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Penggunaan Citra Landsat 8 untuk Menganalisis Kondisi dan Luas Lamun di Desa Matahora, Pulau Wangi-Wangi, Wakatobi, Sulawesi Tenggara, Indonesia

Using Landsat 8 Image to Analyze Seagrass Condition and Areas in Matahora Village, Wangi-Wangi Island, Wakatobi, South-East Sulawesi, Indonesia

Eka Fauziah*, Nurjannah Nurdin, Yayu A. La Nafie, Muh Banda Selamat, Supriadi, M. Rijal Idrus

Program Studi Magister Ilmu Kelautan, Fakultas Ilmu Kelautan dan Perikanan, Universitas Hasanuddin
Jl. Perintis Kemerdekaan Km. 10, Tamalanrea, Makassar, Indonesia
*Corresponding author: yayulanafie@yahoo.com

ABSTRAK

Pemanfaatan teknologi penginderaan jauh dapat digunakan untuk memetakan dan memantau padang lamun secara efektif dan efisien karena mampu menghasilkan informasi secara spasial dan temporal. Penelitian ini bertujuan untuk memetakan perubahan kondisi lamun dan cadangan karbon menggunakan data Citra Satelit Landsat 8 periode tahun 2013, 2017 dan 2022 di perairan Pulau Wangi Wangi dan Pulau Kapota Wakatobi. Penelitian ini dilakukan dengan menggunakan data satelit Landsat 8 dengan resolusi spasial 30 m (diakuisisi pada 6 Oktober 2023, 26 Januari 2017, dan 22 Januari 2022). Metode penelitian: (1) Pengukuran lapangan dan analisa laboratorium untuk menguji keakuratan dan pengukuran nilai karbon lamun dan (2) penginderaan jauh untuk mengetahui kondisi lamun secara luas. Pendekatan kedua juga melakukan klasifikasi citra yang terdiri dari 3 level, hal ini didasarkan pada komposisi lamun yaitu level 1 yang terbagi menjadi daratan, perairan dangkal, dan laut dalam. Permukaan 2 terdiri dari empat kelas habitat yaitu karang bentik, lamun, pasir , dan rubble- dan level 3 merupakan persentase tutupan padang lamun yang juga terbagi dalam tiga kelas tutupan yaitu padat, sedang, dan rendah. Hasil penelitian menunjukkan bahwa 7 jenis lamun di perairan Pulau Wanci dan Pulau Kapota dengan pola sebaran keseluruhan mengelompok. Analisis data menggunakan analisis regresi sederhana, diperoleh hubungan yang relatif kuat antara persen tutupan dengan total biomassa lamun, analisis citra Landsat 8 secara umum lamun mengalami penurunan setiap tahunnya.

Kata Kunci : Lamun, karbon, OBIA, landsat 8.

Pendahuluan

Wakatobi Islands is one of the new districts formed in Southeast Sulawesi Province. At first,Wakatobi was an abbreviation of the names of 4 islands, namely Wangi-Wangi Island, Kaledupa, Tomia and Binongko. To the north, the islands are bounded by the Banda Sea and Buton Island, to the south by the Flores Sea, to the east by the Banda Sea and to the west by Buton Island and the Flores Sea. Southeast Sulawesi Provincial Government (2009); BPS Kab. Wakatobi (2022) Waktobi Regency hasan area of ± 19,200 km2 consisting of ± 823 km2 (3%) of land and ± 18,377 km2 of water (97%). Geographically, Wakatobi Island is located south of the equator, extending ± 160 km from north to south between 5º12' – 6º25' South Latitude and ± 120 km long from east to west between 123º20'– 124º39' East Longitude. UNESCO has also designated the marine waters of Wakatobi, Indonesia, as one of the 20 new biosphere reserves in the world.

As a district famous for its underwater beauty, Wakatobi Regency has promising Natural Resources (SDA) potential, especially in the fisheries and tourism sectors. This is a priority for the local government in carrying out development in the coastal area, besides this itis also supported by the increasing rate of population growth on Wangi-Wangi Island(South Wangi-Wangi 2.28 percent and Wangi- Wangi 1.98 percent) (BPS Kab. Wakatobi, 2022). The increase in population has resulted in an increase in the number of settlements both on land and in coastal areas, the fisheriessector is the main source (94%) of people's livelihoods. The magnitude of marine and fisheries potential can be indicated by the largenumber of people who depend on this sectorfor their livelihood. Therefore a form of management or protection is absolutelynecessary in this area so that the existing resources can remain sustainable and people's sources of livelihood can be maintained.

Remote Sensing

For a global level assessment of various terrestrial and marine ecosystems, field surveys are too time consuming and expensive.Remote sensing, particularly using spaceborne datasets, can provide Fig. 1. Global distribution of seagrass communities (Source: UNEP- WCMC and Short, 2018). B.K. Veettil, et al. Ecological Indicators 117 (2020) 106560 2 relevant and long-term data for analysing ecosystem changes (Murray et al., 2018).

Remote sensing has the ability to provide spatio-temporal data on natural resources, including carbon dynamics in various terrestrial and coastal ecosystems (Wicaksono et al., 2011). IPCC (2003) states that data that can be used for carbon measurement must be complete, representative, consistent over time, and transparent. Remote sensing is able to meet these three requirements. Utilizing the capabilities of remote sensing technology tools,it can determine changes in the area and condition of seagrass beds, and estimate carbon stocks in seagrass beds effectively, efficiently and thoroughly.

The remote sensing technology that has developed to date is inseparable from the development of satellite technology being launched, in this case natural resource satellites. Satellite technology is developing with various capabilities in providing image data related to information on the earth's surface. The resulting satellite images vary from images that have low to high spatial resolution and spectral resolution and from free(open source) imagery data to paid imagery data. There are many choices of image data available based on the type of satellite technology, of course, its utilization can be adjusted according to the needs and desires ofthe data users themselves and their relationship with the analysis of natural resources and the work to be carried out. Various types of satellite data have been developed to date and are often used for exploration of natural resources through remote sensing technology such as Landsat imagery, ASTER, SPOT, ALOS, GeoEye, Pleiades, IKONOS, Quickbird, Worldview, and Sentinel-2 (Mastu, 2018).

Spaceborne and airborne remote sensing has been widely used for monitoring and mapping seagrass ecosystems throughout the world (Chauvaud et al., 1998; Dekker et al., 2007).

Satellite remote sensing has been used for continuous wide-scale monitoring of seagrass biomass and conditions. Synoptic monitoring ofcoastal ecosystems with satellite remote sensing can provide important spatial information about seagrass ecological characteristics as they change over time,supporting coastal management and conservation.(Bramante, et.al, 2018 dan Poursanidis et.al. 2021).

Recently, methods for the acquisition and interpretation of optical/acoustic data for themapping of seagrass habitats have advanced rapidly (Ferwerda et al., 2007; Hossain et al., 2015b). Information on seagrass status in terms of percent cover and biomass needs to be acquired as baseline data to efciently manage and monitor the seagrass ecosystems for conservation purposes. Remote sensing techniques have proven to be efcient and efective tools for seagrass monitoring. Since launched by the European Space Agency (ESA) in 2015, Sentinel-2 (S2) images withhigher spatial resolution that are suitable for seagrass mapping, have been available and can be acquired at no cost. The use of S2 imagery for seagrass meadows ecosystem study was recently demonstrated with regard to seagrass beds on the Atlantic coasts of France and Spain (Zofoli et al. 2020).

In general, digital analysis of remote sensing data has two approaches, namely pixel-based and object-based. The use of object-based classification methods is currently analternative in classifying an object on the earth's surface using either satellite imagery data or aerial photographic imagery data (orthophoto). Object-based classification has proven successful for digital analysis of high and very high resolution images despite havinglow spectral information (Ramadhani et al. 2015).

Seagrass

Seagrass beds are vegetation that is importantin storing carbon (Alongi et al., 2016; Supriadi et al. 2022). In addition, seagrass ecosystems also have an important role in coastal ecosystems because they can form large grasslands to support high biodiversity (Traganos et al., 2018). However, according to Sjafrie et al. (2018) seagrass ecosystems are also vulnerable to damage caused by humans or natural factors. Naturally, disturbances can be in the form of herbivorous animal activities that eat seagrass, natural disasters and so on. While human activities that can cause damage to seagrasses include beach reclamation, dredging, disposal of household waste and mooring ships using anchors in seagrass beds (Cole, 2016; Orth et al., 2017). Therefore, for good seagrass ecosystem management, more accurate spatial and temporal information isneeded.

Seagrass has a functional function in maintaining ecological processes for the sustainability of marine biota and can act as a provider of goods and services for human needs (Ronnback and Torro-Castro 2004). From an environmental perspective, seagrass acts as the foundation of the species (Waycott et al 2009). This can be proven from the various types of animals that make places or burrows and then become the habitat of other species (Coleman and Williams 2002), the function of seagrass which is quite essential in the marine environment is as the primary productivity of the photosynthesis process(Willams et al. 2006). In addition, seagrasses in the marine environment are habitats andplaces to find food for various types of animals such as invertebrates, fish and birds (Waycoot et al 2009). Therefore the existence of seagrasses in the marine environment is for the sustainability of the diversity of reef fish species that use seagrasses as a place to find food (Cullen and Unsworth 2010).

Seagrasses are true flowering plants that have evolved to live in the marine environment; they include approximately 72 different speciesbelonging to four major groups [1]. Although seagrass meadows often receive little attention compared to other marine ecosystems [2], seagrass is one of the dominant primary producers especially in coastal waters around the world, providing an important foundation formarine biological communities and playing important roles for coastal communities, for example through their contributions to fishery yields and cultural values [3]. Seagrass ecosystems are also crucial ecosystem service providers throughout their global extent (up toa maximum of 600,000 km2),are found along the shores of all continents (except Antarctica) to a maximum depth of 50 m [4,5]. Seagrass meadows in Southeast Asia have the highest seagrass diversity in the world, with a recently estimated extent of 36,762.6 km2 [6] Ambo Rrappe 2020.

Materials and Methods

According to Wicaksono (2015) In general, there are two approaches to mapping seagrasshabitat carbon stocks, namely: (1) The first approach is to use direct field measurements and laboratory analysis. Sample interpolation and extrapolation of plot-level data was used toupscale the data to the landscape level, in order to obtain the spatial context of the distribution of carbon stocks. Another alternative is to average the sample values measured and use these values to represent the condition of carbon stocks in an area; (2) The second approach is through remote sensing. Remote sensing is capable of providing general and specific information on large area data, repeated monitoring capabilities for multitemporal analysis, and a comprehensive spatial context. The procedure of this research is carried out as follows:

This research was carried out from November 2022 to February 2023 which included literature studies, field data collection, and dataprocessing. Field data collection in January 2023 in the waters of Wangi-Wangi Island and Kapota Island, Wakatobi Regency.

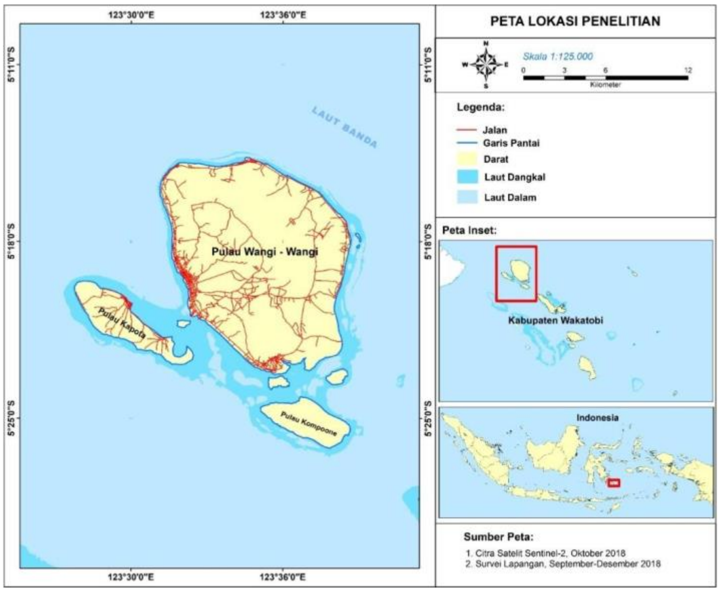
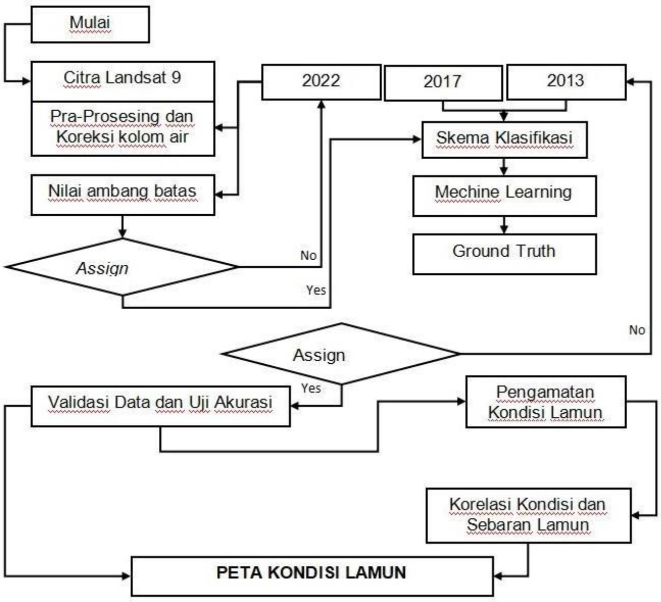


Figure 1. Map of Research Locations Observations were determined based on the mapping results of seagrass conditions which were carried out using Landsat 8 imagery

Observations were determined based on the mapping results of seagrass conditions which were carried out using Landsat 8 imagery through an unsupervised classification approach. All stages of the research are presented in the following figure.



Picture. 2. Research Flow

The Landsat 8 image data to be used is downloaded via the www.earthexplorer.usgs.gov website.

Pre Image Processing
Geometric correction

Calculation of the accuracy of the geometric correction process is done by calculating the root means square error (RMSE) value. RMS is calculated based on the difference between the GCP coordinates and the new estimated coordinates along the x and y axes, using the following formula.

$$RMS_E = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \delta_{Ni}^2} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (E - E_i)^2}$$

And

$$RMS_N = \sqrt{\frac{1}{n}\sum_{i=1}^{n} \delta_{Ni}^2} = = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (N - N_i)^2}$$

Information:
n: total number of field control points (GCP) Ei and Ni: X (east, E) and Y (north, N) coordinates of GCP to i, respectively, which are calculated by the Transform function f1 and f2 in rectification. E and N: the X (east, E) and Y (north, N) coordinates of the reference, respectively.

Based on the RMSE and RMSN, the overall accuracy indicator can be calculated using the formula:

$$RMS_{EN} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (\delta_{Ni}^2 + \delta_{Ei}^2}$$

Radiometric Correction

The radiometric correction used in this study is DOS (Dark Object Substraction) correction in order to improve the radiometric values or pixel values present in the image caused by atmospheric disturbances. Reducing the digitar value of each channel in order to get a zero score for the object with the lowest reflection is the way to go in the correction of the DOS method. Furthermore, according to Eastman (1992), said that the DOS correction can be done through the following equation:

Atmospherically corrected radiance = Li – Lsi

Water Column Correction

Correction of the water column uses the composition of the visible light band by extracting image pixel values on the same (homogeneous) substrate type. The band pairs used in this study are the visible light bands of Landsat 9 images with a spatial resolution of 30 m, namely band 2 (blue), band 3 (green), band 4 (red). The steps for the Depth Invariant Index process are by following the instructions from Green et al. (2000) namely with the equation;

$$^{Ki}/_{Kj} = a + \sqrt{a^2 + 1}$$

Where

$$\alpha = \frac{\sigma ii - \sigma jj}{2_{\sigma ij}}$$

and

$$\sigma ij = XiXj - XiXj$$

Σii is the variance of the Xi measurement, σjj is the variance of the Xj measurement and σij is the variance of Xi and Xj the final stage is the DII calculation, namely with the equation :

$$DII_{ij} = Log(X_{i)} - [\left(^{Ki}/_{Kj}\right) * Log\ (Xj)]$$

Seagrass Conditions

Observation of seagrass conditions was carried out after obtaining seagrass distribution data based on the results of Landsat 8 image data processing that was carried out previously. These observations are as follows:

(1) Identify the percent seagrass cover using 1m x 1m transects randomly at seagrass points based on seagrass cover standards to determine the percentage of total seagrass cover conditions based on the Ministry of Environment no 200 of 2004 and identify the type and seagrass cover in each plot based on seagrass cover percentage (McKenzie 2003)**.** (2) Estimation of seagrass species composition is carried out by identifying seagrass species within a 1m x 1m square in 3 repetitions for each category of percent seagrass cover.

(3) Documentation in the form of taking photos for each square. Give a marker next to the square with the correct code (location, transect and square) before the photos are taken.

Photographs are taken perpendicular to include the entire square frame, markers and tape measure. Try to avoid shadows or water reflections.

(4) Observe the composition of the sediment by making a visual observation of the top layer of the substrate or twisting it with your fingers. Sediment composition is described by recording the size of the sediment grains sequentially according to the dominance of each sediment grain size which can be done in the laboratory.

Data Analysis

First, seagrass cover in the field is delineated, then analyzed, to determine changes in seagrass area. Changes in the area of seagrass beds can be calculated by applying the following equation which shows the trend of seagrass changes that occur every year in each observation. The rate of change can be calculated by looking at the rate of change that occurred in the first year of observation and the rate of change in the following year of observation, namely in the last year of observation, which can be formulated as the following equation:

$\Delta L = (Lt2 - Lt1)/Lt1 \times 100\%$

Information:

ΔL : Area change rate (%)

Lt1 : Area in the first observation year (ha)

Lt2 : Area in the next observation year (ha)

The NDVI (Normalized Difference Vegetation Index) algorithm requires red and infrared channels in remote sensing to evaluate whether the observed target contains live green vegetation or not. NDVI is based on the low level of reflectance caused by photosynthesis (Maglione et al. 2013). Image sharpening with the NDVI algorithm to detect vegetation. The NDVI formula uses the following equation:

$$NDVI = \frac{NIR - R}{NIR + R}$$

Information:
NIR: Spectral reflectance values in the Near Infrared channel
R: Spectral reflectance value on the Red channel

The Normalized Difference Vegetation Index (NDVI) with a high vegetation index value illustrates that the observed area has a high level of greenery, such as dense and dense forest. Conversely, a low vegetation index value indicates that the area has a low level of greenery or low vegetation land or possibly not a vegetation object.

Results and Discussion

Based on the results of the surveillance carried out, 7 species of seagrass were found in the waters of Wanci Island, namely Halophila ovalis, Halodule uninervis, Cymodocea rotundata, Thalassia hemprichii, Enhalus acroides, Thalasodendron ciliatum, and Syringodium isoetifolium with the highest density being dominated by T. hemprichii, H. uninervis, and C. rotundata, a type of seagrass found in the waters of Wanci Island including mixed vegetation

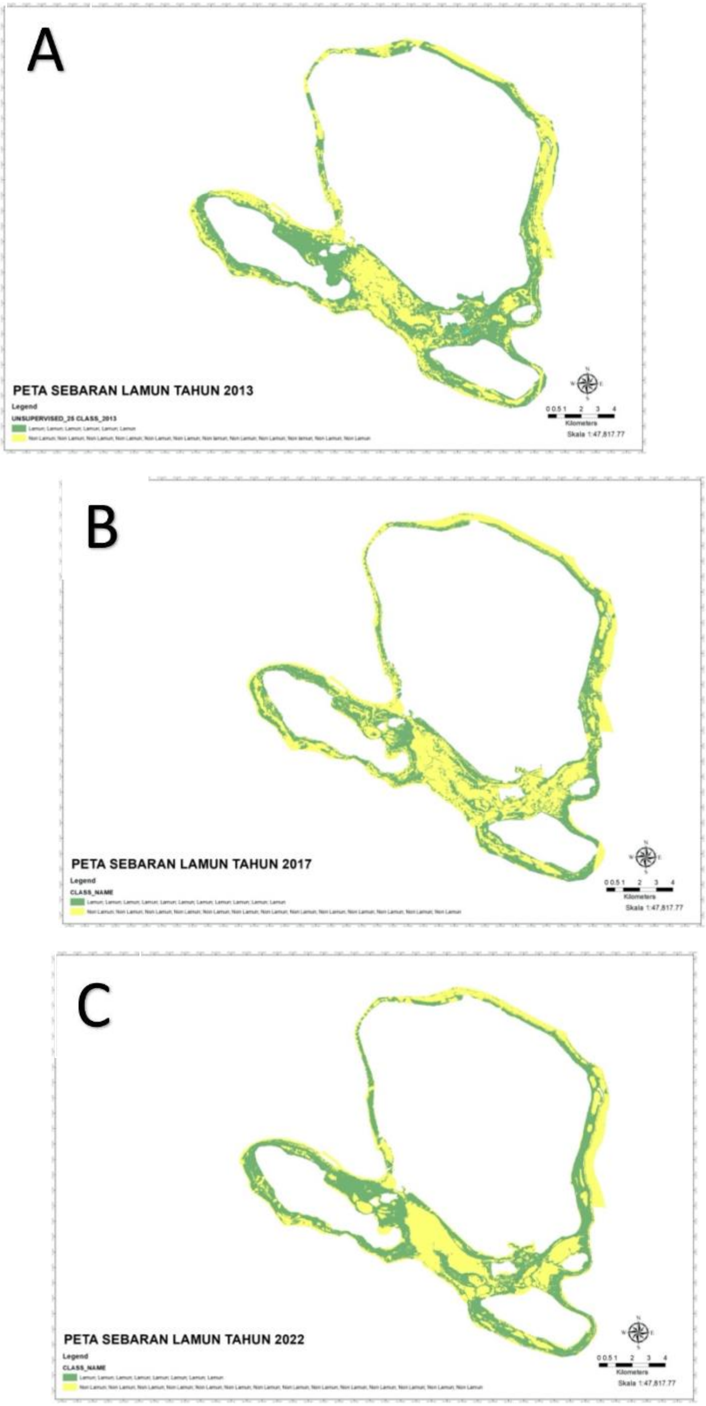


Figure 3. Seagrass distribution in (a) 2013, (b) 2017 and (c) 2022.

The imaging type delineation is based on the results of the 2018 Xincun Seagrass Resource Survey, which is based on the following steps. (1) Station layout, and set sections in each station. (2) Place a 1 × 1 m sample frame, and use an underwater digital camera to photograph the status of seagrass resources in the sample frame. (3) Assess and quantify seagrass species, densities and cover in the sample frame based on field surveys and film images.

Based on empirical knowledge of ground truth data and manual interpretation of imagery, the entire study area can be divided in detail into eight types: high seagrass cover areas, medium seagrass cover areas, low seagrass cover areas, sandy areas, other mixed areas. 20% seagrass cover is a criterion for distinguishing other substrates from seagrass substrates (Vale, 2015; Barille, 2010), 50% seagrass cover is a criterion for distinguishing low cover seagrass from medium cover seagrass, and 80% or more seagrass cover is classified as cover seagrass. high (Zoffol, 2021; Calleja, 2017).

However, the type Cymodocea rotundata, Thalassia hemprichii, and Halodule uninervis is a large type of seagrass which is common in every station observations compared to seagrass species other. Bjork et al. (2008) explained that the presence of seagrasses is large such as Cymodocea rotundata and Thalassia hemprichii in the associated intertidal area with its morphological characters so as to tolerate the conditions dryness or minimize stress due to drought.

The main cause of the difference is the density of seagrass species due to natural factors in the form of differences topography and substrate at each observation location due to type certain seagrass has a different pattern of adaptation different from natural factors. Short and Coles (2001) explained that The density of seagrass is influenced by various factors such as seagrass species, substrate conditions, seasons, tides, energy forces waves, organic matter content in sediments and environmental factors other.

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