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Study of Land Vegetation Quality Index (case study : Sidoarjo)

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Abstract. Since 2011, the Ministry of Environment has issued an Environmental Quality Index (IKLH) with forest cover / vegetation as one of the indicators. The Land Cover Quality Index, hereinafter abbreviated as IKTL, is a value that indicates the quality of the land calculated from the condition of land cover to the function of land. The IKTL calculation refers to the technical rules of the Director General Regulation on Pollution and Environmental Damage Control Number: P.1 / PPKL / PKLAT / PKL.4 / 1/2018 concerning Guidelines for Calculation of Land Cover Quality Index and Land Cover Management. There are three parameters needed in calculating IKTL values; forest cover data, shrubs that are in certain land functions data, and green open space data. Sidoarjo City is one of the regions in East Java Province which in recent years has always experienced an increase in population. The value of the Sidoarjo Regency Land Cover Quality Index (IKTL) for 2018 is 16.82. Land cover included in the IKTL calculation are mangroves, urban forests, green lanes, parks, green open spaces of road, burials, river borders and mud borders, with a total area of 2,514.61 ha. From the results of the analysis of vegetation index, the area of land cover included in the IKTL calculation of Sidoarjo Regency with sparse vegetation density is 1175.79 Ha, which has a moderate vegetation density of 913.48 Ha, while those with dense vegetation density are 425.406 Ha.

1. Introduction

Law No. 32 of 2009 concerning Protection and Management of the Environment mandates the Government to control pollution and damage to the environment. One indicator of environmental damage can be monitored from changes in vegetation cover. Since 2011, the Ministry of Environment has issued an Environmental Quality Index (EQI). EQI is an environmental index study that adopts the Environmental Quality Index issued by Virginia Commonwealth University (VCU). Basically, this environmental index assessment only measures trends in the quality or environmental conditions of water, air, and land media, toxic pollutant loads, bird breeding (biodiversity), and population growth. In the calculation of IKLH, there are three (3) environmental quality indicators that are needed, namely river water quality, air quality, and quality of land cover (forest). What is then developed is the value of calculating land cover index for urban areas by adding shrub factors in certain area functions, and green open space factors.

Land cover is one of the main determinants in calculating environmental quality indicators with a weight of 40%. Indicators of land cover in the assessment of land cover index are green issues or issues in the form of environmental management approach issues that address aspects of conservation or control of environmental damage. In addition to green issues, it is also known as brown issues or issues related to environmental pollution which are generally located in the industrial and urban sectors. Green issues in the calculation of IKLH are represented by indicators of land cover, while the brown issue is represented by indicators of air and water quality. Because the green issue in the calculation of IKLH is only

represented by 1 factor, the land cover index has a greater weight than the indicators of air pollution and water pollution.

Sidoarjo Regency is one of the regions in East Java Province which is a buffer district of the Capital of East Java Province and in recent years has always experienced an increase in population. In 2015 the total population growth in Sidoarjo Regency reached 1.6%. If the population increases, the number of land used for human habitation will increase. In order to meet the needs of housing, people use agricultural land or other land to be converted into residential area. This is what causes the availability of green open space (RTH) and vegetation cover to be reduced. The high function of agricultural land into non-agricultural land (settlements, industry, trade / services, transportation) that occurs and the use of space that does not meet technical requirements causes air pollution to increase due to increased transportation activities and industrial activities.

In this study, calculations are only made for the land cover quality index by referring to the Director General's Regulation on Pollution and Environmental Damage Control Number: P.1 / PPKL / PKLAT / PKL.4 / 1/2018 concerning Guidelines for Calculation of Land Cover Quality Index and Cover Management Land. The latest land cover information is land cover data obtained from the Bappeda of Sidoarjo District. The use of the latest land cover which will later be used in the process of calculating the land cover quality index. In addition to calculating the index value, monitoring of vegetation conditions will be also conducted at the location included in the calculation indicators of land cover quality using NDVI (Normalized Difference Vegetation Index) algorithm. Monitoring the condition of vegetation is needed to determine the land that needs to be prioritized in the land cover quality improvement program.

2. Data And Methods

Sidoarjo Regency, East Java Province, Indonesia is located at 112.50 - 112.90 East Longitude and 7.30 - 7.50 South Latitude, with an area reaching 685.83 km^2 and its administrative area is divided into 18 sub-district. Topography of Sidoarjo District is a delta plain with an altitude between 0 to 25 meters. Height of 0-3 meters covering 19,006 hectares of the area. 29.99% of the area in the eastern region is pond area. The freshwater region of the central region with an altitude of 3-10 meters above sea level is a residential area, trade and government, covering 40.81%. The western region with a height of 10-25 meters above sea level is an agricultural area, covering 29.20%. Sidoarjo Regency is traversed by several large rivers with winding shapes such as those that can be seen in the Brantas River - Surabaya River. This river is the border between Sidoarjo with Mojokerto District in the north. While Kali Mas is the boundary with Gresik District. The Porong River is the boundary with Pasuruan District in the south.

Sidoarjo Regency has several areas with certain functions in the form of local protected areas as stated in the Sidoarjo Regency Regulation Number 6 of 2009 concerning the Sidoarjo Regency Spatial Plan for 2009 - 2029. The local protected areas include the Beach Front Zone, the Area Around the Rolak Songo Reservoir (Tarik Subdistrict), Beachside / Mangrove forested area, Nature Conservation Area (in the form of coastal nature tourism park), and Geological Protected Area. The local protection area will be included as part of the calculation factor for the land cover quality index.

The image used in the process of updating the data and identifying the quality of land cover is Landsat 8 OLI-TIRS imagery by selecting the location of Sidoarjo District which is located on path 118 and row 65. Landsat 8 OIL-TIRS imagery is obtained from the United States Geological Survey website or abbreviated USGS by downloading in the link http://earthexplorer.usgs.gov/. Image data is selected with cloud cover less than 10%. Sidoarjo Distrct is only located in 1 scene of Landsat 8 OLI-TIRS imagery, so it is not necessary to download images in other scenes and mosaicking images. The images that have been downloaded are then clip according to the administrative boundaries of the Sidoarjo District so that they are focused only on the study area. Image clipping is conducted on channel 4 (RED) and channel 5 (NEAR INFRARED) Landsat 8 OLI-TIRS images, because those bands is needed in the vegetation condition analysis process with the NDVI algorithm.

Channel types in Landsat 8 OLI-TIRS images are listed in the following table :

	Bands	Wavelength (micrometers)	Resolution (meters)
Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) Launched February 11, 2013	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 - 0.67	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

Source : https://www.usgs.gov/land-resources/nli/landsat/landsat-8 (accessed on 28 July 2019)

The stage of analysis and plan in the Study of Land Cover Quality Index includes several stages, as follows :

1. Processing NDVI for Determining Vegetation Density

The vegetation index or 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 that has long been used as an indicator of the existence and condition of vegetation (Lillesand and Kiefer 1997).

According to Ryan (1997), the NDVI calculation is based on the principle that green plants grow very effectively by absorbing radiation in the visible spectrum region (PAR or Photosynthetically Active Radiation), while green plants strongly reflect radiation from the near infrared region. The concept of spectral patterns based on this principle using only the red band image is as follows:

$$NDVI = (NIR - Red) / (NIR + Red)$$

Where:
NIR = near infrared radiation from pixels
Red = red light radiation from pixelsNDVI value ranging from -1 (which is usually a water surface) to +1 (dense vegetation)
Image processing starting from the channel clipping process and NDVI analysis is done using ENVI 4.6.1 software.

2. Determination of Land Density Classes

The classification of vegetation density is determined based on the NDVI value range calculated. The total density classification refers to the Guidebook on Vegetation Inventory and Identification issued by the Directorate General of Land Rehabilitation and Social Forestry of the Ministry of Forestry. The division of classification is as follows (Ministry of Forestry, 2005) :

1. Dense canopy density (0.43 to 1.00)
2. Medium canopy density (0.33 to 0.42)
3. Rare canopy density (-1.00 to 0.32)

3. Overlaying with the Existing Land Use Map of Sidoarjo District
From the NDVI classification results into 3 classes for each image used above, then merging with the land use map of Sidoarjo Regency. This process is carried out on the geographic information system (GIS) program to analyze the condition of land cover in Sidoarjo, review the policy, and predict the conditions of future land cover.

4. Calculation of Land Cover Quality
    Calculation of IKTL with the following formula:

$$IKTL = 100 - ((84,3 - (TH \times 100)) \times 50/54,3) \qquad (1)$$

Where,
IKTL = Land Cover Quality Index
TH = Forest Cover

TH is calculated by the formula:

$$TH = LTH / LWKP \qquad (2)$$

Where,
LTH = Forest Cover Area
LWKP = Area of District / City or Province

Forest cover area (LTH) is calculated from the total summation as follows :
1. Primary dryland forest, primary swamp forest, primary mangrove forest, secondary dryland forest, secondary swamp forest, secondary mangrove forest, and plantation forest.
2. Shrubs and shrubs / swamp shrubs, which are in forest areas, river boundaries, around lakes / reservoirs, coastal boundaries and slope lands greater than 25% (multiplied by 0.6).
3. Green open spaces, such as urban forests, botanical gardens, biodiversity parks (multiplied by 0.6).\

3. Data Processing and Results
3.1 Vegetation density analysis
Analysis of vegetation density was carried out to determine the level of quality of vegetation land cover. The results of the analysis of vegetation density with NDVI will later be overlaid with the land use map of Sidoarjo District.
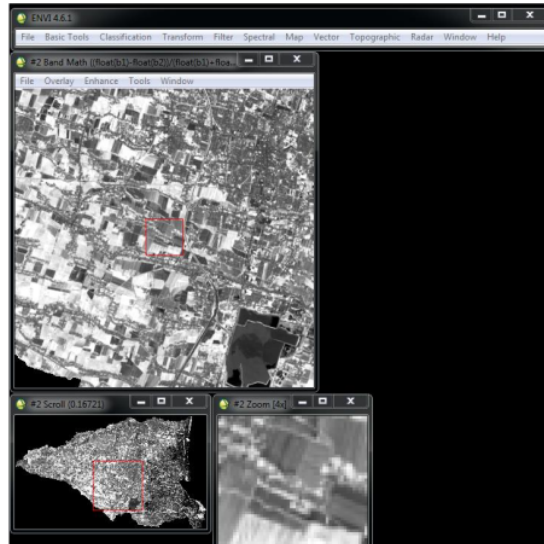
The classification is based on the direction of the density of the Forestry Department in 2005, where the vegetation with a sparse canopy density level is at -1.00 NDVI index up to 0.32, canopy density index was at 0.32 and 0.42, and the dense canopy density index 0.42 to 1.00. Based on the results of the NDVI analysis, the area with vegetation density is obtained as follows :

Table 1. Area Based on Vegetation Density

	Vegetation Density	Area
1	Sparse	57518,91
2	Moderate	11368,35
3	Dense	3108,115
	Total	71995,375

The extent of the area of the entire region including the surface of the water and the road.
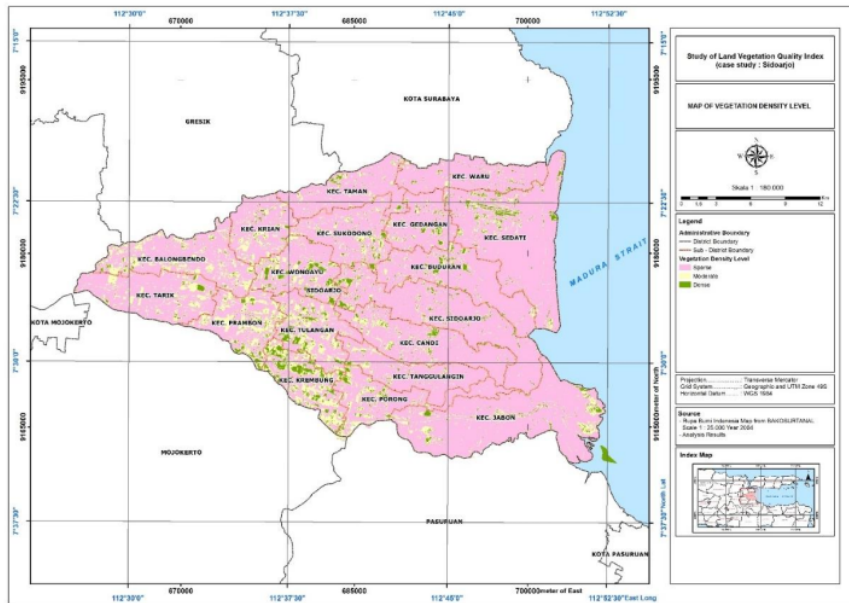
3,2 Calculation of Land Cover Quality Index from Land Use Data

Land cover is a biophysical cover on the surface of the earth that can be observed and is the result of regulation, activity, and human treatment carried out on certain types of land cover to carry out production, change or maintenance activities on the land cover. (Director General Regulation of Pollution and Environmental Damage Control Number: P.1 / PPKL / PKLAT / PKL.4 / 1/2018 concerning Guidelines for Calculation of Land Cover Quality Index and Land Cover Management).

Table 2. Area of Land Use in Sidoarjo District.

	Land Cover	Area (Ha)
1	Mangroves	1299,68
2	Service Trade Area	624,02
3	Office Area	106,23
4	Security Defense Area	157,81
5	Transportation Facility	669,52
6	Sports Facility	10,38
7	Urban Forests	14,18
8	Industry	2671,99
9	Green Lane	417,75
10	Plantation	2892,63
11	Basin	118,14
12	Open Space	1775,94
13	Field	93,17

15	Lapindo Mud Area	582,49
16	Meadow	52,85
17	Yard	8647,82
18	Graveyard	90,61
19	Settlement	7697,12
20	Mining	10,11
21	Agriculture and Livestock	21746,30
22	Swamp	8,39
22	Channel/drainage	198,10
24	River Border	574,017
25	Mud Border	97,84
26	Park	14,52
27	Pond	18005,60
28	Reservoir Border	6,008
	Total	68583,21

Image 3. Map of Land Cover of Sidoarjo District

Based on the existing land cover data, the calculation of the Sidoarjo District Land Cover Quality Index is as follows :

Area of Sidoarjo Regency: 68583.21 Hectares (obtained from the total calculation of existing data on land cover without roads and rivers area, thus allowing differences with the area of administration).

Forest Cover Area : 1299.68 Hectares

      Mangroves   1299,68   +

Forest Cover Area	1299,68

Shrubs and Swamp Shrubs on Certain Land Area: 677.87 hectares.

Shrubs and Swamp Shrubs on Channel/river border	574,017
Reservoir Border	6,008
Lapindo Mud Border	97,84 +
Shrubs and Swamp Shrubs on Certain Land Area	677,87

Open Space Area : 537,06 Hektar.

Urban Forests	14,18	
Green Lane	417,75	
Park	14,52	
Graveyard	90,61	+
Open Space Area	537,06	

Furthermore, the calculation of IKTL values is as follows :

$$TH = \frac{(1299,68) + ((677,87+537,06) \times 0,6)}{68583,21} = 0,02957 \tag{3}$$

$$IKTL = 100 - \left(84,3 - (0,02958 \times 100)\right) \times \frac{50}{54,3} = 17,18 \tag{4}$$

Thus the value of the IKTL of Sidoarjo District obtained is **17,18**

Based on the Director General's Regulation on Pollution and Environmental Damage Control Number P.1 / PPKL / PKLAT / PKL.4 / 1/2018 concerning Guidelines for Calculation of Land Cover Quality Index and Land Cover Management, the area of land use used in the calculation is the sum of the area of existing land use and does not use administrative area. The extent of this existing land does not include roads and rivers. The IKTL value of Sidoarjo District amounting to 17.18 will be included as a parameter value in calculating the Environmental Quality Index along with a level of water quality index and air quality index with a weighting of 30 percent for the water and air quality index and 40 percent for the land cover index (Indonesian Environmental Quality Index 2016). The value of the weighting of the three factors will later be used to classify the status of environmental quality whether in a state of alert or not.

In accordance with the IKTL calculation above the total area for mangrove forests, swamp shrubs in certain areas, and green open spaces in Sidoarjo District is equal to 2514.61 hectares or as much as 3.66 percent of the total land use area of Sidoarjo Regency (68583.21 hectares) . The condition of the land cover has a variety of vegetation conditions that range from rare to dense. The condition of land cover vegetation is obtained by overlapping land use data with vegetation density data from the NDVI analysis. Land use that needs to be aware of vegetation conditions is only land use included in the IKTL assessment, namely mangroves, shrubs in river / river boundaries, bushes in

reservoir boundaries, bushes in Lapindo mud border, urban forests, green lanes, parks, and graveyards.

The following table shows vegetation density conditions from land cover :

Table 3. Vegetation Density Conditions in Sidoarjo District

	Land Cover	Vegetation Condition		
		Sparse	Moderate	Dence
1	Mangroves	325,88	611,79	362,016
2	River Borders	329,73	190,995	53,28
3	Mud Borders	69,905	24,26	3,68
4	Reservoir Borders	5,80	0,28	-
5	Urban Forests	10,57	3,61	-
6	Green Lanes	359,495	53,685	4,57
7	Graveyards	63,69	25,58	1,34
8	Parks	10,72	3,28	0,52
	Total (in Hectares)	**1175,79**	**913,48**	**425,406**

Table area above is the calculation result area of each land cover conditions IKTL. In addition to making efforts to increase the amount of green open space, based on data on the distribution of vegetation conditions, efforts can also be made to improve the quality of land cover in locations that have sparse vegetation density conditions.

Image 4. Map of Vegetation Condition Distribution

Improvements to the quality of IKTL land cover can be carried out following the technical directives of Permen PU No. 5 of 2008 concerning Guidelines for the Provision and Use of Green Open Space in Urban Areas, adjusting to the type and function of land cover in Sidoarjo Regency.

The direction of efforts to improve the quality of land cover in rare canopy density conditions in Sidoarjo Regency is described in the following table :

Table 4. Improvement Direction of Land Cover Vegetation Condition.

	Land Cover	Sparse Condition in Area	Technical Directives	Recommentations for Plant Types
1	Mangroves	325, 88 Ha	1. Adjust to existing types of mangroves 2. Not displaced by the existence of housing and industry that already exists around mangrove locations	Mangrove : Small Mangrove Sonneratia alba Avicennia
2	Channel/river borders, Reservoir Borders	335,53	1. Able to withstand land deformation 2. The spacing is half-tight to a meeting of 90 percent of the area 3. As much as possible invite birds 4. Setting the planting position adjusts to the instructions of the Work Directors	Mimusops Elengi, Samanea Saman, Casuarina, Schima Wallic, Leucaena Lecochepala, Bamboo
3	Mud Borders	69,905 Ha	1. Strong and deep root system 2. Grows well on solid soil 3. Domination of annual plants	Pterocarpus Indicus or can be likened to plants for river border functions
4	Green Lanes	359,495Ha	1. Selection of plants with shady canopy but not too dark 2. Resistant to motor vehicle and industrial pollution 3. Able to absorb air pollution 4. Not deciduous 5. Easy to recover when injured collision	Gnetum Gnemon (6 meters spacing), Mimosups Elengi (12 meters spacing), Lagerstroemia floribunda (12 meters spacing), Michelia champaca (12 meters spacing)
5	Graveyards	63,69 Ha	1. Tree size adapts to space availability 2. Long life 3. Flowering plants and inviting birds 4. Strong erect stems are not easily broken and buttressed	Bougenvilia sp, Plumeria alba, Erythrina Varigata (bird invitee)

| 6 | Parks | 10,72 Ha | 1. Easy to maintain
2. Relative resistant to water shortages
3. Annual or seasonal plants | Plumeria rubra, Muntingia calabura, Lagerstoemia Loudonii |
| 7 | Urban Forests | 10,57 Ha | 1. Having varying heights
2. Can absorb air pollution
3. Tolerance of the limitations of sunlight and water
4. Invite the presence of birds
5. The results produced are quite numerous and not aleopathic
6. Be evergreen
7. Has deep roots | Ficus (Bird invitee), Streblus asper (crop resistant), rare plant |

To increase the amount of IKTL value, it is necessary to add additional green open spaces, especially those in the form of trees, such as parks and urban forests. The addition of green open space can be done by utilizing the distribution of open land and meadow based on the results of the identification of land cover maps (1828.79) Ha. In an effort to increase the area of green open space from open land there are needs of of land evaluation study for lands that are recommended for green open space. The parameters that can be included in the study include certainty of land ownership status and land suitability conditions recommended for green open space.

4. Conclusions and recommendations

Based on the study, the value of the Land Cover Quality Index (IKTL) of Sidoarjo District is 17.18. The land cover included in the IKTL calculation is mangroves, urban forests, green lanes, parks, graveyards, river borders, reservoir boundaries, and mud borders, with a total area of 2514.61 ha.

From the results of the analysis of vegetation index, the area of land cover included in the IKTL calculation of Sidoarjo District with sparse vegetation density is 1175.79 Ha, which has a moderate vegetation density of 913.48 Ha, while those with dense vegetation density are 425.406 Ha. Based on these results 46.76 percent of land cover included in the IKTL calculation in Sidoarjo Regency has rare conditions of vegetation density.

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