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Monitoring the Built-up Area Transformation Using Urban Index and Normalized Difference Built-up Index Analysis

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ABSTRACT

Makassar is one of the metropolitan cities located in Indonesia which recently experiences massive an increased construction because of population growth. Mapping the spatial distribution and development of the built-up region is the best method that can use as an indicator to set the urban planning policy. The purpose of this study is to identify changes in land use and density in Makassar City that occurred in 2013 and 2017 primarily for built areas, including settlements using optical data, especially Landsat data. The data analyzed by using multi-temporal Landsat OLI 8 data taken from 2013 to 2017. Normalized Difference Built-Up Index (NDBI), Urban Index (UI) and Normalized Difference Vegetation Index (NDVI) are the spectral indices produced from Landsat OLI band covering Short Wave Infrared (SWIR) wavelength, visible Red (R) and Near Infrared (NIR) areas that can be revealed by examining changes in land use and area cover. The result shows that both spectral indices namely NDBI and UI indicate an increased built-up area approximately 18 and 6%, respectively over four years. Also, based on NDBI reveals that most an increased built-up area distributes in the north of Makassar (Biringkanaya sub-district), meanwhile UI shows that Biringkanaya and Manggala sub-districts experience an increased built-up area. The development of the city will also never be separated from the history of city growth, current conditions, and the growth of the town to come. The phenomenon of the development of the town will include the development of city elements in detail, aspects of the shape of the town and the development of city regulations.

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1. INTRODUCTION

Identification of overall building density development, when built terrestrially, requires considerable time, cost, and energy so that it is over useful and straightforward to utilize remote sensing imagery [1]. The use of remote sensing imagery in urban management has several advantages such as relatively fast data obtained, reliable data validity, and relatively affordable technology [2].

Land use and land cover are factors that play a significant role in changing environmental conditions such as climate change, global warming, deforestation, urbanization and natural disasters [3]. Urbanization is one of the factors that triggered the increase of built-up areas in municipal region significantly and influences land use change and land cover on a large scale. It happens because the metropolitan area is the center of the economic activities of society such as transportation, industry, offices, and shopping [4].

Like cities in other developing countries, Makassar City has experienced substantial property protection changes due to the fast advance of the population directly affecting the high activity and human needs such as housing, transportation facilities, shopping centers, government, education and industry. According to Maru et al. [5], that now there has been an increase of Makassar's built area by 15.2% in the last 5 years. On the other hand, however, while the increase in municipal zones is a benchmark of fiscal, community, and political

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situation, growth in building area, can directly reduce the size of forests, farmlands, plantations, and parks [6].

Indicator mapping built in municipal region is essential because this type of land cover can use as an indicator of town expansion and ecological quality level [7]. The procedure of mapping and analysis using different spectral techniques and values based on land use categories. In general, land use plotting uses multispectral classification methods, but several ways utilize remote sensing index applications [8].

Research using several remote sensing index methods was conducted by Chen et al. [9]. In a study comparing the temperature relationship with NDVI, Normalized Difference Water Index (NDWI), Normalized Difference Bareness Index (NDBaI) and Normalized Difference Construction Indicator, evaluate the connection among land cover change and Urban Heat Island (UHI) effect by NDBI. From this study, it found that there was a negative correlation when NDVI was incomplete between NDVI, NDWI, NDBaI, and temperature, but a positive affiliation gained for NDBI and temperature.

Other studies undertaken by Zha et al. [10], using the NDVI and NDBI methods for mapping the area constructed successfully allocated concluded arithmetical management. The results obtained indicate an accuracy of 92.6%. The technique can use for mapping areas that created objectively and accurately. Research using a variety of remote sensing methods is reported in literature [11–13].

Transformation aims to sharpen specific information as well as suppress or eliminate other details. Some of the changes that can use to identify building densities are the NDBI and Urban Index transformations. Both conversions have different sensitivities in identifying building density [14]. The translation used expected to produce information that can represent the conditions in the field.

A compelling image transformation model for distinguishing building materials with natural materials typically utilizes near, mid, and remote infrared channels. This channel is sensitive to differences in building materials and natural materials such as water, vegetation, and open land [15]. The circuits used in the NDBI and Urban Index transformations are different. The frequencies used in the NDBI change are near far infrared and far infrared channels while the circuits used in the Built-up Index alteration are near far infrared and infrared canals [13]. The use of Geographic Information System (GIS) has evolved into a wide range of information that can integrate with spatial data.

This paper was conducted to map the circulation and recognition of the growth of the developed area using a mixture of Urban Index (UI) and NDBI approaches that can be used to detect the built and non-built areas, while the NDVI used to detect vegetation and non-vegetation by utilizing satellite descriptions taken from Landsat OLI 8 on changed times. In this research, we shall try to compare the most accurate method in a mapping of built area and try to see the development of wake area in the last four years that is from the year 2013 until the year 2017 by using overlay technique.

2. MATERIAL AND METHOD

2. 1. Study Area This investigation conducted in Makassar City which located on geographical location 119º24'17'38" East Longitude and 5º8'6'19" South Latitude. The map of study area of Makassar City is shown in Figure 1.

2. 2. Data Collection This research utilizes Landsat 8 OLI TIRS satellite image data as the primary data with a 30-meter spatial resolution of Makassar City (Path = 114, Row = 64) taken with the time difference that is 27 April 2013 until 13 September 2017. As for the spectral wavelength ranges and the spatial resolution bands of the data obtained from research by Iron et al. [16].

2. 3. Data Analysis

2. 3. 1. Normalized Difference Built-up Index (NDBI) Charting of built regions must apply satellite imagery using the NDBI technique [10]. It is because the index method generally developed for spectral analysis of Landsat Enhanced Thematic Mapper Plus (ETM +) data on bands 3, 4 and 5 of Landsat series 5 and 7 while for Landsat series 8 using bands 5 and 6 which can detect differences in various types of cover clear land such as forests, agriculture, plantations, open areas, and inland waters. Build and open spaces have increased reflectance values from bands 4 to 5 but for vegetation have a smaller Digital Number (DN) in band

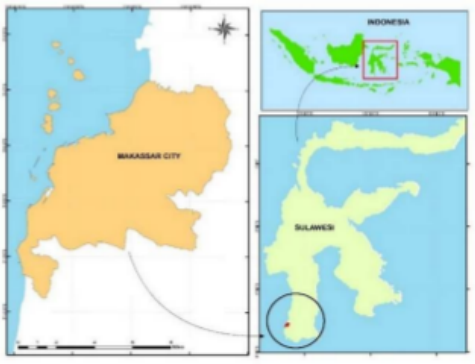

Figure 1. Research area, Makassar City, South Sulawesi Province

four than band 5. It can be used to classify the growing region from other regions [17].

2. 3. 2. Urban Index (UI) Urban Index (UI) was first introduced by Kawamura et al. [18], based on a computer system using Landsat 5 TM band 7 (B-7) and band 4 (B-4) to utilize the brightness relationship of urban areas with the near infrared (0.76-0.90 μm) and mid-infrared (2.08-2.35 μm) spectrum.

2. 3. 3. Vegetation Indices (VI) Vegetation Indices separated into NDVI, EVI, SAVI, and MSAVI. This product comes from the results of 30-m spatial resolution analysis on Universal Transverse Mercator (UTM) or Polar Stereographic (PS) mapping grid. Temporal coverage varies based on sensor selection [19].

2. 3. 4. Normalized Difference Vegetation Index (NDVI) NDVI can calculate based on a proportion among the red (R) and NIR (Near-Infrared) values in conventional method. The imagery used to determine the greenish level, which is very good as the beginning of the division of the vegetation area. NDVI has values ranging from -1.0 to +1.0 [17]. Values greater than 0.1 usually indicate an increase in the degree of greenness and intensity of the vegetation.

3. RESULT AND DISCUSSION

3. 1. Mapping the Built-Up Area and Non-Vegetation Area Tables 1 and 2 show the built-up area of each remote sensing indices. The results indicate that in 2013 the city of built/non-vegetation is 9169.19 Ha, although the NDBI displays different outcomes where space is 3523.78, while Urban Index (UI) is 11902.77 Ha. The wake area of each remote sensing index in Table 2.

While in 2017, shows that the area of built and non-vegetation area based on NDVI is 12640.99 Ha, while based on NDBI the space of a built area is 3523.78 Ha, while according to Urban Index the space of a built area is 13411.35 Ha. The district made from each remote sensing index can see in Table 3. The distribution of built areas based on each remote sensing index from 2013 to 2017 can see in Figures 2 and 3.

TABLE 1. The accumulated built-up area of the remote sensing index in 2013

Remote Sensing Indices	Built up/Non-vegetation area (Ha)
NDVI	9169.19
NDBI	3523.78
UI	11902.77

TABLE 2. The accumulated built-up area of the remote sensing index in 2017

Remote Sensing Indices	Built up/Non-vegetation area (Ha)
NDVI	12640.99
NDBI	5101.90
UI	13411.35

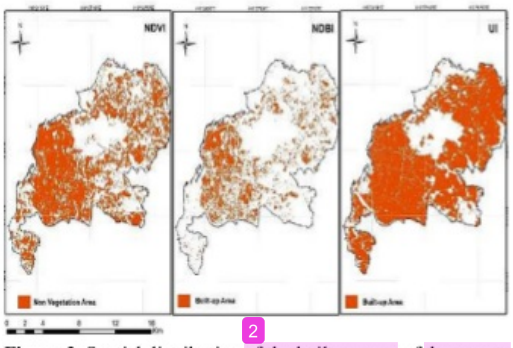

Figure 2. Spatial distribution of the built-up area of the remote sensing index in 2013

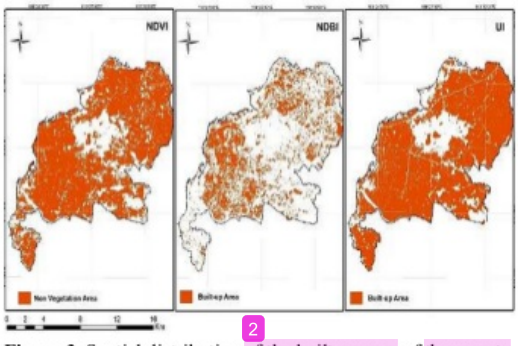

Figure 3. Spatial distribution of the built-up area of the remote sensing index in 2017

3. 2. Mapping the Non-Built Up Area and Vegetation Area Tables 3 and 4 show the extent of the non-built up zone of each remote sensing indices. In this study indicates that 2013 the city not built and the green space based on NDVI analysis is 8335.76 Ha, and the UI analysis is 5605.70 Ha, while the different results show NDBI analysis that the area of an unbuilt area is 13983.98. The non-build-up area of each remote sensing index in 2013 can be observed in Table 3.

While the year 2017, indicating that the area not built and the green space based on the results of NDVI analysis is 4865.11 Ha, while based on the results of UI analysis shows that the city is 4093.17 Ha, while the

TABLE 3. The accumulated non-built-up area of the remote sensing index in 2013

Remote Sensing Indices	Built up/Non-vegetation area (Ha)
NDVI	8335.76
NDBI	13983.98
UI	5605.70

different results indicated from the NDBI analysis states that the district not built is 12406.08 Ha. The non-build-up area of each remote sensing index in 2017 summarized in Table 4.

3. 3. Comparing the Transformation of the Built-up Zone, NDBI and Urban Index (UI) Mapping of built regions using various index analyzes has widely used NDBI and UI analyzes. This study will try to compare changes in the areas constructed from 2013 to 2017 wherein Figure 4 showed that in 2013 the area made based on NDBI analysis is 3523.78 Ha and based on the UI analysis is 11902.77 Ha, whereas in 2017 the city built based on NDBI analysis is 5101.9 Ha and UI is 13411.25 Ha. The percentage of area expansion based on NDBI and UI analysis from 2013 to 2017 can see in Figure 4.

TABLE 4. The accumulated non-built-up area of the remote sensing index in 2017

Remote Sensing Indices	Built up/Non-vegetation area (Ha)
NDVI	4865.11
NDBI	12406.08
UI	4093.17

Overlay technique is one way that used to see the comparison of spatial data. The result of map overlay on each remote sensing index analysis shows that based on NDBI Makassar City from 2013 until 2017 it indicated that there is an increase of 18% wake area where the most dominant area development occurred in the northern part of Makassar City namely Biringkanaya Sub-district. While the result of UI analysis shows that the development of Makassar built area from 2013 until 2017 is 6% where the increase of the built-up region mostly occurs in the northern part of Makassar City which is Biringkanaya Sub-district, and there is also the development of the wake area in the eastern part of Makassar City namely Manggala Sub-district. The result of NDBI and UI overlays also indicates that there is an increase in the area activity built around Losari Beach where this area is an area that is a coastal reclamation project of Makassar City government.

The results of NDBI and UI overlay analysis shown in Figure 4. IDBI remote sensing index analysis shows that there is an increase of wake area in Makassar from 2013 to 2017 by 18%, while UI analysis although showing different result but still indicates an increase of built area of 6% during four years.

It is known that some vegetation indexes obtained from remote sensing could use in assessing vegetative cover in both quantitative and qualitative ways such as the NDVI. NDBI has also developed for open land and open land. Both indices have commonly used in different regions to delineate land cover. Therefore, the use of NDVI and NDBI can represent the type of land cover quantitatively [9].

As the outcomes of the explore [18], indicate that urban index can use to detect building density well and form a substantial positive correlation between urban index with building mass. The public index indifference

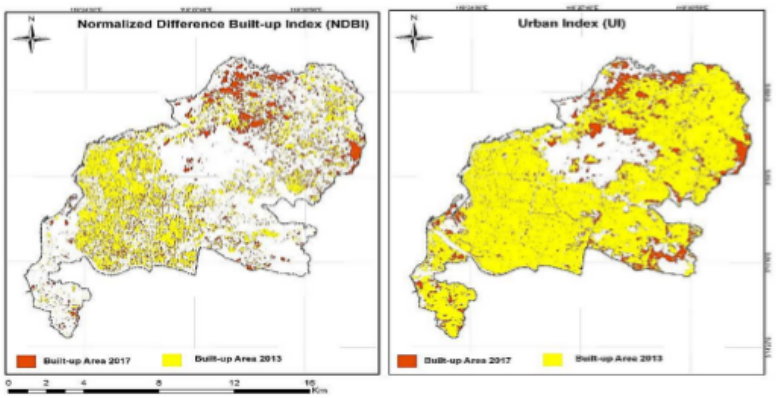

Figure 4. Overlaying spatial sharing of built-up area between 2013 and 2017

to the NDVI (vegetation index), as evidenced by the formation of significant negative relationships between the two. It is quite understandable below the hypothesis that areas with a higher density of buildings mean less vegetation. The urban index based on Landsat TM channels 7 and 4, whereas NDVI bases on channels 4 and [20].

According to Yüksel, et al. [21], surface heterogeneity makes precise map processing in built-up landscapes more difficult. By increasing the spatial resolution increases the precision of remote sensing in shooting minor objects on different surfaces in municipal region [22].

But, the accuracy of such methods can decrease on very complex surfaces which will create problems in dividing urban areas into common types of use and activity on land that grounded on the spectral values of each pixel [23].

According to Huete et al. [24], that the occurrence affected by the saturation of NDVI because the NDVI values are becoming increasingly like the higher surface vegetation values. For such events, it will become very complicated depending on the difference of sensors in the NIR and the red reflectance used to lower the NDVI.

The development of urban areas is heavily influenced by population growth, form and location of cities and city functions on the periphery. The development of metropolitan regions influenced by attracting factors such as employment, health, education, so that the urban population grows, both to stay forever temporarily. It will also affect public space requirements. The city can develop well if there is an interaction between the people with the alignment of urban spatial planning and compliance in the enforcement of existing spatial regulations. Population development and improvement of the city's economy resulted in changes in urban land use that would change the urban spatial layout.

Meanwhile, research by Maru et al. [5], showed that from 1990 to 2010 there has been a variation in land use from cultivation to a settlement area of approximately 23.91%, According to Law article no. 26, year 2007 about green open area, that park city that is at least 30%, with 20 percent of green open spaces public and 10 percent is open space private green. A very significant increase in built areas can cause problems, one of which is an increase in temperature in municipal region. The results of the study in detecting the phenomenon of UHI of Makassar City found that June and May are the hottest months where city temperatures reach the range of 29-31 degrees Celsius, this occurs due to the decreasing of vegetation, the increasing development of the business area, settlements and offices as well as the increasingly large parking area. In general, an increase in the area built in municipal region can significantly affect the temperature conditions of the city.

Urbanization associated with population and economic growth is a primary cause of changes in land use or land cover. Such changes will bring about changes in the average air temperature in the city, where the reduced vegetation replaced by the developed lands will trigger the contrast of surface radiance and air temperatures in municipal region when compared to rural areas [25]. Land needs become the most crucial factor in the expansion of the region or urban areas in assembly the needs of its residents in the settlement. It resulted in the rapid increase of population in Makassar City causing limited availability of land. Physical development of the city that always happens always, causing land that previously became agricultural land to switch functions to place settlements, offices, and other needs.

Information on land use and its alterations enact a significant part in assign the dynamics of changes in land use. The method of computers in digital image processing provides many advances in process, analysis, decision making and generate new data used for object identification while improving image data accuracy [26–27]. SIG can change existing digital data, may not be in the form of maps to a known format, and then utilized [19, 28].

4. CONCLUSION

Part mapping was built apply Remote Sensing Index Technique such as Urban Index and NDBI is the best way to classify the built-up area and non-built up areas, although it can give different outcomes and precision different too. The effect of NDBI analysis shows that Makassar built area has increased about 18% in the last four years, while UI analysis result indicates that Makassar built area increased by 6% from 2013 until 2017. Land use is a kind of human effort gradually and periodically to meet the needs of his life, both material and spiritual by utilizing the so-called land resources. Thus, the use of land is the result of human activities that affected by the state of nature (physical environment) as well as socio-economic activities and culture of a region's community.

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چکیده

مک کاسر یکی از شهرهای بزرگ اندونزی است که به دلیل رشد جمعیت، به دلیل افزایش جمعیت، ساختمان های بزرگی را به وجود آورده است. نقشه برداری توزیع فضایی و توسعه منطقه ساخته شده بهترین روش است که می تواند به عنوان شاخص برای تعیین سیاست های برنامه ریزی شهری استفاده شود. هدف از این مطالعه شناسایی تغییرات در استفاده و تراکم زمین در شهر ماکاسار است که در سالهای ۲۰۱۳ و ۲۰۱۷ رخ داده است که عمدتا برای مناطق ساخته شده است، از جمله شهرک سازی با استفاده از داده های نوری، به ویژه داده های لندست. داده های مورد تجزیه و تحلیل داده ها با استفاده از داده های ماهواره ای Landsat OLI 8 چند ساله از ۲۰۱۳ تا ۲۰۱۷ گرفته شده است. شاخص NDBI، شاخص شهری ((UIو شاخص پوشش گیاهی (Normalized Difference Vegetation Index) (NDVI) شاخص های طیفی تولید شده از گروه Landsat OLI پوشش موج کوتاه موج مادون قرمز (SWIR) مناطق سرخ و مناطق مادون قرمز نزدیک (NIR)را می توان با بررسی تغییرات در استفاده از زمین و پوشش منطقه نشان داد. نتیجه نشان می دهد که هر دو شاخص طیفی یعنی NDBI و UI نشان دهنده افزایش تقاضای مسکن در حدود ۱۸ و ٦ درصد به ترتیب بیش از چهار سال است. همچنین براساس NDBI نشان می دهد که اکثر منطقه افزایش یافته در شمال مازار بخش فرعی (Biringkanaya)توزیع می شود، در عین حال UI نشان می دهد که مناطق فرعی Biringkanaya و Manggala منطقه افزایش یافته را تجربه می کنند. توسعه شهر نیز هرگز از تاریخ رشد شهر، شرایط فعلی و رشد شهر پیشی نخواهد گرفت. پدیده توسعه شهر شامل توسعه عناصر شهر به تفصیل، جنبه های شکل شهر و توسعه مقررات شهرستان است.

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