to provide the best solution for the residents and the slum area (Kekana et al., 2023; Surya et al., 2020). One of the cities that has slums is Bandung, where this area is the city that is used as the most migratory place (Leonita et al., 2018). In addition to migrants, the number of people in 2023 recorded by the Population and Civil Registration Office is 2,569,107 people. The population density in Bandung is the government's focus to become a big city and to meet the population's welfare level. Although in reality, to prosper, a city needs to overcome poverty and slums, that is still a problem today.

Population growth can occur due to urbanization, which causes many slums. The high population causes problems everywhere, for example, irregular land consumption patterns, mismatches in transportation density, declining natural resources, uneven fulfillment of basic needs, and so on (Arymurthy & Purwandari, 2012). The Millennium Development Goal (MDG) estimates that 1.4 billion people in the world, spread across developing countries, are in a poor condition (Force, 2008). Likewise, Indonesia has the same problem, namely poverty. The program that state and government leaders prioritized in the past 10 years is to reduce the number of population poverty. It can be seen from the massive development and social welfare programs carried out, but in the past 10 years, the management of slums has not been successful. This is evidenced by a survey conducted by BPS in March 2024, which stated that the number of people in poverty in urban areas in Indonesia is 11.79%, or around 11.74 million people. Of course, compared to the previous year, there has been progress, but if you look at the reality, settlements in big cities are still very concerning (Nadzir et al., 2024).

Based on the survey, it is still necessary to carry out poverty alleviation programs in the city. Solutions that the government can implement to overcome these problems can be in the form of rearranging residential development and improving the quality of life of the community with the National Community Empowerment Program (PNPM) or Direct Cash Assistance (BLT). Certain stakeholders from other sectors must also be invited to deal with this poverty (Rahmawati et al., 2023). The program to map the distribution of the poor population through manual poverty index data collection is carried out in certain administrative areas; it will be less efficient if there are continuous changes to the definition of poverty itself. This data collection limits our ability to understand slums globally, whereas we need adequate data to map slums (Noviansyah et al., 2023).

Slum Inventory is the first step in determining the Areas used as the basis for policies and handling poverty problems. The development of remote sensing technology can be used to identify slums by mapping spatial distribution patterns. Many other countries are already using remote sensing technology to analyze the population, typology, and morphology of slums (Tan & Kamruzzaman, 2018). Using satellite imagery sensors, consistent observational images can be obtained to estimate the quality and quantity of poor people. Therefore, inventorying slums requires high-resolution remote sensing images to archive the growth documents of residential areas interactively. The government hopes to educate the city and solve several poverty issues in Indonesia. Poverty is a country's dilemma, because poverty is not only measured by income but also by the condition of the environment where you live and how much of the family's needs are met with the income obtained (Diyanah & Bioresita, 2023).

The problem in optimizing urban welfare in Bandung and other smart cities is the issue of smart cities, which is revealed from some literature that lacks clarity in the concept of smart cities, because there are so many definitions. Suppose there are problems in the distribution map while identifying slums. In that case, the definition of a smart city is pluralistic and variable; this becomes a possibility involving a long time scale and adaptation scale. The researcher focused this study on hospital imagery using previous research journal literature on the use of remote sensing, which explained the implementation, methods, technology, satellite imagery, and results that show the potential and solutions for the implementation of urban education.

The current research presents a novel approach by integrating remote sensing technologies with community engagement strategies, which is less emphasized in previous studies. While earlier research primarily focused on the application of remote sensing for mapping urban slums (2018-2023), this study uniquely addresses the challenges of stakeholder engagement and local knowledge in urban planning. It proposes a participatory framework that utilizes satellite imagery and actively involves community members and local government officials in planning. This dual focus on technology and community participation distinguishes the current research from prior studies, which often overlooked the importance of local input in interpreting and applying remote sensing data effectively.

RESEARCH METHOD

The research process to thoroughly research the condition of settlements requires the right method so that maximum research and smart city planning can be conducted. In this study, the researcher will conduct in-depth research related to the right method to record slum settlements and conduct a literature analysis. The research method used is a *Systematic Literature Review* (SLR). The term SLR is a term for designing a review, conducting a review, analyzing, writing results, discussion, and conclusion of a review (Ramdhani, 2021). This SLR research aims to find the right strategies to help overcome the problems faced and identify different perspectives from previous research on the same theme. Based on the theories researched by previous researchers, it provides a new perspective on the inventory of slums. There are five stages in SLR research, namely:

Stage of formulating the problem

At this stage, the researcher makes a Research question, which is used as a reference in choosing the literature to be used, so that the case study is the same as the theme of the research we are doing (Mahabir et al., 2018a). The list of questions made in this study is:

Table 1. Research Question on Literature Review

ID	Research Question
RQ1	Which journals conduct research using the remote sensing method?
RQ2	Who is the most active and influential researcher in the slum inventory?

RQ3	What are the topics and trends of research chosen by the researcher on the slum inventory?
RQ4	What is the most commonly used method for such research?
RQ5	What methods perform best and provide maximum results in slum research?
RQ6	What methods are proposed for inventorying slums?

Searching for Literature

The data used in this study is secondary data obtained not from field research but from previous studies. The data source is nationally accredited articles or journals with the same theme as this research. The search process uses Google Scholar.

Choosing the results of the literature search that are in accordance with the screening and eligibility, choosing the journal based on the guidelines of the questions that are had, the articles to be discussed are articles that meet the inclusion and exclusion criteria.

The researcher analyzed the literature results to find differences in the research with Rq1-Rq6.

The last stage of the research is to understand the search results summarized at the Analysis stage. The researcher then concludes with a thorough final answer to the questions asked.

The study area is the city of Bandung, which has been transformed into a metropolitan area. The city is divided into 30 sub-districts and 151 urban villages, with a city area of 167.31 KM3 and 700 meters above sea level. This study does not use field studies, but the methodology the researcher is currently studying will later be used to conduct remote sensing in the smart city of Bandung.

RESULT AND DISCUSSION

Research Topics

Research on slum inventory is a significant topic in smart city development planning, because this research topic identifies problems in slums, with the most problems in the research area. The identification optimizes to find the causes of settlement problems and choose solutions to the problems (Kuc & Chormański, 2019)The researcher will later obtain conclusions so that further research can be carried out using related methods.

Table 2. Title and Research Results

No.	Research Title	Research Results
1.	A Critical Review of High and Very High-Resolution Remote Sensing Approaches for Detecting and Mapping Slums: Trends, Challenges and Emerging Opportunities	Slums are a global problem in cities, especially in developing countries. To address this, we need adequate data on location, spatial coverage, and changes in slums. High-resolution, ultra-high-resolution remote sensing images are an important source of data. However, analysis has shown that research on mapping slums tends to be limited to a few regions and uses only a single approach, such as image texture analysis. This limits our ability to

No.	Research Title	Research Results
		understand slums globally. Therefore, a more comprehensive approach is needed, considering new geospatial data sources, such as voluntary geographic information, and technological advances such as geosensor networks. By integrating and analyzing data from these various sources, we can develop better methods for mapping slums. This will help us overcome existing challenges and develop new approaches to dealing with slum problems.
2.	Sentinel-2 Imagery For Mapping And Monitoring Imperviousness In Urban Areas	Satellite imagery can be a powerful source of data for seeing the impact of humans on the urban environment. The Copernicus Sentinel constellation provides high-quality, free satellite imagery that is useful in estimating parameters related to the structure and resilience of cities. Sentinel-2 data, which includes the urban expansion index and the vegetation normalized difference index, can help detect changes in the percentage of tightness in urban areas. This study aims to combine multi-temporal and multi-resolution MSI Sentinel-2 data to develop an innovative approach to water management in urban areas. The study results will be compared with HRL Imperviousness data from the Copernicus Program, OpenStreetMap, and the high resolution of the Planet, to gain a more comprehensive understanding.
3.	Textural segmentation of remotely sensed images using multiresolution analysis for slum area identification	Many cities in developing countries face the problem of rapid growth of slums, but often lack detailed information and analysis of these informal settlements. A multiresolution texture analysis method has been developed to identify slums in remote sensing images. This method uses statistical moments and energy to retrieve texture information at different scales and directions with the help of wavelet and contour transformations. The results of this method are compared to wavelet-based multiresolution segmentation methods. Accuracy evaluation is performed on segmented images, and comparative analysis is performed in terms of class-based and overall accuracy. The results showed that the proposed method had better differentiation power and an overall classification accuracy of 91.4-95.4%. This method can be used to provide more detailed information about slums within cities facing rapid growth.

Discussion

In the first study, the international journal identified the problem of urbanization. Mahabir, et al. (2018b) highlighted the quality of remote sensing images used to observe settlements requiring high imagery. Limitations will only make the research conducted futile, given the need for accurate mapping. A more comprehensive remote sensing technique considers new geospatial, voluntary geographic, and geosensing. Digging further into the study of geographic distribution using H/VH-R imagery to study Slums shows that they tend to be concentrated in multiple locations in a particular country. Many countries with very large slum populations have also been found to have little or no research. Therefore, this may limit our understanding of slums globally, and we risk taking an overly specialized approach to the context of specific slums in place of a more holistic analysis.

The second research is about understanding the depth of urban areas. G. Kuc and Chormanci (2019) found that the differentiation between built-up and undeveloped areas is better with the processing of SENTINEL-2 data for NDVI-based urban mapping, which is very accurate. The lower spatial compatibility for NDBI results may occur independently of the band resolution used to calculate this indicator. A quantitative comparison of the results obtained with the Resilience Level given within the framework of the Copernicus Programme may be difficult due to time differences. HRL data is available for 2015, while satellite imagery is acquired for 2018. However, comparative visual analysis shows that the watertight surface identified at the base of the satellite imagery is more detailed than that of the Copernicus product.

A third study conducted by Rizwan Ahmed Ansari and Krishna Mohan Buddhiraju (2019) found that experimental results for curvelet—and contourlet-based methods showed good performance in terms of visual interpretation and feature discrimination and were quite strong against random pixels while maintaining spatial arrangement. The curvelet method achieved a classification accuracy of 91.4–95.4% with precise boundary shapes. This will facilitate the monitoring of slum dynamics by urban authorities to conduct further analysis for planning.

The fourth study by Stark et al., (2019) explains that class imbalance in slums is a challenge in the context of the diversity of slums within cities, and its possible similarities with other urban buildings. FCN transfer learning capabilities for slum mapping with respect to training on unbalanced datasets and available training image quantities. Increasing the total number of images will increase the IU by 20% to 50%. Transfer learning has proven invaluable in retrieving information about complex and heterogeneous urban structures such as slums.

The fifth research conducted by Fadhilah et al., in (2021) highlighted the problem of accuracy values generated by all layers using low-grade Pleiades-1B, SPOT-7, and Sentinel-2 imagery for land use classification. Especially in the category of needs to make slum settlements. This happens because the classification process only uses spectral and textured information derived from the surface response of the studied residential roof. Classification is based only on the appearance of the top. Using detailed survey slum mapping, you should also get information about the environmental conditions.

Furthermore, the sixth study conducted by Najmi et al., (2022) explained that remote sensing with RSI is limited in understanding the urban environment, such as building size, density, roofing materials, and road network patterns. However, other features related to such living conditions as building construction materials and open drainage are important for identifying slums, yet they are very difficult to capture in the RSI. This gap can be filled by SVI, in particular by integrating SVI and RSI—the FCN-DK6_2 network. The modifications presented here significantly improve Recall, F1 scores, and IoU. More research is needed to explore more optimal ways of integration.

The seventh research conducted by Rahmawati et al. (2023) in Bogor states that 2020 is when land use changes are confusing and do not follow previous trends. The percentage of land use change with positive value (increased) is water bodies and deforested land, while those with negative value (decreased) are forests, built land, and agricultural land. The classification results of this study showed a fairly good accuracy value, around 86% (OA) and 0.82 (kappa). This study still has various shortcomings, where land use in food crop areas and vacant land has a significant error rate based on the percentage of UA and PA.

The eighth study conducted by Kebede et al. (2022) produced data on the accuracy of LULC changes between 2016 and 2020 showed that the area of built land, open land, and water bodies increased by 9,084.5 ha, 813 ha, and 2 ha, respectively, while the area of vegetation and forest decreased by 9,279.3 ha and 620.2 ha, respectively. The overall accuracy of the classification was 81%, 86%, and 82% for the 2016, 2018, and 2020 images, thus confirming that the spectral indices formed in urban environments can quickly and accurately extract watertight surfaces.

The ninth study used the same method as the eighth study, but with slightly different data accuracy. The slum settlement area in the Kenjeran sub-district can be identified using the NDBI method with an area of 198.474 hectares, and in the OBIA method, it is 189.396 hectares from the original area in the Kenjeran area, which is 865.67 hectares. From the study's results, it can be seen that 22% to 23% of the area in Kenjeran can be categorized as slum areas.

The tenth research study, conducted by Darwin Noviansyah, Erwin Hermawan, and Nurul Kamila (2023), uses the remote sensing method with Google Earth Engine. This study shows that the accuracy test of the Kippa coefficient for building density and population density in Bogor using the NDBI method obtained a score of 83.10%. From the results of this accuracy, it indicates that the conformity of the processed values with the field index data gets a good score, where the data obtained from this sensing will be visualized with the display of information on population density and building density of the city of Bogor based on WebGIS.

From research one to ten conducted by previous researchers, it can be understood that remote sensing as a method of collecting population density data is effective for use in mapping. However, the satellite images or accuracy tests used are very diverse, judging from the many methods used by previous researchers. The results obtained from this literature research are that the characteristics of slums in Indonesia are the same as those of other developing countries, with a decline in natural function, accumulation of roofed buildings, and dangerous settlement locations. Remote Sensing technology can see the relationship between physical morphology and poverty index. Then, for research on the Bandung area, which is home to slums, it is necessary to conduct a manual data analysis first to find out the existing poverty index. Remote sensing is carried out using the right method according to the settlement conditions to be studied. Previous research did not inventory slums, but there are methods that researchers can use to identify slums in many locations.

CONCLUSION

The systematic literature review (SLR) of publications from 2018 to 2023 indicates that dense urban settlements persist globally, with remote sensing applications and satellite imagery offering potential solutions for mapping and addressing slum issues in urban Indonesia. The low quality of these settlements is attributed to a mismatch between population growth and available housing, compounded by inadequate local government intervention and limited public knowledge of development planning methods. Future research could focus on integrating remote sensing technologies with community engagement strategies to enhance urban planning effectiveness, particularly in slum areas. This study would explore combining remote sensing data with community input, identify barriers to stakeholder engagement, and develop educational programs to improve local planning knowledge. The research aims to create a framework that facilitates actionable urban development plans by conducting case studies and participatory workshops, ultimately contributing to sustainable urban development in Indonesia.

REFERENCES

Arymurthy, A. M., & Purwandari, E. P. (2012). Analisis Topologi Dan Populasi Penduduk Pemukiman Miskin Menggunakan Teknologi Remote Sensing. *Jurnal Sistem Informasi*, *6*(1), 20. https://doi.org/10.21609/jsi.v6i1.275

Diyanah, I., & Bioresita, F. (2023). Analisa Kawasan Permukiman Kumuh di Kecamatan Kenjeran Surabaya Menggunakan Metode NDBI dan OBIA serta Data Citra Sentinel-2 Tahun 2022. *Journal of Geodesy and Geomatics*, *19*(1), 180.

Fadhilah, A., Widayani, P., & Hidayati, I. N. (2021). Deteksi permukiman kumuh menggunakan informasi spektral dan tekstur citra penginderaan jauh. *Geomedia: Majalah Ilmiah Dan Informasi Kegeografian*, *19*(1), 35–45.

Force, M. D. G. G. T. (2008). *Delivering on the global partnership for achieving the Millennium Development Goals*. UN.

Gunn, A. M. (2013). *Habitat: Human settlements in an urban age*. Elsevier.

Kebede, T. A., Hailu, B. T., & Suryabhagavan, K. V. (2022). Evaluation of spectral built-up indices for impervious surface extraction... *Environmental Challenges*, *8*, 100568.

Kekana, H. N., Ruhiiga, T. M., Ndou, N. N., & Palamuleni, L. G. (2023). Environmental justice in South Africa: the dilemma of informal settlement residents. *GeoJournal*, *88*(4), 3709–3725.

Kuc, G., & Chormański, J. (2019). Sentinel-2 imagery for mapping and monitoring imperviousness in urban areas. *ISPRS Archives*, *42*(1/W2), 43–47. https://doi.org/10.5194/isprs-archives-XLII-1-W2-43-2019

Leonita, G., Kuffer, M., Sliuzas, R., & Persello, C. (2018). Machine learning-based slum mapping in support of slum upgrading programs: The case of Bandung City, Indonesia. *Remote sensing*, *10*(10), 1522.

Mahabir, R., Croitoru, A., Crooks, A., Agouris, P., & Stefanidis, A. (2018a). A Critical Review of High and Very High-Resolution Remote Sensing Approaches for Detecting and Mapping Slums: Trends, Challenges and Emerging Opportunities. *Urban Science*, *2*(1), 8. https://doi.org/10.3390/urbansci2010008

Mahabir, R., Croitoru, A., Crooks, A., Agouris, P., & Stefanidis, A. (2018b). A Critical Review of High and Very High-Resolution Remote Sensing Approaches for Detecting and Mapping Slums. *Urban Science*, *2*(1), 8. https://doi.org/10.3390/urbansci2010008

Nadzir, Z. A., Simarmata, N., Agustina, L. K., & Welly, T. K. (2024). Identifikasi Permukiman Kumuh dari Citra Pleiades... *Geomatika*, *30*(1), 33–46.

Najmi, A., Gevaert, C. M., Kohli, D., Kuffer, M., & Pratomo, J. (2022). Integrating Remote Sensing and Street View Imagery for Mapping Slums. *ISPRS International Journal of Geo-Information*, *11*(12). https://doi.org/10.3390/ijgi11120631

Nchor, J. U. (2022). *Housing problems and vulnerability in Nigeria's informal settlements*. Newcastle University.

Onokala, P. C. (2015). Transportation development in Nigeria: The journey so far and the way forward. *The 97th Inaugural Lecture. University of Nigeria, Nsukka*.

Rahmawati, A. D., Asy'Ari, R., Ranti, A., Prameswari, F. A., Ameiliani, T. H., & Khairunnisa, Z. N. (2023). Mapping of land use change using Sentinel-2... *IOP Conference Series: Earth and Environmental Science*, *1220*(1). https://doi.org/10.1088/1755-1315/1220/1/012024

Ramdhani, A. (2021). Manfaat Teknologi Informasi Terhadap Kinerja Karyawan: Systematic Literatur Review (SLR). *Chemistry & …*, 1–15.

Stark, T., Wurm, M., Taubenböck, H., & Zhu, X. X. (2019). Slum Mapping in Imbalanced Remote Sensing Datasets Using Transfer Learned Deep Features. *2019 Joint Urban Remote Sensing Event (JURSE)*, 1–4. https://doi.org/10.1109/JURSE.2019.8808965

Surya, B., Saleh, H., Suriani, S., Sakti, H. H., Hadijah, H., & Idris, M. (2020). Environmental pollution control and sustainability management of slum settlements in Makassar City, South Sulawesi, Indonesia. *Land*, *9*(9), 279.

Tan, Y., & Kamruzzaman. (2018). Does smart city policy lead to sustainability of cities? *(Details Incomplete)*.

Uddin, N. (2018). Assessing urban sustainability of slum settlements in Bangladesh: Evidence from Chittagong city. *Journal of urban management*, *7*(1), 32–42.