Media Komunikasi FPIPS
Volume 21 Number 1, April 2022, pp. 74-82
DOI: http://dx.doi.org/10.23887/mkfis.v21i1.43007
Open Access: https://ejournal.undiksha.ac.id/index.php/MKFIS/index

Comparison Normalized Dryness Built-Up Index (NDBI) with Enhanced Built-Up and Bareness Index (EBBI) for Identification Urban in Buleleng Sub-District

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Article history: Received 14 January 2022; Accepted 31 March 2022; Available online 01 April 2022

Abstract

The research aims to determine how much accuracy is improved in developing settlements and distinguish the areas built up and vacant land in Buleleng, Bali district. This study used remote sensing methods to monitor and detect changes in the waking area using Landsat 8 OLI imagery. Identify settlement developments using the Normalized Difference Built-up Index (NDBI) and Enhanced Built-Up and Bareness Index (EBBI) algorithms. Both algorithms use red and infrared bands as the basis for identifying building differences. As a result, NDBI and EBBI have differences where the accuracy of EBBI is higher than NDBI by 84% and 82%. The difference in accuracy is influenced by the appearance of vegetation and clay-roofed buildings. Based on that, it can be concluded that in identifying the building, EBBI has a higher capacity compared to NDBI, but it must be ensured that in the use of EBBI, the area studied has a more dominant appearance of the building.

Keywords:
Landsat 8; NDBI; EBBI.

1. Introduction

Regional development is a condition or the living needs of the population to live. Regional development occurs through continuous urbanization in urban areas. One of them is the regional development in Buleleng, and this can be seen from the birth rate of Buleleng District in 2009 of 5.63 people and 2012 by 8.56 people (BPS Kabupaten Buleleng, 2021) from the data the number of residents annually increased to cause land cover. Therefore, monitoring is needed to determine how much accuracy increases in the region's development by using remote sensing methods to distinguish the built area and vacant land in the Buleleng sub-district. This remote sensing capability is supported by spatial resolution conditions and appropriate channels for monitoring urban change (Sutanto, 1986). In addition, remote sensing advantages can monitor changes in coastlines, surface temperature measurements, and urban heat islands (Hasan dkk., 2019; A Sediyo Adi Nugraha & Atmaja, 2020).

Thus, methods in remote sensing to identify land cover use the Normalized Difference Built-up Index (NDBI) and Enhanced Built-Up and Bareness Index (EBBI) algorithms. The two algorithms were compared to determine the accuracy of the development of built-up areas and land cover with the population growth rate in the Buleleng Subdistrict. Rahman & Nugraha (Rahman & Nugraha, 2021) states that the NDBI algorithm has the advantage of providing accurate information such as patterns and location of the distribution. This NDBI method is expected to assist city development planning activities in preparing the Regional Spatial Plan (RTRW). Disadvantages in NDBI are limitations of development that in general can only map urban areas, such as industrial areas, commercial, and urban housing can not be separated.

While the EBBI algorithm has the advantage of being very effective in distinguishing built-up areas and vacant land, which is one of the main limitations of applying the built area index, it is based on remote sensing data. The use of three infrared channels (NIR, SWIR, and TIR) that reflect contrast differences in detecting built-up areas, vacant lots, and vegetation is responsible for a high degree of accuracy compared to other awakened region indices. Therefore, this study aims to find out the development of existing regions with an increasing growth rate by using two methods to compare the accuracy of region changes.

2. Methods

2.1 Study Area

The study was conducted in Buleleng Subdistrict, which is located at 08°03'40" LS - 08°23'00" LS and 114°25'55" BT- 115°27'28" BT (Figure 1). Based on Census data (BPS Kabupaten Buleleng, 2021), Buleleng is a district that experiences an increase in population every year that can be known from the birth rate of Buleleng District in 2009 of 5.63 % people and 2012 by 8.56 % people (BPS Kabupaten Buleleng, 2021). Buleleng District is used as a research location because Buleleng is one of the educational cities, so that the development of Buleleng city has increased (Rahman & Nugraha, 2021).

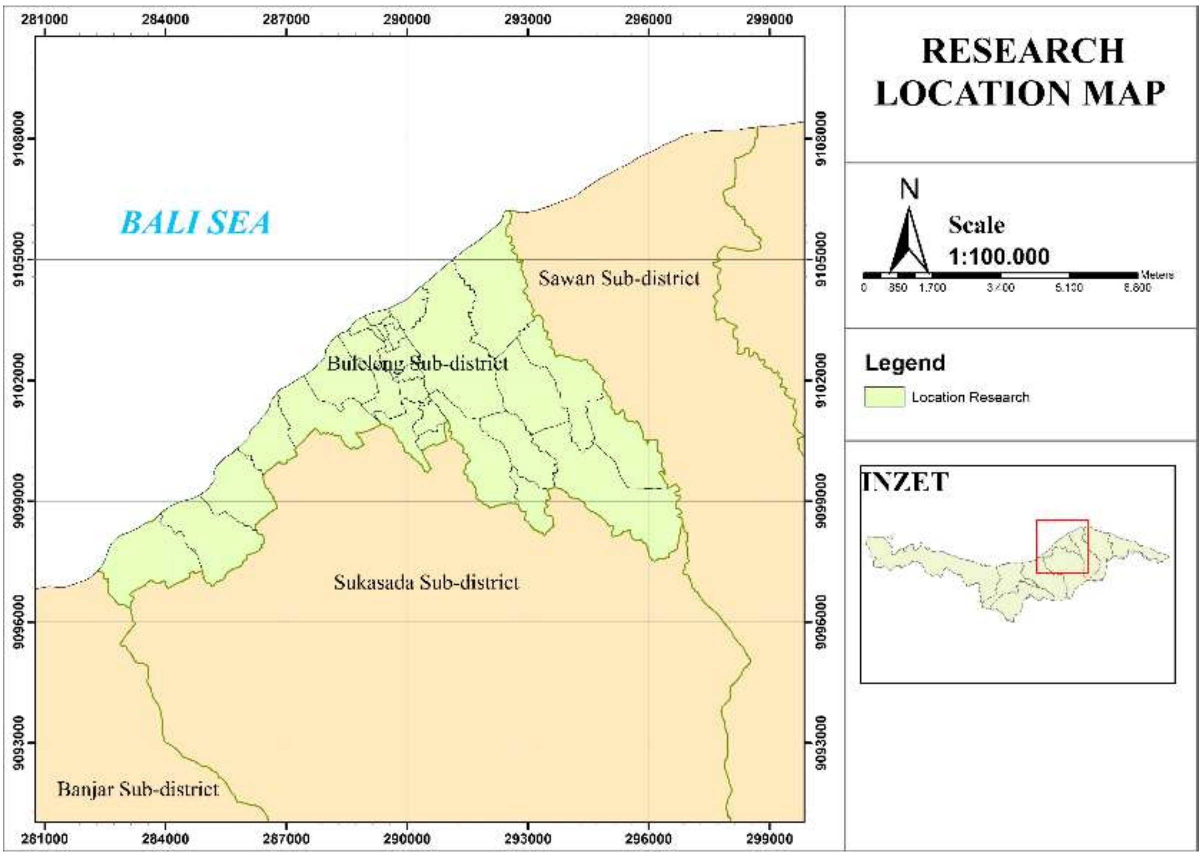

Fig 1. Study Area Map

2.2 Remote Sensing Data

The study used remote sensing methods to monitor and detect changes in the built-up region using Landsat image 8 OLI. This image carries two primary sensors, namely operational land imager (OLI) sensor and thermal infrared sensor (TIRS), with the number of bands 1-9 in OLI and two bands (Band 10 and Band 11) on TIRS (Department of the Interior U.S. Geological Survey, 2016). In managing data on Landsat 8 sensors are used, namely Operational Land Imager (OLI). Then, in this remote sensing data, before processing Landsat 8 OLI / TIRS image data, it is necessary to do the pre-processing process. Pre-processing on Landsat images includes; radiometric correction, geometric correction and atmospheric correction, and cropping.

2.3 Radiometric Correction

Radiometric correction is used to correct pixel values to match what they should be, taking into account atmospheric disturbance factors as the primary source of errors (Habib, 2007; A Sediyo Adi Nugraha, 2016). This radiometric correction uses channels (Band 2, band 3, band 4, band 5, band 6, band 7), and on this channel is carried out the process of changing from digital number to reflectance value, then continued the Top of Atmosphere (TOA) process. This radiometric correction uses the TOA (Top of Atmosphere) data, then corrected into pixel values.

There are two things in the process stage in Landsat imagery, namely pre-processing and processing, as shown in Figure 1.

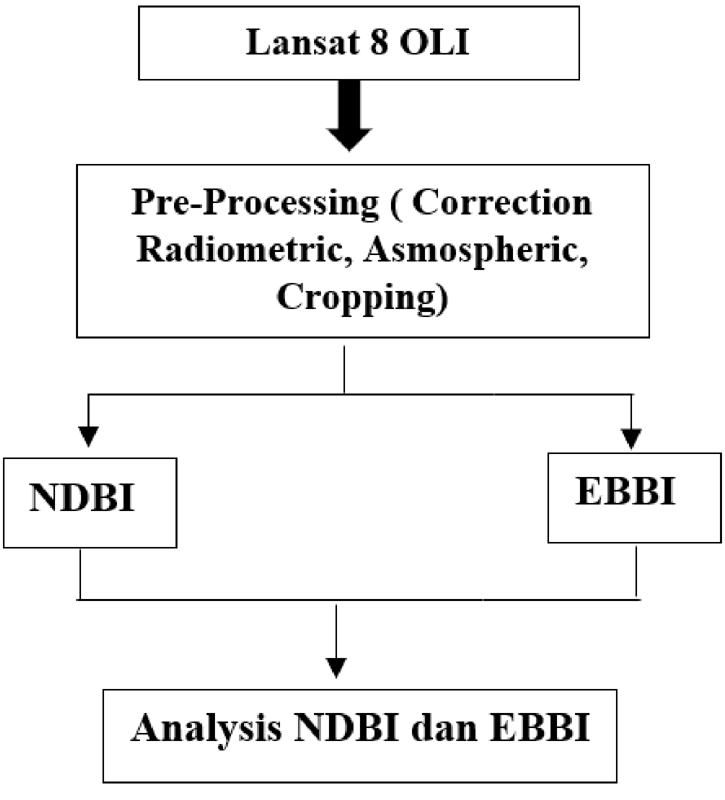

Fig 2. Research Flowchart

2.4 Atmospheric Correction

This method is used to perform atmospheric correction, known as the relative atmospheric correction method developed by Chaves (Chavez, 1988). This atmospheric correction was done by the Dark Object Subtraction (DOS) method. That has been done on channels 2,3,4,5,6,7. There is no atmospheric correction in thermal channels because the radians will be later converted into Brightness Temperature values (A. S.A. Nugraha dkk., 2019; A Sediyo Adi Nugraha, 2019a, 2019b). In atmospheric correction, this uses pixel values as correction values due to atmospheric disturbances caused when recording images. Below is an algorithm used to perform atmospheric corrections shown in equation (1).

DOS = band – (Mean – (2*Standard Deviation)..(1)

2.5 Normalized Difference Built-Up Index (NDBI)

NDBI (Normalized Difference Built-up Index) or built-up land index is an algorithm for showing the density of bare soil (Guo, G. et al., 2015). NDBI is very sensitive to open or vacant land, so this algorithm is often used to check the Built-up index. NDBI in Landsat 8 image uses SWIR and NIR channels. The merging of Band Math on bands six and five images is done to find out the existing vegetation index. The vegetation index combines several bands that can accentuate aspects of chlorophyll concentration and produce information related to vegetation density. James B. Campbell (James B. Campbell, 2011) states that the phenomenon of absorption of red light by chlorophyll (0.4 μm - 0.7 μm) in vegetation and near-infrared light reflection by mesophilic tissue (0.7 μm -1.1 μm) in leaves will make a difference in brightness values. Therefore, the transformation of the selected vegetation index is one involving red ducts and infrared channels. The Normalized Difference Index is selected to see the maximum value of one band and the minimum value used in another. For example, the combination of NIR1 and Red, then mathematically the highest reflection in infrared NIR channel one will be reduced on the red channel. The NDBI algorithm is shown in equation (2) and the formula used.

NDBI = (NIR-SWIR)/(NIR+SWIR)..(2)

The NDBI on this Landsat 8 image uses SWIR and NIR channels, merging band five and band 6. NIR is the near-infrared spectral band of Landsat 8 OLI, and SWIR is the short-wave Infrared spectral band of Landsat 8 OLI.

2.6 Normalized Built-Up and Bareness Index (EBBI)

The Enhanced Built-Up and Bareness Index (EBBI) is a remote sensing index that applies wavelengths. This method is almost the same as NDBI, only the algorithm used is different, and the results of red and infrared light reflection also experience differences. In EBBI, wavelengths are selected based on the range of contrast reflection and absorption in built-up and vacant land. The reflectance value of the awakened area is higher because the longer wavelength is associated with a high degree of contrast to detect awakened areas and vacant land. EBBI algorithm shown in equation (3)

EBBI = (SWIR1-NIR)/10√(SWIR1+TIRS1)..(3)

3. Result and Discussion

Population growth in 2000, the number of settlements reached 628.2 hectares, while in 2019 increased to 1891.8 hectares (Rahman & Nugraha, 2021). Increased population growth usually occurs due to the movement of residents from other sub-districts and from outside Bali province that wants to improve their economy. The Buleleng district is referred to as the city of Education. However, the Buleleng district development of tourism is also significantly intensified so that the development of settlements will increase over time. The increase in population certainly increases the land of settlements. Thus, this needs remote sensing methods to determine how much accuracy is in the development of settlements and distinguish the built area and vacant land of Buleleng subdistrict, Bali. Here are the results of remote sensing data that is carried out in the Buleleng Subdistrict.

From the classification model in Table 1, to see land-use changes need a classification made based on the combination of relationship characteristics of the four indicators used so that changes in each class can be seen in the direction of change (Himayah dkk., 2016). The technique used to assess accuracy using 48 randomly selected points for sampling in Buleleng District. The resulted in a difference where the accuracy of EBBI was higher than NDBI by 84% and 82% with the spread of built land and vacant land by looking at current seasons that have limitations in distinguishing between awakening and another land cover such as deforested land. Moreover, dry surrounding the city due to the overlapping spectral reflectance for this land cover type (He, C.; Shi, P.; Xie, D.; Zhao, 2010). The following is a sample which states that there are limitations in distinguishing built-up land and cover.

Table 1
Accuracy of NDBI and EBBI

No	Region	Algorithm				Different (%)
		NDBI		EBBI		
		Built-up	Non - Built-up	Built-up	Non – Built-up	
1.	Kalibukbuk	-	11,2 %	-	11 ,05 %	0,15
	Kalibukbuk	-	9,5 %	-	9, 20 %	0,3
2.	Anturan	-	3,9 %	-	4,6 %	0,7
	Anturan	3,5%	-	3,9 %		0,4
3.	Tukadmungga	-	3,5 %	-	3,9 %	0,4
	Tukadmungga	-	3,1 %	-	3,3 %	0,2
4.	Pemaron	-	5,8 %	-	6,1 %	0,3

	Pemaron	-	6,2 %	-	6,5 %	0,3
5.	Bakti Seraga	-	7,2 %	-	8,5 %	1,3
6.	Banyuasri	11,50 %	-	11,78%	-	0,28
7.	Kaliuntu	11,9 %	-	11,12%	-	0,78
8.	Kampung Anyar	10 %	-	10,9 %	-	0,9
9.	Kampung Bugis	4,9 %	-	5,3 %	-	0,4
10.	Banjar Bali	8,3 %	-	8, 9 %	-	0,6
11.	Astina	6,3 %	-	6,7 %	-	0,4
12.	Banyuning	7,4 %	-	7,5 %	-	0,1
13.	Sari Mekar	-	1,2%	-	1, 7 %	0,5
	Sari Mekar	6,2 %	-	6,9 %	-	0,7
14.	Petandakan	5,8%	-	6,2 %	-	0,4
15.	Petandakan	-	0,81 %	-	0,95 %	0,14
16.	Nagasepaha	0,56 %	-	0,68 %	-	0,12
	Nagasepaha	-	10,9 %	-	9 ,55%	1,35
17.	JinengDalem	5,8 %	-	5,12%	-	0,68
18.	Alasangker	-	18,71 %	-	18,95%	0,24
	Total	82,16%	82,02%	85,00%	84,3 %	

Source: Data Processing and Filed Survey 2021

The pixel value of Tukadmungga territory and Nagasepaha on EBBI is 0,023 with a high vegetation index and NDBI 0,017 for built-up value (Figure 2). The accuracy value is in the algorithm EBBI where NDBI still has limitations in distinguishing between built-up and land cover such as bare and dry on which are around the city, because of the overlapping spectral reflectance for this type of land cover, according to (He, C.; Shi, P.; Xie, D.; Zhao, 2010). So that the difference in accuracy is influenced by the appearance of vegetation and clay-roofed buildings, previous research also explained that NDBI underperformed for mapping the built-up areas in the semi-arid cities of Urumqi and Shihezi in western China. So that the level of accuracy possessed is higher than Algorithm EBBI.

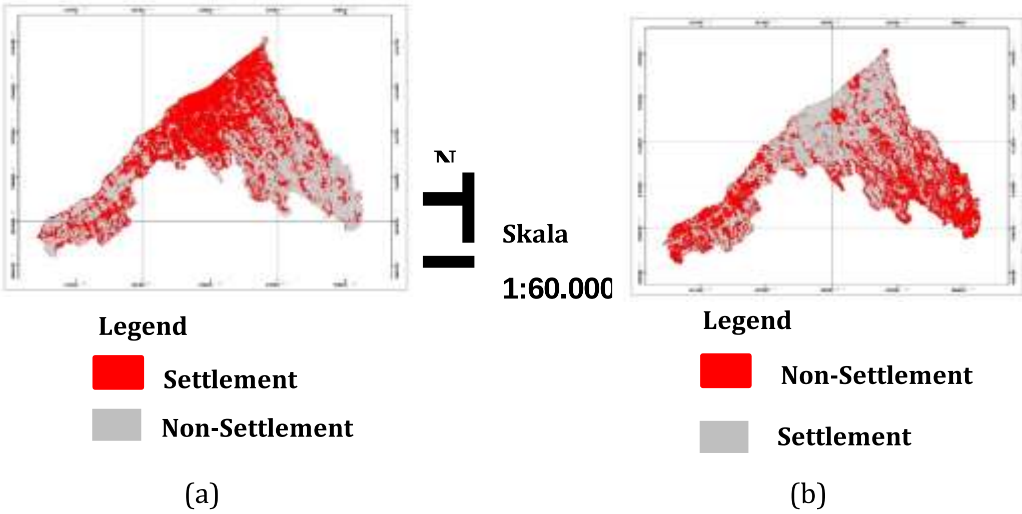

Fig. 3. Result (a) EBBI and (b) NDBI

The remote sensing method uses Landsat image 8 OLI in its data processing grouped into 2, namely, NDBI and EBBI with settlement land and non-settlement land classification. The classification method used is a guided classification with NDBI parameters to limit urban areas (Figure. 3). The Buil-up index (NDBI) derived from Landsat (TM/ETM/OLI) development of the built-up land use index is based on a spectral response from the awakened surface that better reflects the middle infrared part of the electromagnetic spectrum than in near-infrared (Padhee dkk., 2017). NDBI results produce high values for bare earth; Generally, NDBI is more efficient in places where the NDVI value is greater than 0 (Zha & Gao, 2003). NDBI also cannot separate between the land awakened with barren land. Although NDBI is already widely used to extract urban built-up areas, NDBI still has limitations in distinguishing between building and other land covers such as deforested and dry soil surrounding the city due to spectral overlap of reflectance for this type of land cover (He, C.; Shi, P.; Xie, D.; Zhao, 2010). Therefore, it is necessary to develop new methods by combining multiple indices and improving the accuracy of map awakened regions.

(a)

(b)

Fig 4. Field Survey (a) non-built-up and (b) built-up

The EBBI can map the built-up and vacant land using a single calculation. EBBI was the first to be built up, and the vacant land index implemented NIR, Short Wave Infrared (SWIR), and Thermal Infrared (TIR) channels simultaneously. This new index is applied to distinguish established land and vacant land in Denpasar (Bali, Indonesia) and has a high level of accuracy when compared to existing indices (Suwarsono & Khomarudin, 2014). EBBI is more effective in distinguishing built-up land and vacant land, and because of the distinguishing features, its accuracy is also high. Thus, EBBI is more effective in distinguishing abandoned land and vacant land and further increases the density and abandoned land percentage accuracy than the Built Building Index (IBI), Normalized Difference Built-up Index (NDBI). So, by using two algorithms, we know that the EBBI algorithm has a higher level of accuracy in monitoring land changes in urban areas in terms of distribution locations and patterns.

4. Conclusion

The study used remote sensing methods using two algorithms: NDBI (Normalized Difference Built-up Index) and EBBI (Enhanced Built-Up and Bareness Index). An algorithm is used to determine existing settlements in the Buleleng Subdistrict by distinguishing the built-up area and vacant land. This distribution occurs in all areas of the Buleleng Subdistrict with the collection of 48 samples. Of the 48 samples that can show the accuracy value on the EBBI algorithm with the distribution of settlement locations by 84% and 82% obtained from algorithm NDBI.

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