

# Availability of Green Open Space at Informal Settlement in Malang City

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**Abstract:** Residential, especially informal settlements in Malang City, is strongly influenced by the interaction of various factors. Problems with the quality of informal settlements in Malang City, one of which is lack of management and increasing in the area of green open space. Malang City still does not meet the minimum percentage in providing green open space, which is 20%. Thus, efforts are needed to increase the area of green open space in order to improve the quality of informal settlements and create a sustainable city in accordance with sustainable development goals. For this reason, the purpose of this study is to identify availability of green open space in informal settlements in the city of Malang. The analytical technique used in this study is image interpretation analysis by comparing the conditions of Malang City in 2012 with the conditions of Malang City in 2022. The method used in the analysis of image interpretation is NDVI analysis. The result of this research is that in 2012, Malang City was dominated by very low vegetation density of 44%. Then, in 2022, Malang City will still be dominated by very low vegetation density with the percentage increasing to 57%. This shows that there is a decrease in the area of green open space in informal settlements in Malang City. Based on this, it is necessary to increase the area of green open space in informal settlements according to the characteristics of each settlement, such as providing river border green open space and local garden green open space.

**Keywords:** Informal Settlement, Green Open Space, NDVI Analysis

## 1. Introduction

Regulation of the Minister of Public Works of the Republic of Indonesia Number 5 of 2008 [1] concerning Guidelines for the Provision and Utilization of Green Open Space in Urban Areas states that Green Open Space (GOS) is an elongated area/lane and/or clustered, whose its use is more open, place where plants grow, both those that grow plants naturally and those that are intentionally planted. The minimum percentage of green open space provision in urban areas is 30% (thirty percent), consisting of 20% (twenty percent) public green open space and 10% (ten percent) private green open space.

Green Open Space Planning (GOS) aims to maintain the availability of land as water catchment areas, maintain the balance of the natural environment and the artificial environment, and improve the quality of a healthy, beautiful, clean and comfortable urban environment [1]. GOS consists of public green open space and private green open space. GOS planning also aims to maintain balance, harmony, and harmony between built and undeveloped land. In addition, the provision of green open space can function as a forum for human activities and preserve the beauty of plants within the scope of green open space [2].

Malang City has an open green space area, both private green open space and public green open space. Private green open space in Malang City consists of residential areas, office parks, and commercial building parks. Public green open space in Malang City consists of green open space for roads, green open space for parks, monuments and city gates, green open space for sports fields and cemeteries, urban forest green open space and nursery gardens, and safety green open space for railway lines, high voltage air line, river, and buffer zone Regional Spatial Plan Malang City 2010-2030 [3]. Currently, the area of public green open

space in the city of Malang still does not meet the minimum percentage of providing public green open space. Malang City only has public green open space covering an area of 958 ha or 8.62% of the total area. It is necessary to provide public green open space to meet the minimum percentage stipulated in the Regulation of the Minister of Public Works of the Republic of Indonesia Number 5 of 2008 concerning Guidelines for the Provision and Utilization of Green Open Space in Urban Areas [1].

The residential environment, especially informal settlements in Malang City, is strongly influenced by the interaction of various factors. Human activities directly or indirectly cause air quality to decline, thus affecting the quality of settlements [4]. The quality of informal settlements has a close meaning with the conditions of a settlement in accordance with the capabilities of its inhabitants. Problems with the quality of informal settlements in Malang City include not optimal quality of city facilities and infrastructure in good condition (friendly and comfortable), not optimal management and utilization of waste and waste in an integrated manner, and the existence of slum settlements [5].

GOS is an open space with vegetation located in an urban area. Green open space has a function as a recreation area, socio-cultural, aesthetic, physical, ecological, and economical for both humans and the city [6]. Harmony between informal settlements and green open space can reduce the negative impacts of environmental degradation. Given that Malang City still has green open space less than 20% of the area, it is necessary to increase the area of green open space, especially in informal settlements. In addition, increasing the area of green open space is also one of the efforts to create a sustainable city in accordance with sustainable development goals [7].

Based on the previous explanation, it can be concluded that

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there is a need for research to determine the distribution pattern of green open space in informal settlements in Malang City. If an informal settlement has less green open space, it is necessary to increase the green open space area to improve the quality of informal settlements in Malang City.

## 2. Research Objectives and Scope

### 2.1 Research Objectives

The purpose of conducting research on the distribution pattern of green open space in informal settlements is to identify the availability of green open space in informal settlements in the city of Malang.

### 2.2 Research Scope

The scope of the area in this study is informal settlements in Malang City with an area of 11.006 ha. The delineation of informal settlements uses the criteria of slum settlements, so that 31 urban villages will be the objects of research.

The scope of the material in this study was arranged based on the research objective, namely to identify the distribution pattern of green open space in informal settlements in the city of Malang. The study begins by identifying the distribution pattern of green open space in informal settlements in Malang City using image interpretation analysis. The analytical technique used is NDVI analysis. Through this analysis, the density of vegetation for informal settlements in Malang City will be obtained. In addition, the distribution pattern of green open space will also be compared between 2012 and 2022, so that changes in the distribution pattern of green open space in informal settlements in Malang City can be seen. The results of this analysis will be input in the preparation of recommendations for increasing the area of green open space in the city of Malang

## 3. Methods

Research with the title "The Pattern of Green Open Space Distribution in Informal Settlements in Malang City" is a research that uses quantitative methods with data collection techniques in the form of observations, interviews, and agency surveys for secondary data needs. The analysis technique used is image interpretation analysis. With this analysis technique is expected to answer the objectives of this research.

**Table 1:** Objectives, Variables, and Analysis Techniques

Objectives	Variables	Sub variables	Analysis Techniques
To identify the distribution pattern of green open space in informal settlements in Malang City.	Informal Settlement	Buildings	Image Interpretation Analysis
		Local Street	
		Water Supply Provision	
		Local Drainage	
		Waste Water	
		Waste Management	
		Fire Protection	
	GOS Availability	Area	
		Distribution	

## 4. Result

Malang City is the second largest urban area after Surabaya City and is also a tourist destination in the province of East Java, which is located about 90 kilometers south of the city of Surabaya. Astronomically, Malang City is located at 112°06'-112°07' East Longitude and 7°06'-8°02' South Latitude. Malang city is located in the middle of Malang Raya area and makes this city has a strategic location, especially in supporting regional development and growth. Administratively, it can be seen on the regional administration map, that the Malang City area has the following boundaries:

West : Wagir District and Dau District  
 South : Tajinan District and Pakisaji District  
 East : Pakis District and Tumpang District  
 North : Karangploso District and Singosari District

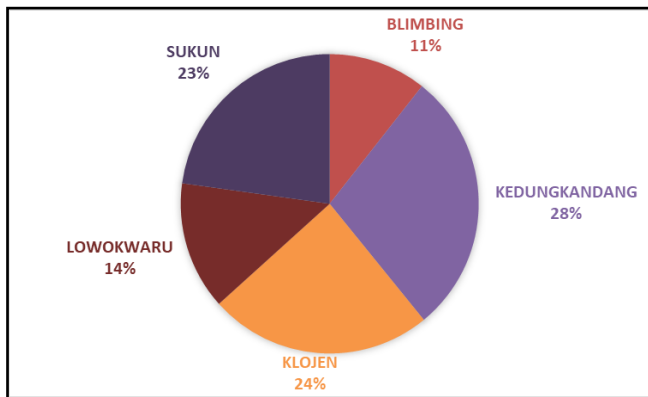
These sub-districts are all areas located in Malang Regency. The area of Malang City is divided into 5 sub-districts and 57 urban villages with an area of 114.2616 km<sup>2</sup>. Based on the stipulation on regional division, Malang City is administratively divided into 5 (five) sub-districts with a total of 57 (fifty-seven) villages which are divided into 557 Hamlet and 4,286 Neighborhood.

### 4.1 Identification of Informal Settlements in Malang City

The delineation of informal settlements in this study uses the criteria for delineating slum settlements. This is because the characteristics of informal settlements and slums are almost the same, namely a degraded environment, uninhabitable and high-density buildings, underserved basic infrastructure, especially sanitation and clean water, poverty, and social exclusion.

Regulation of the Minister of Public Works and Public Housing of the Republic of Indonesia Number 14 2018 concerning Prevention and Quality Improvement of Slum Housing and Slum Settlements [8] states that slum settlements are uninhabitable settlements due to building irregularities, high building density levels, and quality of buildings and facilities and infrastructure. not eligible. Malang City based on Malang Mayor Decree concerning Determination of Housing Environment and Slums [9], has an area of 608.60 Ha of slum settlement area. The city of Malang again identified new slum areas in 2020 with an area of 282.33 ha of slum areas in Malang City.

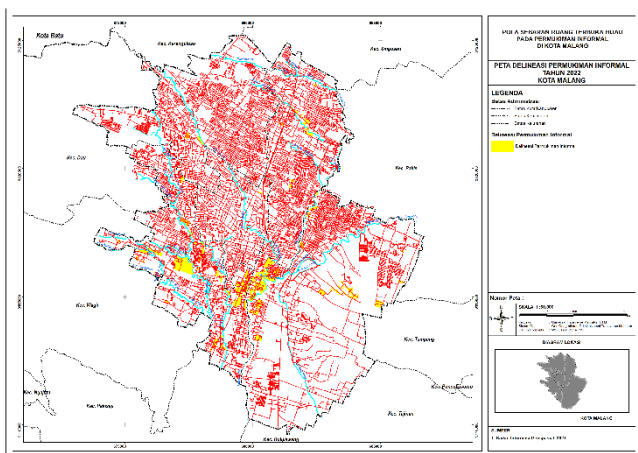
The classification of slum areas in Malang City shows that slums in Malang City are dominated by slum areas with the classification of Light Slums as much as 90% and 10% moderate slums. Medium slum areas are Mergosono, Bandungrejosari, and Gadang Villages. Mergosono Village is located in the Brantas watershed area so that the most slum areas are located on the banks of the river. Meanwhile, the Bandungrejosari slum area is located in the Metro DAS area. The Gadang slum area is mostly located in the center of community activities, namely the Gadang Market area. The following is the percentage of slum area per sub-district in Malang City.



**Figure 1:** Percentage of Slum Area Per District of Malang City

Based on Figure 1, it can be seen that the largest slum area is Kedungkandang District of 80.44 Ha or 28% of the total area of Malang City slum area, while the sub-district with the smallest area is Blimbing District of 30 Ha or 11% of the total. Meanwhile, when compared by kelurahan, the largest slum area is the slum area in Mergosono Village, which is 28.37 ha. While the area of the slum area is the least, namely the Blimbing slum area.

Slum areas in Malang City have two categories of slums based on land legality, namely slum areas of legal land and slum areas of illegal land. Slum areas located in illegal areas, namely the land in the area still does not have a registered letter or is still an asset of the government, institution, or certain company, so it uses a land lease system. There are 14 illegal slum areas in Malang City reaching 9.52 hectares out of a total area of 282.33 hectares of slum areas. The largest illegal slum area in Malang City is the Kotalama slum area, which is 2.75 hectares or 28% of the total area of illegal slum areas in Malang City.



**Figure 2:** Informal Settlement Delineation Map

**4.2 Image Interpretation Analysis**

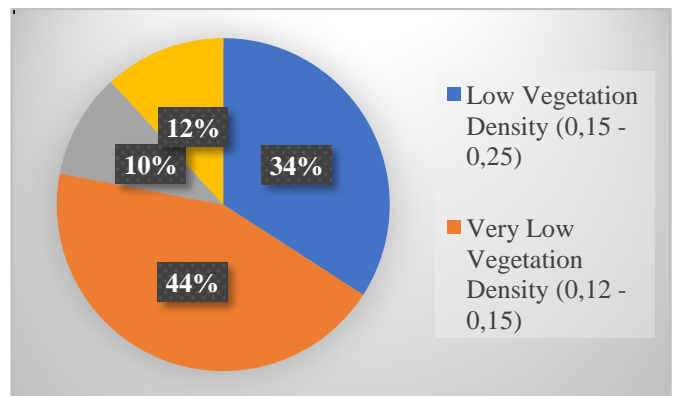
Measurement of the availability of green open space is very important for the sustainability of a city. One way to identify the availability of green open space is by utilizing photogrammetry and remote sensing technology. Image interpretation analysis used in this study is the vegetation index or NDVI. NDVI is an index that describes the greenness of a plant. The vegetation index is a mathematical

combination between the red band and the NIR (Near-Infrared Radiation) band which has long been used as an indicator of the presence and condition of vegetation. NDVI is based on the observation that different surfaces reflect different types of light waves. Vegetation that is actively carrying out photosynthesis will absorb most of the red waves of sunlight and reflect higher near infrared waves. Dead or stressed (unhealthy) vegetation reflects more in the red and less in the near infrared. NDVI values range from -1 (which is usually water) to +1 (heavy vegetation). Image interpretation analysis was carried out in 2012 and 2022 to compare the distribution patterns in the two years.

**1. Year 2012**

Analysis of image interpretation in 2012 using Landsat 7 data. This analysis is used to see the distribution of vegetation in informal settlements spread over 24 urban villages in Malang City.

The distribution of vegetation density in formal settlements in Malang City in 2012 has several classifications, namely low vegetation density, very low vegetation density, medium vegetation density, and high vegetation density. Based on this classification, Bumiayu Village has the highest area for low vegetation density which is 14.99 Ha, Bumiayu Village has the highest area for low vegetation density which is 19.01 Ha and medium vegetation density is 6.73 Ha. Meanwhile, Ciptomulyo Village has the highest area for very low vegetation density, which is 29.82 Ha. For the classification of high vegetation density, Cemorokandang Village has the highest area of 8.36. If viewed based on these data, the highest area is very low vegetation density (0.12-0.15). This shows that in the classification the vegetation land is in the form of ground cover such as empty fields or roads with soil pavement.



**Figure 3:** Analysis of Image Interpretation in 2012

From the number of informal settlements spread over 31 urban villages in Malang City, there are 19 villages that have high vegetation density, meaning that in 2012, the vegetation land in the area that can be identified is in the form of plantations, grasses, and weeds. - reed.

NDVI values range from -1 (which is usually water) to +1 (heavy vegetation). Based on the graph, it can be seen that informal settlements in Malang City are dominated by very low vegetation density of 44% and low vegetation of 34%. The results from the NDVI show that informal settlements have low vegetation (little vegetation). This shows that there

is a need for the provision of green open space both as an ecological function as well as a socio-cultural function, an economic function, and an aesthetic function for an informal settlement in Malang City.

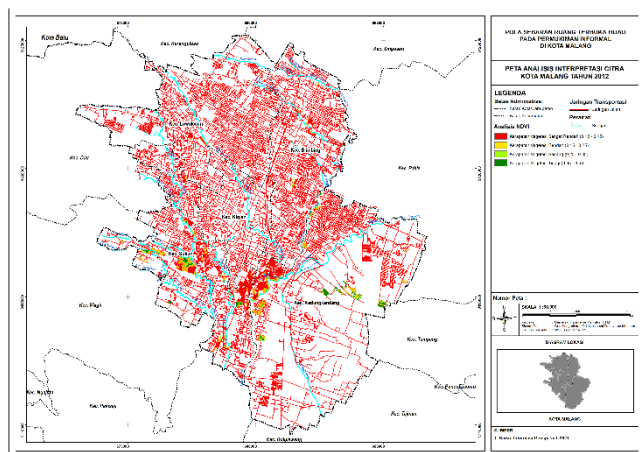


Figure 4: 2012 Image Interpretation Analysis Map Year 2022

Lands at used for image interpretation analysis is Landsat 8 OLI. Landsat 8 has several advantages, especially regarding the specifications of the bands it has and the length of the spectrum of electromagnetic waves that are captured. As is well known, the color of objects in the image is composed of 3 basic colors, namely Red, Green and Blue (RGB). With the increasing number of bands that make up the composite RGB, the colors of objects become more varied. The result of the analysis of image interpretation is the grouping of green open space in each sub-district.

The distribution of vegetation density in formal settlements in Malang City in 2022 has several classifications, namely low vegetation density, very low vegetation density, medium vegetation density, and high vegetation density. Based on this classification, Bumiayu Village has the highest area for low vegetation density, which is 14.99 Ha, Ciptomulyo Village has the highest area for very low vegetation density, which is 29.77 Ha, Bandulan Village has the highest area for medium vegetation density, which is 14.91 Ha. and Kedungkandang Village has high vegetation for a high vegetation density of 4.54 Ha. If viewed based on these data, the highest area is very low vegetation density (0.12-0.15). This shows that in the classification the vegetation land is in the form of ground cover such as empty fields or roads with soil pavement.

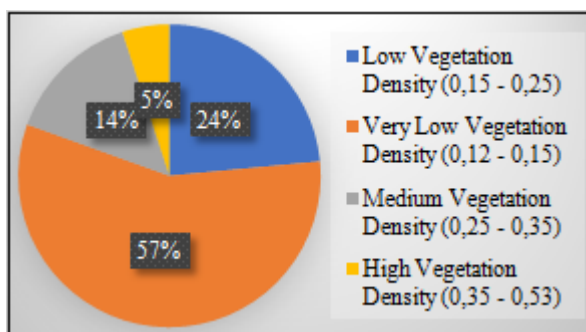


Figure 5: Image Interpretation Analysis in 2022

The NDVI results in the table above can describe the level of greenness of a plant in an area. Based on the table, it can be seen that there is a fairly varied vegetation density in each sub-district in Malang City. Kedungkandang District has the highest green open space area, which is 3978.61 Ha. Meanwhile, Blimbing District has the smallest green open space, which is 1769.67 Ha. The following is a graph of the distribution of image interpretation analysis of Malang City in 2022 based on the NDVI classification and sub-districts in Malang City.

NDVI values range from -1 (which is usually water) to +1 (heavy vegetation). Based on the graph, it can be seen that informal settlements in Malang City in 2022 are dominated by very low vegetation density of 57% and low vegetation of 24%. Meanwhile, for medium vegetation density is 14% and high vegetation is 5%. This shows that along with population growth, the area of vegetation is decreasing due to land changes from undeveloped areas to built areas. This, of course must be a special concern considering the characteristics of the land that are fixed or cannot increase in area. Based on the results of the NDVI in 2022, it shows that the area of vegetation in informal settlements is decreasing and is classified as very low and low (little vegetation). This shows that there is a need for the provision of green open space considering the obligations of a city based on Law Number 26 of 2007 concerning Spatial Planning, namely that a city area is required to have green open space of at least 30% of the city area and at least 20% is public green open space.

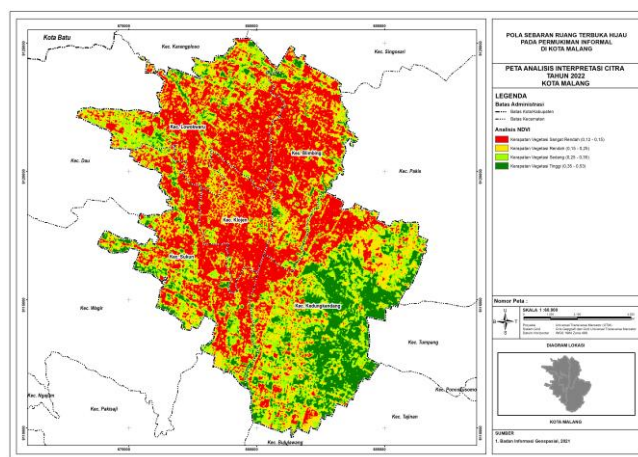


Figure 6: 2022 Image Interpretation Analysis Map Comparison of Year 2012 and Year 2022

After analyzing the image interpretation for 2012 and 2022, the next step is to compare the vegetation density in informal settlements. The following is the result of changes in vegetation density in the span of 10 years in Malang City.

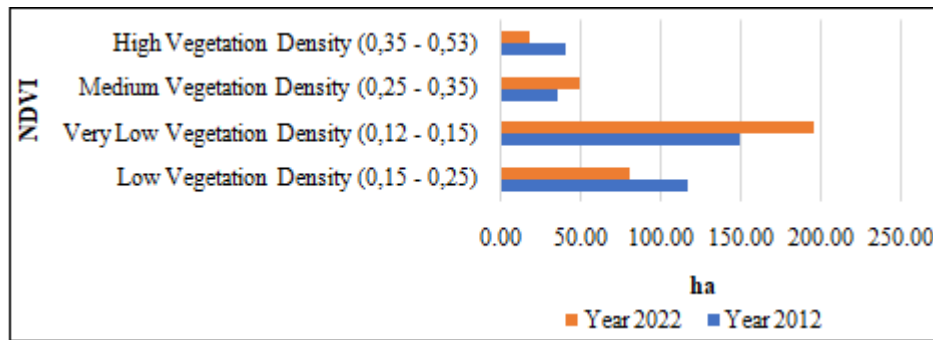


Figure 7: Comparison of NDVI Results in 2012 and 2022

Based on the graph, it can be seen that there is a reduction in vegetation area in informal settlements in Malang City. This will certainly be a serious problem if not controlled. The area of very low vegetation density will increase to 194.58 Ha in 2022. Meanwhile, the high vegetation density will decrease in 2022 to an area of 17.21 Ha. Referring to Law Number 26 of 2007 concerning Spatial Planning that a city area is required to have green open space of at least 30% of the city area and at least 20% is public green open space. Based on the results of the NDVI in 2012-2022, it shows that the area of vegetation in informal settlements is decreasing and is classified as very low and low (little vegetation). This shows that there is a need for the provision of green open space both as an ecological function as well as a socio-cultural function, an economic function, and an aesthetic function for an informal settlement in Malang City.

## 5. Conclusion

GOS is an open space with vegetation located in urban areas. Green Open Space has a function as a recreation area, socio-cultural, aesthetic, physical, ecological, and economical for humans and for the city. Harmony between informal settlements and green open space can reduce the negative impacts of environmental degradation. Given that Malang City still has green open space less than 20% of the area, it is necessary to increase the area of green open space, especially in informal settlements. The following are the conclusions from the study of the Effect of Improving the Quality of Informal Settlements on the Area of Green Open Space as follows:

- 1) The total slum area in the city of Malang is 282, 33 Ha. The largest slum area is the slum area in Mergosono Village, which is 28.37 ha. While the area of the slum area is the least, namely the Blimbing slum area.
- 2) Based on the analysis of image interpretation using the NDVI method, Kedungkandang District has the highest green open space area, which is 3978.61 Ha. Meanwhile, Blimbing sub-district has the smallest green open space, which is 1769.67 ha. Malang City is dominated by the classification of low vegetation density spread over four sub-districts, namely Blimbing, Klojen, Lowokwaru, and Sukun. Meanwhile, Kedungkandang District still has the highest area with a high vegetation density classification.
- 3) Based on the analysis of image interpretation using the NDVI method, the distribution of green open space in informal slums is as follows:

- a) In 2012, informal settlements in Malang City were dominated by very low vegetation density of 44% and low vegetation of 34%. As for the classification of medium vegetation density by 10% and high vegetation density by 12%.
- b) In 2022, informal settlements in Malang City in 2022 are dominated by very low vegetation density of 57% and low vegetation of 24%. Meanwhile, for medium vegetation density is 14% and high vegetation is 5%. This shows that there is a reduction in the area of vegetation/GOS in informal settlements in Malang City.

## 6. Other Recommendations

Based on the results that have been obtained, suggestions are needed that can be recommendations based on the limitations in this study. The recommended suggestions include the following:

1. Recommendations for the Community  
Not only the government, the community has an obligation to provide private green open space of 10% of the plot area. This can be maximized by providing vegetation on private green open space as an effort to fulfill green open space in Malang City. In addition, the provision of green open space can improve the ecological function, aesthetic function, and economic function of informal settlements in Malang City.
2. Recommendations for the Government  
Referring to Law Number 26 of 2007 concerning Spatial Planning, namely that a city area is required to have green open space of at least 30% of the city area and at least 20% is public green open space. Based on the results of image interpretation, it can be considered to provide green space according to the characteristics of green open space in formal settlements, such as river border green open space, hamlet park green open space, neighbourhood park green open space. GOS in informal settlements such as boezem and green open space in environmental parks plays an ecological role as water absorption which will affect water catchment or water storage which later can also be a source of drinking water for communities around informal settlements.

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