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OBIA CLASSIFICATION AND BUILT-UP LAND INDICES NDBI FOR ESTIMASTION OF SETTLEMENT DENSITY IN PONTIANAK CITY

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Info Artikel

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Abstract

Settlement density data is very important because the density of settlements is one of the main indicators of slum settlement in Pontianak City. The one of way to obtain settlement density information is to use remote sensing data like satellite imagery or aerial photo. This is a problem considering the budget and more time to get high resolution satellite imagery and extract the information we want.

The one method for the detection of settlements using Landsat 8 satellite imagary is the built-up land indices NDBI (Normalized Difference Build-up Index). Objective of this research is build spatial model of settlement density in Pontianak City using built-up land indices NDBI (Normalized Difference Build-up Index), moreover combining with OBIA Classification (Object Base Image Analysis).

The results of this research indicate that built-up land indices NDBI has a value of determination (R2) is high that is equal to 0.628 and has a strong correlation of 0.792 to the density of settlements calculated from aerial photo. The spatial model of settlement density estimation has a R2 of 0.75 and a RMSE value of 5.10

Kata kunci: OBIA, NDBI, Landsat 8, Kepadatan Permukiman

Abstrak

Data kepadatan permukiman sangatlah penting dimana kepadatan permukiman adalah salah satu indikator utama permukiman kumuh di Kota Pontianak. Salah satu cara praktis untuk mendapat informasi kepadatan permukiman adalah memanfaatkan data penginderaan jauh berupa citra satelit atau foto udara. Hal ini terdapat masalah mengingat dibutuhkan biaya yang mahal dan waktu yang cukup lama untuk mendapatkan citra satelit resolusi tinggi dan mengekstraksi informasi yang kita inginkan.

Salah satu metode untuk deteksi permukiman dengan menggunakan citra satelit Landsat 8 adalah indeks lahan terbangun NDBI *(Normalized Difference Build-up Index).* Penelitian ini bertujuan untuk membuat model spasial kepadatan permukiman di Kota Pontianak menggunakan indeks lahan terbangun NDBI, selain itu mengkombinasikan dengan klasifikasi OBIA (Object Base Image Analysis).

Hasil penelitian ini menunjukkan bahwa indeks lahan terbangun NDBI mempunyai nilai determinasi (R2) cukup kuat yaitu sebesar 0,628 dan memiliki korelasi yang kuat sebesar 0,792 terhadap kepadatan permukiman yang dihitung dari foto udara. Model spasial estimasi kepadatan permukiman memiliki memiliki R2 sebesar 0,75 dan nilai RMSE sebesar 5,10

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1. INTRODUCTION

Pontianak faces complex problem related to settlement management planning. The number of slum areas in Pontianak is 84.28 Ha. In addition, the demand for houses is increasing due to high population growth. The number of residents in Pontianak each year has increased significantly. In 1990, the total population reached 431,328 people, and in 2000 increased to 464,534 people or with growth of 7.7%. Then in the period of 10 years later in 2010 to 554,764 people, or experienced growth of 19.42% (Bappeda Kota Pontianak, 2015).

In this case Pontianak City has a policy for livable settlement. Where it is one part of Indonesia New Urban Agenda. Indonesia New Urban Agenda its elf is the implementation of the 11th Goal from Sustainable Development Goals (SDGs) inaugurated by the UN 2015 ago. Some of these policies and strategies include: the development of residential and settlement areas in priority areas, the application of a balanced residential environment, the stabilization of housing and settlement institutions, spatial planning of residential areas and slums and new settlement areas planning.

The availability of data like spatial data is necessary to achieve policies and strategies to realize livable and sustainable settlements in Pontianak City. Settlement density data is very important because the density of settlements is one of the main indicators of slum settlement and a reference in the development of settlement areas in Pontianak City. One practical way to obtain settlement density information is to use remote sensing data in the form of satellite imagery or aerial photo. But this is a problem considering the satellite image used is high resolution satellite imagery. It takes expensive and long enough time to get high resolution satellite imagery and extract the information we want.

Remote sensing technology offers many methods that can be used to detect the settlement region efficiently, not to mention using medium-resolution satellite imagery. Advantage medium-resolution satellite imagery such as Landsat 8 satellite imagery are having more band to make it possible to create compositions and indeces for extraction of settlement information.

A method for the detection of settlements using Landsat 8 satellite imagery is the built-up land index NDBI (Normalized Difference Build-up Index). Built-up land index NDBI was once applied by Zha et al (2003) to map urban land in Nanjing City, China. The mapping results show an accuracy of 92.6%. Suwarsono and Khomarudin (2014) also used the NDBI index for the detection of settlement areas in the volcanic landform with an accuracy rate of 61.74%. In addition Bhatti and Tripathi (2014) also use NDBI for identification of settlement areas in Lahore City, Pakistan. The NDBI used is also compiled with the BAEM (Built-up Area Extraction Method) index, where BAEM is a combination of NDBI, NDBI and MNDWI, the results of this model have an accuracy value of 71.5% for NDBI and 80.5% for BAEM.

Objective of this research is build spatial model of settlement density in Pontianak City. In this study, the built-up land index NDBI is used to estimate the density of the settlements in Pontianak City. In addition to using the NDBI index, this study also use object-based image classification or OBIA classification. The integration between the OBIA classification and built-up land index NDBI is expected to be an efficient in time and cost in estimating settlement density using high resolution satellite imagery and aerial photo.

2. METHODS

This research uses remote sensing analysis. The data used in this research are:

a. Landsat 8 satelitte imagery path 121 row 60. Date acquired 21 August 2014.
b. Aerial photo with geometrically corrected area Pontianak City in 2014 with spatial resolution 15cm.
c. Land use map of Pontianak City.

Steps of this reseach are satellite image processing, identification of settlement areas, image transformation to built-up land indices NDBI, regression analysis and determining the accuracy of settlement density values from aerial photo with pixel values in Landsat 8 satellite imagery. The description of all these steps is as follows.

2.1 Pre-processing Satelitte Imagery

Pre-processing of satellite images in this reseacrh is radiometric correction. Radiometric correction is a calibration of spectral values to the Planetary Reflectant's ToA (Top of Atmosphere) value. The calibration formula to the ToA Planetary Reflectant (USGS, 2013) is as follows:

$$\rho\lambda' = \frac{M\rho Qcal + A\rho}{\cos(\theta SZ)} = \frac{M\rho Qcal + A\rho}{\sin(\theta SE)}$$

Where:

ρλ' : ToA planetary reflectant with solar angle correction
Mp : Value of reflectant multi Band
Qcal: Pixel value
Ap : Value of reflectant add band
ΘSZ: Solar zenith angle in degree
ΘSE: Solar elevation angle in degree

The radiometric correction results are show the sensor reflectance only, to minimize interference from other spectral and to get the original spectral of the object so we must do the atmospheric correction. The atmospheric correction used is DOS (Dark of Substraction) to get the lowest reflectant value of 0.

2.2 Identificaiton of Settlement Area

This reseach use remote sensing analysis spesifically Object Based Image Analysis or OBIA. It can define object classes based on spectral aspect and spatial aspect as well. This method can overcome the weaknesses of classification methods that have been per-pixel or operate at pixel level individually (Danoedoro, 2012).

The result of the OBIA classification is only a class of built-up land which is then used to for the masking process. Masking process between Landsat 8 satelitte imagery and OBIA classification's result is obtain information on the real area of settlement, because the data used is Landsat 8 satellite imagery which can not distinguish precisely the settlements, industrial areas, economic and service areas. The masking process is done by cutting the OBIA classification results with settlement delineation area results from aerial photo and also assisted by land use map of Pontianak City in 2013 from Local Development Planning Agency of Pontianak City (Bappeda Kota Pontianak).

2.3 Identification of Settlement Density

This research uses built-up land index NDBI (Normalized Difference Building Index) from Landsat 8 satelitte imagery for estimation of settlement density. NDBI in this research obtained by adopting the calculation method from Zha et al (2003).

$$NDBI = (SWIR - NIR)/(SWIR + NIR)$$

Where:

NDBI : Built-up land index NDBI
SWIR : Shortwave Infared Band
NIR : Near Infared Band

The next is the settlement density calculation. Density of settlements can be defined as the density of the house and the use of the roof of the house between one house to another (Soemarwoto, 1991). Based on the his statement, it can be concluded that the settlement density formula is as follows:

$$\frac{Roof\ landmass}{Block\ settlement\ landmass} \times 100\%$$

Information of settlements density extracted from air photo of Pontianak City. Aerial photo can easily identify and calculate the rooftops of a house within a settlement block. The settlement block in this study is 30x30 meter, this refers to the spatial resolution of Landsat satellite imagery used for NDBI transformation.

The result from identification of settlement density using Landsat 8 satelitte imagey and settlement density calculation using aerial photo are analyzed by statictic. Correlation analysis is intended to determine the degree of relationship between variables Y which is the density value of measurement results in aerial photo with variable X that is the transformation of NDBI built-up land index. Regression analysis is used to determine the influence of the effect caused by changes in each variable X. The relationship of the influence of both data is determined by the correlation (R) and the coefficient of determination (R^2) generated.

3. RESULT AND DISCUSSION

3.1 Identification Settlement Area Using OBIA Classification

The accuracy value of the identification of built-up areas using OBIA classification is 82,50%. Then, to consider the settlement area, masking is done, which is cutting the OBIA classification with the result of settlement delineation from aerial photo consider the settlement area with the help of land use map of Pontianak in 2013.

The total area of settlements in Pontianak city from the classification of OBIA is 3268.83 Ha or 30.36% of the total area of Pontianak City. The result from this classification cant be used as a reference for the area of the settlements in the field, since the results are sufficiently biased due to the presence of mixed pixels where, the pixels should contain barren land or water bodies, but in the classification process they are described as the object of built-up areas and vice versa.

Factors that influence the accuracy of the area are the image spatial resolution and the size of the area which is being studied. Because image spatial resolution used in this study is medium resolution, it will produce a large enough area of bias, in this study using medium-resolution image with a considerably narrow area of study, so the error in the determination of area is high.

One way to minimize misclassification is by using layered classification method, which accommodates various algebraic processes of image. In this multilayered classification process the multichannel data from the beginning has been separated into two parts such as by its elevation (Danoedoro, 2012). In the case of land identification, DEM (Digital Elevation Model) data in form of DSM (Digital Surface Model) is used to separate the largest land area with open field where elevation <5 is barren land or using distance data (it can be buffer or distance) where the distance of built-up areas from the river is <5000 and so on.

3.2 Built-up Land Index NDBI

In this research, the minimum, maximum, and average value of NDBI after masking process according to settlement area is -0,35, 0,32, and -0,02 respectively.

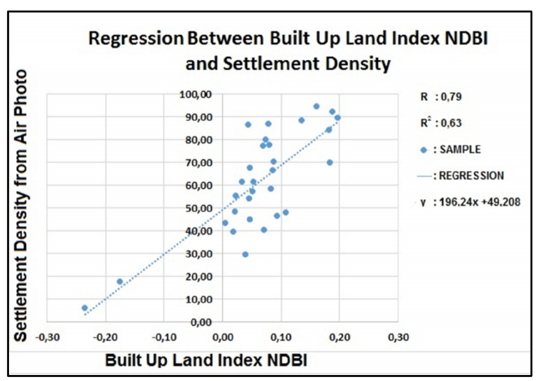

Figure 1. Result of Regression Between NDBI and Settlement Density

The results of the OBIA classification integration with NDBI built land index are then analyzed statistically based on the calculation of the density of settlements from aerial photographs. The results of statistical analysis has a strong enough value of determination (R^2) which is 0.628 and has a strong correlation of 0.792.

The NDBI transformation results are not so accurate in providing information on the density of the settlements due to the transformations made from Landsat 8 satellite images that have a spatial resolution of 30m where the object of land paving covered or asphalt road will be detected as a building that makes the NDBI value higher, while the calculation of the value of settlement settlement of aerial photographs of land covered paving and paved roads are not counted since those are not a building objects.

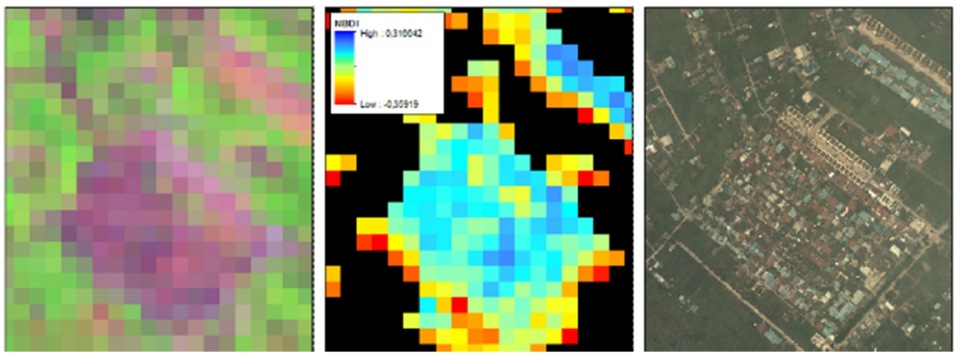

Figure 2. Comparation of built-up land in Landsat 8 satelitte imagery composite 654, NDBI index and aerial photo

The solutions from that problem are try and compare built-up land indexes, because built-up land index are so many among other NDBaI (Normalized Difference Bareness Index), IBI (Index Built-Up Index), UI (Urban Index), EBBI (Enhanced Built-Up And Bareness Index), and others.

As-syakur et al. (2012) developed the Enhanced Built-Up and Bareness Index (EBBI) parameter of Landsat-7 ETM + data as a model for mapping built-up land and barren land with a single calculation. EBBI is more effective in distinguishing between built-up and vacant areas (barren land) and further increasing the percentage accuracy of developed land density, compared to the IBI NDBI, UI, NDBaI and NDVI indices.

In addition, sharpening of the image with pan sharpening method can also help improve the results of accuracy of built-up land index. The sharpening results will increase the spatial resolution of the satellite imagery, thereby reducing the bias between built and non-built land.

3.3 Settlement Density Estimation

The equation result of statistical analysis of regression is the transformation formula of building density. Spatial density model of settlement is made based on the equation. Furthermore the spatial model of settlement density needs to be tested for accuracy using RMSE (Root Means Square Error) calculations. In contrast to the sample to be performed for regression analysis of 30 samples, the sample for the accuracy test only amounted to 12 samples and the location was spread also far apart from the sample for the regression analysis.

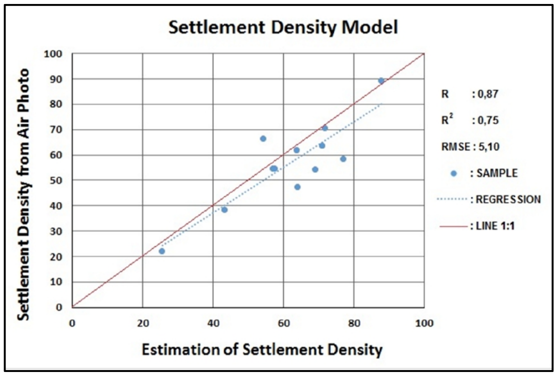

Figure 3. Result of Regression and Accuracy Test Settlement Density Model

Accuracy calculation using RMSE accuracy method using regression approach and 1 to 1 line. The result of regression shows that R2 value of 0.75 means that the result of accurate sampling between field observation data and density estimation data has a strong correlation, but its low RMSE (Root Means Square Error) value is 5.10, which the good value is near 0. This is because between Measurement data in aerial photographs with estimation data is more likely to be dominant in aerial photographs, thus affecting the results of the resulting RMSE values. From 1 to 1 line it can be seen that the sample plot is more leaning towards the estimate of settlement density, then the data generated from the estimation of this image can be said as being overestimated.

The next step is doing classification based on building density class from the Directorate General of Human Settlements, Ministry of Public Works of 1999 as follows:

Table 1. Density Classifitaion

Building Densisy	Classification
<40%	Low
40 – 60%	Medium
>60%	High

Source: Diroctерate General of Human Settlement. Department Public Work in Prasetyo and Rahayu (2013)

Based on Estimated Map of Density of Settlements in Pontianak City, the region with the highest density settlements spread in every Subdistrict. Pontianak Barat Subdistrict, Pontianak Kota Subdistrict, Pontianak Utara Subdistrict, Pontianak Selatan Subdistrict and Pontianak Selatan Subdistrict have the same solid dispersion characteristic of settlements, which is near the center of government and the center of trade and services.

Except Pontianak Timur Subdistrict where dense settlements are scattered in Kelurahan Tambelan Sampit and Kelurahan Dalam Bugis. Both urban villages are the first settlement area in Pontianak City, which is named Kampung Beting and this area is also the center of Pontianak city government in the old time that is Sultanate Kadariyah.

Figure 4a. Location of Kampung Beting from Satelitte Imagery 4b. Settlement in Kampung Beting (Source: Google Image)

According to Hassanudin, et al (in Sari, 2015) the initial form of the capital city of West Kalimantan, Pontianak is influenced by geographical location in the river rivers, the Landak and Kapuas rivers. This path is an easy path in organizing transportation and communication around the city of Pontianak. In addition to Kampung Beting, the distribution of densely populated settlements in Pontianak Timur Subdistrict is also located in Banjar Serasan Urban Village which is a slum area in Pontianak City. Its village is located on the banks of the Kapuas River.

The results of the spatial model are presented in Table 1. From the table it can be seen that the settlements in Pontianak are mostly medium settlements density. The largest percentage of dense settlements is Pontianak Barat Subdistrict with 21.48% of the total settlement area while Pontianak Utara Subdistrict is the region with the largest percentage of low settlement density that is 41,82%. This is reasonable considering the Pontianak Barat Subdistrict is a central area of government and economy where government offices Pontianak and trade areas.

Therefore, Pontianak Barat Subdistrict became a strategic area from the point of economic interest based on Pontianak City Regulation No. 2 of 2013 on Spatial Planning of Pontianak City together with Pontianak Kota Subdistrict which is the expansion of Pontianak Barat Subdistrict on October 23, 2002. This is different from Pontianak Subdistrict North that still has a lot of vegetation land because it is far from the center of government and economy.

The access to Pontianak Utara Subdistrict is via Kapuas I bridge and River Landak Bridge or using ferry boat.

The total area of settlement of this modeling is 3263,72 Ha, the total area of low settlement density is 197,36 Ha, the medium settlement density is 300,30 Ha and the high settlement density is 102,34 Ha. The built-up index results are different from the OBIA classification results by the difference of 5.11 Ha or 57 pixels bias. Its case similar with Putra (2016) research about mangrove forest mapping in Alas Purwo National Park in Banyuwangi Regency using vegetation index NDVI, RVI, SAVI, MSAVI2, ARVI and SARVI. The results of the calculation of the area of each index will vary, this is due to the density range that is used as the reference for each different vegetation index. This also applies to NDBI's built-up land index.

Table 2. Landmass of Settlement Density

Subdistrict	Density	Landmass (Ha)	Percentage
Pontianak Barat	Low	156,76	23,47
	Medium	366,96	55,06
	High	143,46	21,48
Pontianak Kota	Low	209,05	30,37
	Medium	380,55	55,4
	High	97,94	14,23
Pontianak Selatan	Low	218,03	32,56
	Medium	331,20	49,58
	High	119,59	17,86
Pontianak Tenggara	Low	117,00	34,82
	Medium	155,50	46,53
	High	62,67	18,65
Pontianak Timur	Low	151,57	34,32
	Medium	210,17	47,78
	High	79,05	17,9
Pontianak Utara	Low	194,51	41,82
	Medium	212,87	45,95
	High	56,85	12,22
Total		**3263,72**	

Source: Analysist, 2017

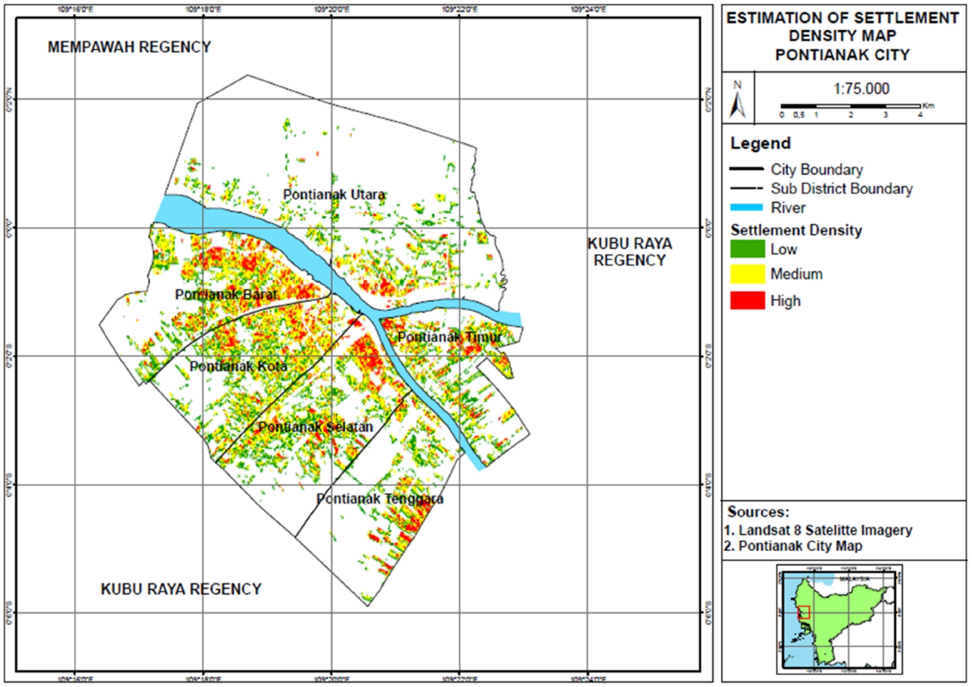

Figure 5. Esmitation of Settlement Density Map

The total area of settlement of this modeling is 3263,72 Ha, the total area of low settlement density is 197,36 Ha, the medium settlement density is 300,30 Ha and the high settlement density is 102,34 Ha. The built-up index results are different from the OBIA classification results by the difference of 5.11 Ha or 57 pixels bias. Its case similar with Putra (2016) research about mangrove forest mapping in Alas Purwo National Park in Banyuwangi Regency using vegetation index NDVI, RVI, SAVI, MSAVI2, ARVI and SARVI. The results of the calculation of the area of each index will vary, this is due to the density range that is used as the reference for each different vegetation index. This also applies to NDBI's built-up land index. The better the accuracy, the more the resulted area matches the OBIA classification results.

4. CONCLUSSIONS

Spatial model of density estimate estimate from OBIA classification and built-up land index NDBI has R^2 of 0.75 means that the accuracy samples available between

ata and density

have strong correlation but it have RMSE (Root Means Square Error) low at 5.10. The total area of low settlement density is 197,36 Ha, medium settlement density is 300,30 Ha and high settlement density is 102,34 Ha with bias 57 pixel.

The use of OBIA classification and built-up land index NDBI can still be an alternative in finding information on the density of settlements in a city with efficient in time and cost. This model still needs to be developed such as using sharpening of image in the form of pan sharpening, OBIA classification which is integrated with GIS is more stringent also method of built-up land index for more varied result.

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