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Research Article

# Detection of Development and Density Urban Build-Up Area with Satellite Image Overlay

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**Abstract:** The growth dynamics of urban areas and the increase in land requirements are a series of each other influence each other The method used in this study is a quantitative method through spatial analysis using Geographic Information Systems. The purpose of this study was to see the extent to which the development of urban areas using the Urban Index (UI) method. Data analysis carried out by overlapping techniques using a map of the built area of Land Use in 2013 and the results of image interpretation for the built area in 2017. The results of the study showed that there was a percentage increase in the built area from 2013 to 2017 of 12.67%. Then from the total area of Makassar City, around 60.72% of the area built in 2013, and there was a significant increase in 2017 to 76.30%. The process of expansion of built-up land without control often impacts on the loss of land that has ecological functions and then impacts on the emergence of environmental problems. One of the things that can be done to prevent the adverse effects of the development of built land is to monitor and predict its development so that solutions can found before the adverse effects occur.

**Keywords:** Geographic Information System (GIS), Landsat 8 OLI TIRS, Land Use, Urban Index (UI), Remote Sensing.

## 1. Introduction

Regional development is an effort to encourage social development, the economy to grow well and maintain the sustainability of life through preservation and environmental balance both for the region and between regions. In line with what stated by Acemoglu [1], that basically, development cannot be separated from growth, this means that regional development can cause growth both physically and non-physically. In other words, growth can be in the form of development/distribution or improvement of activities carried out by individuals or by the community [2].

Cities that generally originate from a small spatial settlement have a strategic location for trade activities, along with the passage of time experiencing growth and development because of population growth with socio-economic and cultural levels and their interactions with other cities and surrounding areas. Physically, the development of a city can be seen from its growing population and increasingly congested, and its buildings are increasingly meeting and build-up areas, especially settlements that tend to be increasingly widespread, as well as the more complete urban facilities that support the city's social and economic activities [3].

That the city is a form of expression of human life as an acculturation of cultural, economic and social life contained in physical form, while morphology is the expression of urban spatial forms, which not only includes the display of visual products (cities as products) but also involve non-physical elements that participate in the process of change (city as a process) [4]. Urban development influenced by several aspects such as population development, progress in the economic, social, cultural, and technological fields in urban areas that will encourage improvement in living standards and levels of mobility. City morphology products can see as the result of the evolution of life-history, which is determined by two

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decisions, namely by planners and by the development process of the city [5].

The progress of a city is often associated with the development of land built because one of the physical characteristics of the development of urban areas is expanding, and more land built. It is following the theory which states that the existence of urban development can viewed from various dimensions, such as the urban morphology that emphasizes the physical aspects of the city which reflected in the system of road networks and building blocks [6].

Cities will always grow and develop in line with the social and economic life in them. Richnau [7], states that urban development influenced by three things, namely ecology, technology, and social organizations. The development of the city will also never be separated from the history of city growth, current conditions, and the growth of the city to come. The development and shape of the city is a unity that cannot separated and reviewed by the morphological pattern of the city. The phenomenon of urban development will include the development of city elements in detail, the shape of the city and the development of city regulations [8]. The city also offers a variety of facilities, ease of transportation, facilities, and infrastructure that are adequate so that it affects the population to move from village to city. In another sense, urbanization is a change in rural settlements into urban settlements which directly influences changes in the urban environment.

Regional development is synonymous with built-up land. Built land is an appearance on the surface of the earth that has undergone human interference and has specific functions for human life, limited by the physical appearance built up such as houses, factories, asphalt. Land use relates to human activities on a plot of land, while the land cover is more a physical manifestation of objects that cover land without questioning human activities on these objects [9]. Urban planning requires real-time data along with its rapid changes. Remote sensing methods can help provide the latest spatial data quickly and economically. One of the information needed is the level of building density or BCR (Building Coverage Ratio). This data can utilize in building density monitoring, monitoring the expansion of cities, searching for slum areas (slums) and other applications [10].

Identification of city morphology can make by utilizing remote sensing to find trends in the direction of development and regional development based on land use conditions in a specific time that can presented on a map so that it can compared. Remote sensing is science or art to obtain information about objects, regions, or symptoms, by analyzing the data obtained by using a tool, without direct contact with objects, regions or symptoms to analyzed [11]. Urban development that often occurs is the development of land built due to the process of expansion, namely changes in non-built land cover to built-up land [12]. The expansion process can have an impact on the loss of land that has a protected function, cultivation, and ecology so that it can lead to environmental problems.

Multitemporal analysis with remote sensing data can help in continuous monitoring of the development of the city so that it can use to predict the development of built land. Interpretation of Landsat imagery make by looking at the essential characteristics of each appearance of land use/closure in digital images which assisted by elements of interpretation [13], [14]. Remote sensing is science and art to obtain information about an object, region, or phenomenon through the analysis of data obtained with a tool without direct contact with objects, regions, or phenomena studied [15]. A sensor records objects on the earth's surface based on the reflected values of the electromagnetic waves emitted by objects on the earth's surface, and then the energy. There are three main groups of objects on the surface of the earth that can detected by sensors, namely: water, soil, and vegetation, each of which emits electromagnetic energy with the ability to map images depending on the characteristics of each satellite image. These channels and characteristics are used by remote sensing to identify objects or types of land coverage on the earth's surface [16].

Landsat TM and Landsat ETM + digital images have the same characteristics. It is just that the Landsat ETM + digital image is the latest version, with additional panchromatic channels, and a thermal channel that sharpened by its spatial resolution (enhanced thermal band). The thermal channel on Landsat TM images has a spatial resolution of 120 m, while in Landsat ETM + images the sharpening becomes 60 m. With the availability of information on the development of built-up land, it can utilize for consideration in planning a region [17], [18]. Makassar City, as the gateway to the Eastern Region of Indonesia, is exciting to predict the development of its built land because, from year to year, the expansion continues to increase.

## 2. Research Methods

### 2.1. Location

This research chose Makassar City Region as an object because besides being the largest city in eastern Indonesia but also a city of urbanization of the population. Makassar City is one of the regions in South Sulawesi Province which is geographically located precisely on the west coast of South Sulawesi at the coordinates of 119° 18' 27.97" 119° 32' 31.03" East Longitude and 5° 00' 30,18" - 5° 14' 6.49 " South Latitude with an area of 175.77 $km^2$ with the following limits:

- Northern Limit: Pangkajene Islands Regency
- South Limit: Gowa Regency
- Eastern Limit: Maros Regency
- Western Limit: Makassar Strait

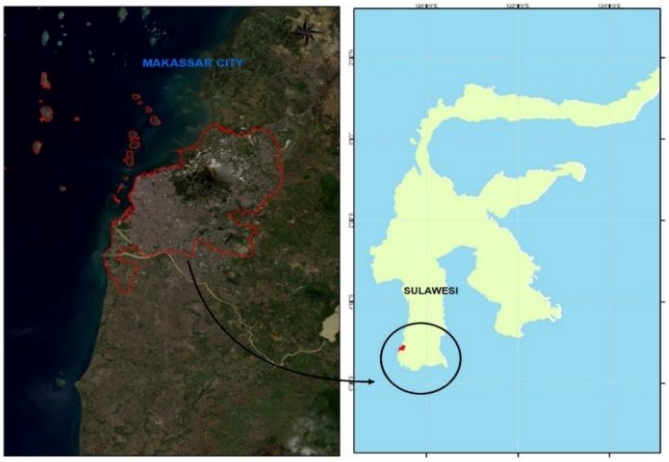


**Figure 1.** Objects Area (Makassar City)

2.2. Data Collection

The data used in this study is the Landsat 8 OLI TIRS Satellite Image with a spatial resolution of 30 meters from Makassar City (Path = 114, Row = 64). Data retrieval obtained from different times, namely on April 27, 2013, until September 13, 2017.

Landsat 8 which has Onboard Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) sensors. Landsat has 11 bands, 9 of which are in OLI and the other 2 are in TIRS. Some of the bands on Landsat have similarities with Landsat 7 satellite imagery. Landsat 8 can use to determine the density and extent of vegetation.

**Table 1.** Landsat 8 Band Specifications.

| Band | Wavelength (micrometer) | Resolution (meter) |
|---|---|---|
| Band 1– Coastal Aerosol | 0.43 – 0.45 | 30 |
| Band 2 – Blue | 0.45 – 0.51 | 30 |
| Band 3 – Green | 0.53 – 0.59 | 30 |
| Band 4 – Red | 0.64 – 0.57 | 30 |
| Band 5 – Near infrared (NIR) | 0.85 – 0.88 | 30 |
| Band 6 – SWIR 1 | 1.57 – 1.65 | 30 |
| Band 7 – SWIR 2 | 2.11 – 2.29 | 30 |
| Band 8 – Panchromatic | 0.50 – 0.68 | 15 |
| Band 9 – Cirrus | 1.36 – 1.38 | 30 |
| Band 10 – Thermal infrared (TIRS) 1 | 10.60 – 11.19 | 100 |
| Band 11 – Thermal infrared (TIRS) 2 | 11.50 – 12.51 | 100 |

According to Lo [19], Landsat is a result of an earth resource program developed by NASA (The National Aeronautical and Space Administration) of the United States in the early 1970s. Landsat launched on July 22, 1972, as ERTS-I (Earth Resources Technology Satellite-I) which later renamed Landsat 1.

2.3. Data Processing and Analysis

Urban Index (UI) first proposed by Kawamura [20] based on computing using Landsat 5 TM band 7 (B7) and band 4 (B4), exploited observed inverse relationships between brightness of urban areas in the near-infrared (0.76 μm - 0.90 μm) and mid-infrared (2.08 μm - 2.35 μm) portions of spectrum [21]. Formula 1 is an urban index formula (urban index/UI).

$$\mathrm{UI} = \left[\frac{B7 - B4}{B7 + B4} + 1\right] \times 100 \quad (1)$$

Urban Index (UI), B7 is channel 7 (middle infrared II), and B4 is channel 4 (near-infrared). On channel 7, the object that has the highest spectral reflection is the dry land object. On channel 4, the object that has the highest spectral reflection is the vegetation object. From the urban index formula, the object of the building will look bright with a high urban index, and the object of vegetation will appear dark with a low urban index.

## 3. Results and Discussions

Land built in urban areas is an exciting thing to study. Coupled with the dynamics of land use in urban areas that are very fast-changing. Various methods developed for urban land extraction, starting from a multispectral, object-based approach to index-based research. Urban indexes can use to detect building density well. As the results of the study Kawamura [20], indicate that a significant positive correlation exists between urban indexes and building density. Land built in Makassar City using Urban Index (UI) can see in Figure 2 and 3.


**Figure 2.** Built-Up Area by Urban Method Index Makassar City in 2013 and 2017


**Figure 3.** Built-Up Area by Urban Method Index Makassar City in 2017

Figure 2 and 3 shows the built area in Makassar City from 2013 to 2017 more developed in the northern area (Biringkanaya sub-district) and southeast of the city (Manggala sub-district). Biringkanya area which is the largest area or sub-district in Makassar with 48.22 km2. The area included in the category of Business, Industry and Education Regions as well as densely populated settlements.

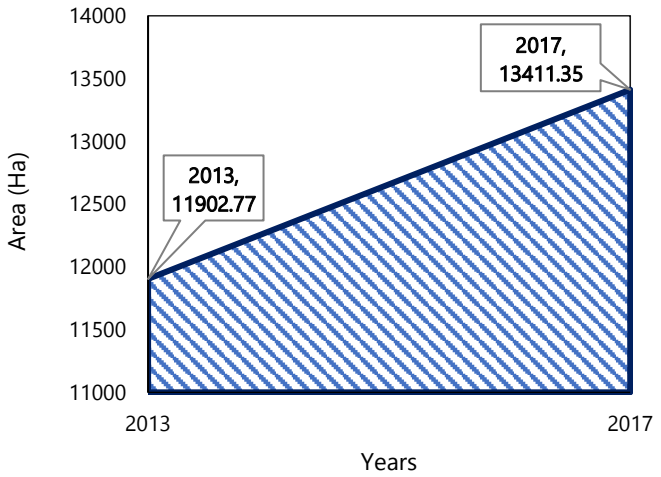


**Figure 4.** The Area of Land Built-in Makassar City in 2013 and 2017 (Ha).

Figure 4 is the area of land use and land cover through the Urban Index (UI) method, which shows that in 2013 the area built covering an area of 11902.77 hectares, but significantly in 2017, the area of use increased to 13411.35 hectares. These results show that there was a rather drastic increase of around 12.67% from 2013 to 2017. The increase was a result of economic growth and the development of the urban area.

Development in urban areas continues to grow, which accompanied by an increasing population. This increase has an impact on the growing need for urban space. It causes the area to build in urban areas to increase and the open space to decrease to encourage the use of paddy fields as residential areas and offices [22]. Therefore, it is necessary to do a study or evaluation through spatial analysis to determine changes in the use of paddy fields in the city in a certain period [23]. The spatial pattern of growth in an industrial, business and residential area when viewed from the aspect of dynamics of regional growth and increasing land demand, can be reduced to several variables, namely economic dynamics related to the level of community welfare, political dynamics associated with regional policies that can affect spatial patterns the region and the socio-cultural dynamics, namely its influence on the characteristics of the community as the spearhead of the activities [24]. The three variables above are a basis that can influence each other in an urban system. The process of interaction of the three variables can form a pattern of interrelated relations that can describe the spatial pattern of housing growth in a region. When viewed more closely, the influence of the three variables into the structure of urban space, where there is functional interdependence of areas such as one part of the region serves as a servant for other areas [25]–[27].

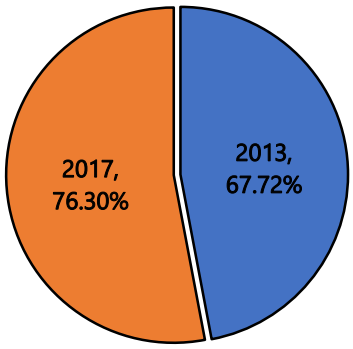


**Figure 5.** Percentage of Built-in Area from the Area of Makassar City in 2013 and 2017.

Figure 5 shows that there has been a significant increase around construction between 2013 and 2017. It can see from increasing the percentage of built-up areas in Makassar, which only started around 60.72% of the total area of Makassar in 2013 and then expanded to 76.30 %. Looking at the map of Makassar City, it is evident how little the green land is, indicating a lack of green open space. In fact, based on the Earth Conference in Rio de Janeiro, Brazil 1992 and reaffirmed at the Johannesburg Summit in South Africa 10 years later in 2002, it agreed that a city should ideally have a minimum green open space of at least 30% of the total city area [28], [29]. However, it seems that for cities in Indonesia, including Makassar City, it will generally be challenging to realize due to continued growth

pressures and the needs of urban facilities and infrastructure, such as building construction and the development and expansion of road lines that continue to increase and increase in population. Green Open Space development activities are inseparable from the spatial planning policies and plans contained in the Regional Spatial Planning and Detailed Spatial Planning of Makassar City.

The maintenance of Green Open Space currently not maximally and effectively implemented so that the extent and quality of Green Open Space continue to decline [30]. A process of regional development is very influential or directly related to the environment in an area. The most specific influence is on the housing and settlement environment so that the above variables can lead to a tendency towards a pattern of housing and residential area patterns [31]. That the trend of spatial patterns or spatial patterns of regions formed at the level of spatial structure can be viewed from the morphological approach of the city, where this approach is one approach that relates to aspects of land use in a region that shows variations in spatial expressions or spatial expressions. It aims to describe the pattern of space formed so that it can help deal with problems of accuracy and change in city design and help determine the guidelines for basic guidelines in a city environment design. From this context, it can conclude that the trend of the pattern of space for residential and residential areas could be reviewed based on 2 (two) variables, namely a review of land use patterns and spatial expressions of urban areas [32]. The demand for urban land use that continues to grow and is accelerative for the construction of various municipal facilities, including advances in technology, industry, and transportation, besides frequently changing the natural configuration of urban lands/landscapes also seizes these lands and various other forms of open space. These urban spaces arranged in a related and mutually sustainable manner have multiple approaches to planning and development. Land use, transportation systems, and utility network systems are the three main factors in managing urban space [33]. In further developments, the concept of urban space in addition to linked to the main urban problems that will seek for solutions also associated with achieving the goal of spatial planning, namely for the welfare, comfort, and health of citizens and their cities. The city's green open space has many functions, such as recreational areas, socio-cultural, aesthetic, city physical, ecological and has high economic value for humans and the development of the city [34], [35].

## 4. Conclusions

The increasing land use seen from the built-up area obtained from satellite imagery is getting higher. From this, it can see that the existing land use management conditions have not well planned and what happens later is that the allotment of land is not following the current spatial and regional plans. If this not managed correctly, then undue land use will occur.

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