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Interpreting built-up areas on sentinel-2 imagery and recognizing slums in Semarang City

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Abstract

This research examines the interpretation of built-up areas on Sentinel-2 imagery using interpretation keys and recognizes the appearance of slums from remote sensing data. The use of interpretation keys in visual interpretation is the first step for interpreters to recognize objects in the image. The research objectives were: 1) to interpret built-up areas; 2) to recognize slum conditions based on visual interpretation of sentinel-2 imagery and; 3) to determine the affordability of remote sensing data for slum parameters. The method used is a visual interpretation that is carried out in stages on the classification of built-up areas and settlements. The introduction of slum conditions is done by object interpretation in slum delineation. The result of this study is the mapping of built-up areas in Semarang City from the visual interpretation method obtained an accuracy of 87.5%. The effective use of interpretation keys at the land cover interpretation level are shape, pattern, size, and color. The condition of slums with remote sensing is visually depicted on the key interpretation of shape and pattern. The affordability of remote sensing data for slum parameters has limitations. The ability to extract remotely sensed data for slum parameters can help narrow down field studies in assessing slum parameters.

Introduction

The population in 2015 according to BPS (statistical center agency) data was 255.6 million and projections in 2025 the population of Indonesia will be 282.4 million. The data is BPS data in 2018 from the SUPAS survey (Inter-Census Population Survey) and shows a population increase of 26.8 million. According to calculations from Widjaja, (2014) a simple housing unit can be inhabited by 5 people. From this assumption, the population growth of 26.8 million in 2025 will require 5.36 million additional new housing units. This increase in both population and housing needs will be significant in urban areas.

One of the cities in Central Java is Semarang City which is the capital of the province. Semarang City has an area of 15,089 hectares of land for building/yards with an area of 37,378 hectares from the BPS calculation in 2021. The calculation illustrates that 40.4% of Semarang City is available for building/yard land and this is almost half of the city area. The limitations of the city in spatial planning or providing land for settlements will cause problems. Problems from the condition of the area in Semarang City such as tidal flooding and subsidence (Land Subsidence) are also a concern for people from year to year about where they live. The expansion of the tidal flood area in Semarang City in 2018 was 4,320 Ha (Setyaningsih et al., 2019). The results of land subsidence monitoring from the LAPAN research team (2020) average vertical land subsidence in Semarang City from 2015-2020 is estimated to reach 0.9-6 cm per year.

Sentinel-2A MSI imagery supports the mapping of urban areas and disasters due to its channel characteristics and spatial resolution of 20 meters and 10 meters (ESA, 2015). Sentinel-2 imagery has a multi-scale spatial resolution. The spatial resolution consists of 10 m in 4 channels, 20 m in 6 channels, and 3 channels in 60 m in spatial resolution. The wavelength width has visible, near-infrared, and shortwave infrared spectra.

Image interpretation is the act of reviewing an aerial photograph or image to analyze and find the significance of the object. Interpretation is done manually or digitally. Manual interpretation is carried out on

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aerial photographs or images by exploring the characteristics of objects based on interpretation keys. Meanwhile, digital interpretation is based on numerical values such as spectral classification which is done statistically (Ambarasakti, 2013).

Interpretation keys are the identifying elements in object identification. Lillesand and Kiefer (1979) mentioned the interpretation keys as hue and color, shape, size, pattern, shadow, texture, site, and association. The use of interpretation keys can be with some combination of interpretation keys to recognize objects in the image or even using all interpretation keys.

The level of interpretation complexity can be assessed by how many interpretation keys are used to recognize objects in the image. Kuffer et. al, (2016) explain the level of complexity of the interpretation key to recognize objects and the scope of observations on the use of interpretation keys. Image object recognition using interpretation is influenced by the size of the spatial resolution of the image. On the topic of urban Kadhim et. al (2016) explained that it can still use up to medium resolution.

Mapping perceptions through visual interpretation of land cover from medium-resolution imagery has been conducted with Landsat 8 imagery at a scale of 1:100,000 (Arifin, 2014). In this study, medium-resolution imagery in the form of Sentinel-2 is used so that spatial resolution can be increased. Sentinel-2 imagery is considered good for mapping cities with its 10-meter resolution in four spectral channels (red, green, blue, and IR). Mapping of urban areas at a scale of 1:50,000 defines built-up areas as an area that has experienced the substitution of natural or semi-natural land cover with an artificial land cover that is usually impermeable and relatively permanent. Meanwhile, settlement is defined as an area or land used as a living environment or residential environment and a place for activities that support life (SNI 7645, 2010).

Visual interpretation can divide the boundaries of the city from the suburbs by the visible boundaries of vegetated land and vacant land and the appearance of accessibility such as roads and rivers that are not very visible with Sentinel-2 imagery (Tiara, 2021). This can be used as a reference for delineating the study area for the residential part of Semarang City. Semarang City has a denser urban built-up areas condition than the suburban areas.

Slums have complex problems. Widjaja (2014) explains that the negative impacts of slums affect health problems and social insecurity. This is because poor sanitation conditions, lack of clean water supply, poor drainage, waste systems, and uncollected waste have the potential to cause health problems. Based on this, slums have negative impacts that need to be addressed in urban problems. Mahabir et.al, (2018) explained that in general there is a key approach in mapping slums through remote sensing data. This is based on 3 processes, namely:

1) Detection: This stage is a method to find unique features in an image and is the initial stage in image classification.
2) Delineation: This stage involves identifying the spatial presence of features.
3) Characterization: This stage is the labelling of features into specific classes.

This research will interpret land cover in Semarang City using visual interpretation for detailed classification of built-up areas. The interpretation keys that have been used for land cover interpretation are also used to recognize settlement and slum objects. In simple slum object recognition, the interpretation key is used to recognize slum parameters in the field. It is also used to assess the capability of remote sensing data in slum studies. The objectives of this research are to: 1) interpret the built-up areas cover in Semarang City; 2) recognize slum conditions based on the physical appearance of the visual interpretation of sentinel-2 imagery and 3) determine the affordability of remote sensing data for slum parameters.

Methodology

Data

This research uses Sentinel-2 image data recorded in 2021. Vector data was used in addition to administrative boundaries and roads of Semarang City for base map. The slum study took residential areas within the slum delineation set in 2021 based on government regulation criteria PUPR No 14/PRT/M/2018. Land cover data was obtained by visual interpretation of Sentinel-2 imagery assisted by land use data from the Semarang City Spatial Planning Office as a reference. Field observations were required to compare the objects in the Sentinel-2 imagery with field conditions that had been conducted in the same year.

Methods

The research was conducted in two main stages. The first stage was to perform a visual interpretation of built-up areas divided into physical characteristics for use (settlements, industries/factories, and public facilities). The second stage was to identify the appearance of slums from Sentinel-2 imagery. The description of this research method is as follows:

1. Interpretation of built-up areas cover
    a) Identify the city's built-up areas cover class
    b) Perform visual interpretation based on interpretation keys (hue, color, shape, size, pattern, shadow, texture, site, and association) on developed land with maximum magnification up to 1:25,000.
    c) Assessing the accuracy of land cover interpretation results in a confusion matrix
    d) Assess the ease of interpretation of objects from the interpretation key used

2. Recognizing slum conditions
    a) Select observation areas based on slum delineation locations
    b) Identify settlement conditions based on interpretation keys in slum delineation
    c) Identify slum parameters that can be observed with remote sensing

Research Area

The research area used is in Semarang City. Geographically, Semarang City is located at 6° 50' - 7° 10' South latitude and 109° 35' - 110° 50' East longitude. Administratively, there are 16 sub-districts and 177 urban villages included in the coverage. Semarang City was chosen as the study area due to its territorial form as a provincial city with a high presence of built-up areas compared to other cities/regencies in Central Java. It has a high level of economic activity due to its status as the provincial city center and its diverse topography of urban plains, Ungaran hills, and coastal areas on the north coast of the Java Sea. The relevance of the study area to the topic of slums in Semarang City is that all of its wards are included in the government's collaborative program to prevent and improve the quality of slums, KOTAKU (Cities Without Slums).

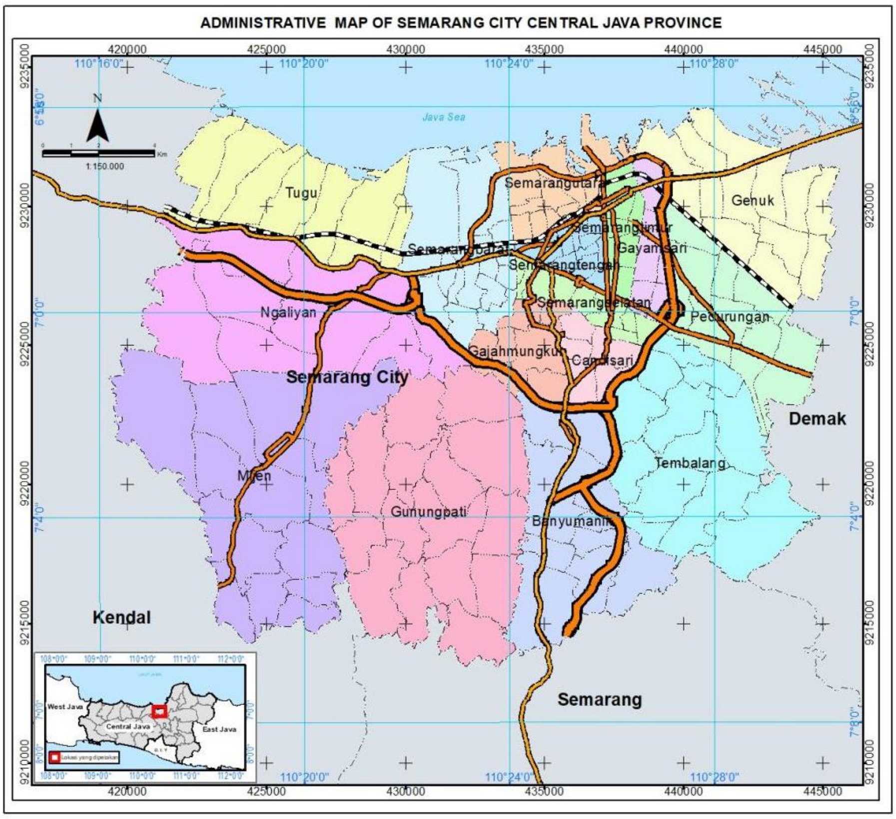

Figure 1. Administrative map of Semarang City

Result and Discussion

Interpretation of built-up areas has an appearance that can be distinguished from non-built-up areas. The interpretation results on Sentinel-2 imagery for built-up areas found 6 classes of built-up areas. Meanwhile, non-built land is not divided into land cover classes anymore.

Identification of built-up areas from visual interpretation on Sentinel-2

The land cover derived from the Sentinel-2 imagery is divided into built-up and non-built-up areas. The scale of land cover used to derive this interpretation is equivalent to 1:50,000 from the 10-meter resolution of the Sentinel-2 imagery. Suwargana (2013) states that images with spatial resolution between 4-30 meters fall into the medium resolution category. Non-built land appearances that are found to be either vegetation or water are classified into one class as non-built land. built-up areas appearances that are found are identified again to be divided based on their shape, pattern, and association.

Identification of built-up areas by visual interpretation was conducted on Sentinel-2 true color composite (432) imagery. The color composite has a good resolution for urban identification. built-up areas in this study is divided into 5 classes: settlement, road network, industry, airport, and port. The pervasiveness of objects for visual interpretation in the identification of built-up areas cover is done up to 1:25,000 pervasiveness, beyond which the appearance of objects becomes unclear or in the form of pixels that also do not detail the shape of the object.

The appearance of built-up areas obtained from the visual interpretation of the Sentinel-2 image magnification of 1:25,000 for urban areas can be observed in **Error! Reference source not found.** This part of the image is a sample for each object. In the airport and port objects, enlarging the image will result in a less recognizable image. This is because both objects require a key combination of interpretation of shape and association with the surrounding environment. environment.

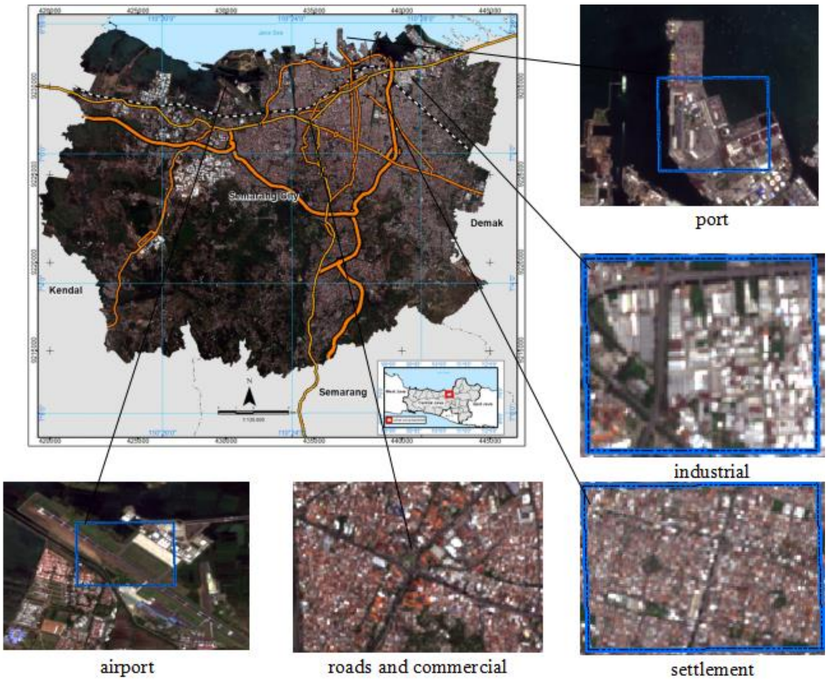

Figure 2. Landcover Object

Interpretation of residential built-up areas in the area Error! Reference source not found. which can be identified by shape, pattern, color, and association. Settlements are residential dwellings along with the living environment/common facilities. Recognition through shape in settlements will look like square objects that are clustered due to their uniform shape and proximity.

The appearance of the road network in Figure 2 the road network in urban areas will be more obvious than in suburban areas. Roads in urban areas are wide with asphalt cover material and the road network appears to be interconnected with intersections. This helps in recognizing road objects, especially in the typical road shape of a long lane. The road cover material in the form of asphalt emphasizes the appearance of the object and spectroscopically has reflective characteristics. The road network class cannot be divided in more detail. Only road sections that are wide enough can be identified.

Industrial objects have a similar appearance to that of settlements. These two objects have similarities to some of the interpretation keys used. Mainly because the study area is an urban area and there are parts of the city that become residential areas or industrial areas. The difference for industrial objects is in terms of size. The size of the industry tends to be larger than settlements. Even if it is an industrial area, there will be a building pattern that emerges and the shape of the building becomes clustered. Judging from this size that can be a differentiator from other objects.

Airports and port are urban transport facilities. The airport is easier to recognize than the port. Figure 2 the airport object is characterized by an elongated runway with asphalt cover material. The recognition of this object can be done with the key to shape interpretation and from the shape, the area of the airport environment can be estimated. Meanwhile, the port object is difficult to recognize. The interpretation key that gives an impression of this object is the association with sea waters. The use of other easy-to-use interpretation keys such as size, shape, and color is still unable to recognize the port object.

The level of ease of interpretation of urban land cover with medium-resolution sentinel-2 imagery can be observed in Table 1. The table shows the assessment of the use of interpretation keys and the ease with which urban land cover objects can be recognized using visual interpretation. The interpretation keys used to recognize urban land cover consist of: hue, color, shape, size, pattern, shadow, texture, site, and association. Then the results of the land cover class of built-up areas are divided into settlements, industrial buildings, road networks, port, and airports.

Table 1. Object interpretation score with an interpretation key.

Interpretation keys	Settlement	Industrial	Roads	Port	Airport	Commercial	Total
Tone	3	3	3	2	2	3	16
Colour	3	3	3	2	3	3	17
Shape	3	3	3	2	3	3	17
Size	3	3	3	2	3	3	17
Pattern	3	3	3	2	3	1	15
Shadow	1	1	1	1	1	1	6
Texture	3	3	3	1	1	1	12
Website	3	2	3	3	2	1	14
Association	3	2	3	3	2	2	15
Total	25	23	25	18	20	18	

Description:

3 = Visible
2 = Less Visible but still recognizable
1 = Not Visible

Based on the results of the table assessment, the land cover that is easily identified is the land cover of settlements and road networks. In the use of interpretation keys for the identification of urban built-up areas cover, the dominant use is hue, color, shape, size, and association. This can be seen from the highest number of judgments from the sum of each land cover and the number per land cover unit against the interpretation key.

The land cover results were initially divided into built-up and non-built-up areas cover. Interpretation of the 2 land cover classes can be easily recognized as follows in Figure 3. built-up areas was reinterpreted and resulted in 6 classes of built-up areas. Interpretation of the sentinel-2 imagery resulted in a 1:50,000 scale output built-up areas map with magnification up to 1:25,000. The classification of 2 land cover classes helps in distinguishing the classes in the southern part of the study area. This is because the southern side of the study area has a hilly topography and high vegetation land. On the southern side, there is some built-up areas as a form of built-up areas development from Semarang City. The distribution of built-up areas can be observed in **Error! Reference source not found.**

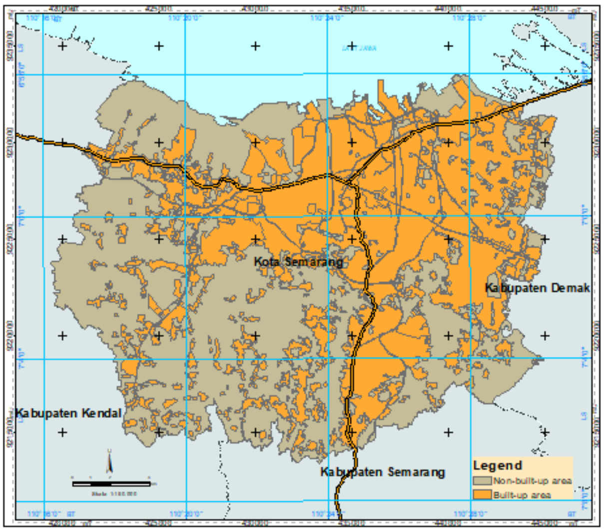

Figure 3. Semarang City land cover map

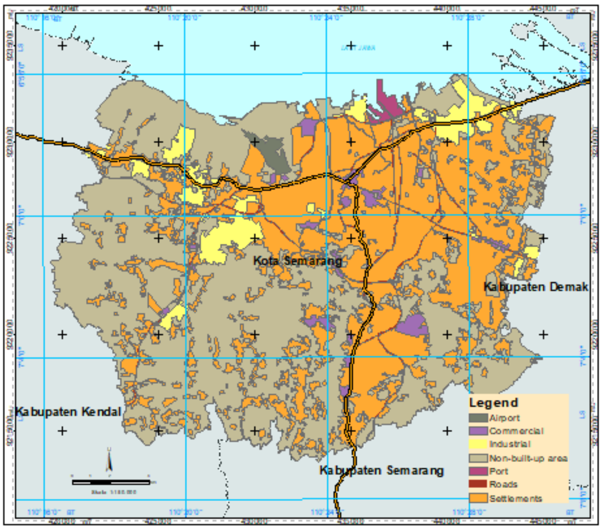

Figure 4. Built-up area map of Semarang City

built-up areas that has been interpreted is divided into settlements, industries, road networks, airports, port, offices, and services. The distribution of built-up areas is in Figure 4. The settlement area is the largest built-up areas area that can be identified at 15,617 Ha. The distribution of settlements is in the city center to suburban areas. The industrial area is a built-up areas area with large and clustered buildings. The distribution is in the suburban area and close to the national road/big road as an accessibility route.

Visual interpretation of built-up areas with 10-meter resolution imagery mostly classifies built-up areas as settlements in the study area. Industrial areas have more specialized specifications compared to other classes of built-up areas. Trade and service areas are quite difficult to identify. This is because built-up areas is seen from the activities in it which are less physically visible buildings. This is also the case for port. Apart from being a place for ships to pull over, there are port activities such as loading and unloading containers so that the boundaries of the area are formed by the activities in it or it can be said that the physical boundaries are less observable.

Table 2. Confusion matrix of developed land

		Interpretation						**Total**	**Omission**	**Commission**
		Settlements	Roads	Airport	Industrial	Port	Commercial			
Reference	Settlements	23	0	0	0	0	2	25	8	14,81
	Road	0	7	0	0	0	0	7	100	100
	Airport	0	0	3	0	0	0	3	100	100
	Industrial	1	0	0	10	0	0	11	9,09	16,67
	Port	0	0	0	1	3	0	4	25	100
	Commercial	3	0	0	1	0	10	14	28,57	16,67
		27	7	3	12	3	12	56		
									Accuracy =	87,5

The accuracy test of the land cover map was carried out with the confusion matrix method in Table 2. The overall accuracy reached a value of 87.5%. The omissions value was found to be 8% the lowest value for the interpretation of residential objects. The highest omissions accuracy value is the road and airport object which can reach up to 100% accuracy. This is because these objects have special characteristics such as large size, are in one place, and can be easily recognized. The commission value obtained is 14.81%, the lowest in the interpretation of settlements and the highest in roads, airports, and port reaching a value of 100%.

Identification of Settlement land

Previously, the identification of urban built-up areas cover with Sentinel-2 has been carried out. Furthermore, the built-up areas cover of settlements will be explored further about the density and regularity of buildings in these settlements. In the 1:50,000 scale settlement interpretation, the settlement land cover class can be divided into urban settlements and rural settlements (Wiweka et al, 2012). The division of settlements is seen from the conditions of density and distribution of residential buildings.

Figure 5. Orderly Settlement

Figure 6. Urban Settlement

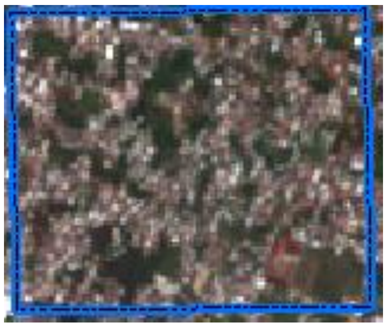

Figure 7. Village Settlement

Figure 5 to Figure 7 are images of residential areas from Sentinel-2 composite 432 with a magnification scale of 1:25,000. The images of regular settlements and dense urban settlements tend to be difficult to distinguish. This is because the shape of the building with a magnification of 1:25,000 and an image resolution of 10 meters, and the shape of the building becomes a box-like pixel. The appearance of settlements is recognized based on the color of the roofing material. Both settlements are located in urban areas so their development is compact. The thing that determines the regularity of settlement objects is seen based on the road pattern seen from the dark/black color and the gap of vegetation space between the settlements. Figure

5 There appears to be a settlement pattern of a combination of vegetation gaps and built-up areas. This form of settlement shows a well-planned development plan. Figure 6 Settlement conditions are highlighted in the form of information on the high density of residential buildings. The shape of the pattern in this observation is less observable. Accessibility space is less visible but density is very high in the neighborhood.

Figure 7 Village settlements are characterized by gaps in vegetation interspersed with residential buildings. This form of settlement tends to be non-residential self-help settlements. In these areas, the identification of image objects tends to be difficult. This is because accessibility facilities are not visible, which indicates low mobility and is on the outskirts of the city. Some settlement images have different environmental conditions. Based on observations in these residential areas, high residential buildings have low accessibility conditions despite being in the city area. However, in residential areas that still have space for open space or accessibility, the condition of environmental infrastructure facilities is not necessarily high.

Residential appearance condition of slum problems

Slums have a negative impression of the condition of the environment. The decline in quality of settlements to support life in the area is less good or even degraded. Detecting the presence of slums is one of the steps in planning slum upgrading. Government Regulation No. 14 of 2016 concerning the implementation of housing and settlement areas in article 106 states that improving the quality of slum housing or slums is preceded by determining slum locations through data collection from local governments and involving the role of the community. Data collection includes location identification and location assessment. Williams et. al, (2020) mentioned a variation of remote sensing image analysis is used to find slum features through its physical characteristics approach.

The introduction of slum objects using sentinel-2 imagery is seen from the condition of settlement land cover. The observation results show the condition of settlements in the slum delineation is dense settlements. Previous research by Dalilah & Ridwana (2019) using very high-resolution Quickbird imagery has been conducted and can explain the condition of settlements in slum areas by the visual physical appearance of images of building conditions.

The use of 10-m resolution imagery makes building objects unclear and patterns less visible in the slum delineation of Semarang City. Figure 8. Building patterns in this case refer to gaps in vegetation land cover and road networks between buildings. Generally, in the presence of a building, there will be road accessibility around it, especially on the front side of the building. Shape and pattern as keys to the visual interpretation of imagery that previously had good value for the interpretation of built-up areas when used in the same data conditions but with a different scope of object detail, their effectiveness can be reduced. Other interpretation keys such as hue and color provide a different view of the building objects in this slum.

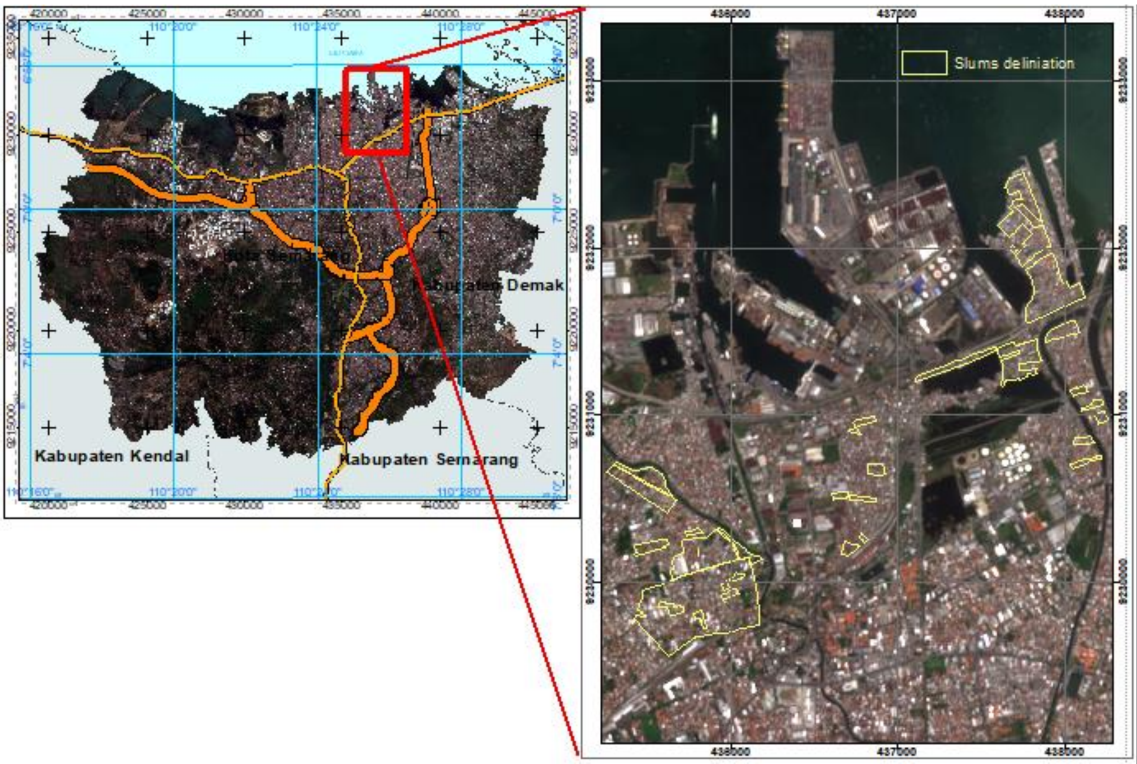

Figure 8. Spatial distribution of slum delineations in Semarang City

Figure 8 shows the distribution of slum delineations in the northern part of Semarang City for 5 of the 45 total slum areas determined in 2021. In the figure, the selected slum delineations determined by local government that have the criteria are clustered and have a large delineation area of more than 10 hectares for this research. The location of these slum delineations is on the north side of Semarang City in the lowlands close to the waters of the Java Sea. There are port and industrial activities near the slum delineation area. The use of visual interpretation on settlement objects in the slum delineation displays a blurred form of settlement. The size of buildings tends to be smaller than the resolution of the image, so the shape of the building in the image is a collection of several buildings. The color of the building roof can still be observed although it is less clear due to the combination of several buildings. Some building areas are visible with orange, white, and dominant grey roofs. The building pattern is identified as an area with high building density because there is no visible road gap or vegetation land in the settlement. The comparison of built-up areas with non-built-up areas shows the intensity of settlement presence, which may indicate a decline in environmental infrastructure.

The assessment of slum indicators in Indonesia based on ministerial regulation PUPR No 14/PRT/M/2018 is carried out on buildings, roads, drinking water, drainage, wastewater, waste, and fire protection. Each indicator has a derivative assessment based on its parameters. Slum indicators are assessed using field methods, so the parameters are also assessed based on field conditions. Previously, simple land cover interpretation with Sentinel-2 could recognize settlement objects. The use of visual interpretation with interpretation keys on land cover in Semarang City that has been obtained is used to analyze settlement conditions in slum delineation.

Remote sensing capabilities for slum parameters have a degree of affordability. Medium-resolution remote sensing such as Sentinel-2 used in this study supports data extraction for some slum parameters based on ministerial regulation PUPR No 14/PRT/M/2018. The addition of other remote sensing data models is useful to complement this slum-related data extraction and visualization. The identification of slum parameter adjustments in the field and the affordability of remote sensing data in this study with Sentinel-2 can be observed in Table 3.

Table 3. Slum indicators and affordability of Remote Sensing data

PUPR Regulation No 14/PRT/M/2018		Remote sensing affordability		
Indicator	Parameters	VHR/HR	Med-Res (10 m)	Others
Building	Building Irregularity	√		Thematic GIS data integration
	Building Density	√	√	
	Non-conformance with Building Technical Requirements			
Roads	Local Road Service Coverage	√	√	
	Quality of Local Road Surface	√		
Drinking Water	Availability of Safe Access to Drinking Water			
	Unfulfilled Drinking Water Needs			
Drainage	Inability to Drain Runoff Water		√	
	Unavailability of Drainage			
	Drainage Construction Quality			
Waste Water	Wastewater Management System Does Not Meet Technical Standards			
	Wastewater Management Infrastructure and Facilities Not following Technical Requirements			
Waste	Waste Infrastructure and Facilities Not following Technical Requirements			
	A waste management system that does not comply with technical standards			
Fire Protection	Unavailability of Fire Protection Infrastructure			
	Unavailability of Fire Protection Facilities			

Based on Table 3 Remote sensing data extraction to support slum parameter data can be done for several parameters. Remote sensing data extraction can be done by various methods ranging from visual interpretation to the use of machine learning. The medium-resolution remote sensing image in this study has a resolution of 10 m sentinel-2. While high-resolution imagery/very high-resolution imagery is an estimation of object detailing from visual interpretation observations. In addition to remote sensing data, the integration of thematic GIS data will further complement the spatial data needs for slum identification. The thematic GIS data is adjusted to the desired output including the detail of mapping that can be done by participatory mapping.

Building indicators have more potential than other slum indicators that can be extracted from remote sensing data. In this research, a simple land cover interpretation has been carried out with visual and stepwise interpretation of the objects studied. Buildings are part of the first observable land cover in a land cover class. Land cover class level 1 is referred to as built-up areas. The role of remote sensing in the extraction of building density or regularity parameters is to present built-up areas information according to the time of recording. Spectral transformation is one technique for extracting built-up areas. In some studies, it is also used to assess the level of building density such as Tiara (2022) with spectral transformation and Ayo (2020) using machine learning to determine the density, pattern, and size of buildings in the context of slums.

Road indicators from remote sensing data can be interpreted for their presence. This further depends on the level of information required and the data available. At medium resolution such as sentinel-2, which has been done for major roads, they can be identified. However, for neighborhood roads, there are obstacles so some can be identified and some can be identified from the shape of the built-up areas pattern. Therefore, the use of high-resolution imagery to fulfill this data is highly recommended. This is because the width of neighborhood roads can reach 0.5 meters for the smallest size. The width of roads identified with 10 meters resolution on sentinel-2 requires a road width of at least 10 meters or an intersection of several lanes measuring 10 meters. Once the road objects have been identified, the thematic mapping will provide information on the coverage of road services between built-up areas.

Drainage indicators through remote sensing data can be generally identified. The use of medium-resolution image data can provide information related to the topography of the area. This can be observed from land cover. Densely vegetated land cover potentially indicates areas with high topography. Areas with built-up areas indicate urban areas with flat topography. The shape of the topography helps to give an idea of the direction of flow in the area. The appropriate remote sensing data for this drainage slum parameter is that which has elevation information for the general study.

Field measurements have a high level of detail for each of the other slum parameters. However, this can be done in potential slum areas. The use of remote sensing data is useful to find these potential areas and minimize the scope of the field study to make field measurements more efficient

Conclusion

This research uses sentinel-2 imagery as easily accessible remote sensing data with a resolution of 10 meters for urban studies. Visual interpretation can involve many interpretation keys at once to help the operator gradually recognize objects in the image. In this research, conclusions are obtained in the form of:

The interpretation of built-up areas in the study area resulted in 6 built-up areas classes using a combination of interpretation keys. The overall accuracy result was 87.5% for the built-up areas classes of settlement, road, airport, industry, port, and commercial. The interpretation keys that contributed most to the interpretation of the built-up areas were color, shape, size, and pattern.

Settlement areas from sentinel-2 are recognized as residential built-up areas objects or built-up areas accompanied by public facilities in residential environments. The comparison of residential built-up areas with non-built-up areas shows the intensity of the presence of settlements, which can indicate a decline in environmental infrastructure. The condition of settlements in slum delineation through sentinel-2 imagery has a less clear building shape because the object size is smaller than the image resolution. The building pattern is not clear so it is identified as high building density and the roof color consists of a combination of orange, white, and grey.

The affordability of remote sensing for slum assessment based on slum parameters can only be done for a few parameters and requires GIS spatial support data. Remote sensing support for slum parameter extraction can help narrow the scope of the field assessment and thus help shorten the work.

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