DEPIK
Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Journal homepage: www.jurnal.usk.ac.id/depik

Dynamics of mangrove species dominant area changes in Timbulsloko and Bedono, Demak

Zahra Safira Aulia[1,*], Rudhi Pribadi[1,2], Muhammad Helmi[1,2]

[1]*Department of Marine Science, Fisheries and Marine Science Faculty, Universitas Diponegoro, Semarang, Indonesia.*
[2]*Center for Coastal Rehabilitation and Disaster Mitigation Studies (CoREM), Universitas Diponegoro, Semarang, Indonesia.*

ARTICLE INFO

Keywords:
Mangrove Species
Dynamics
Coastal Area
Sentinel 2
Remote Sensing

DOI: 10.13170/depik.12.2.32538

ABSTRACT

Mangrove forests in Timbulsloko and Bedono villages have very important benefits in minimizing abrasion, due to tidal flooding and land absorption in this area. A large number of people have planted mangroves to restore the function of mangrove forests in coastal areas which conducted by NGOs, students, government agencies, and awareness from local residents. This study aimed to determine the dynamics of mangrove area and mangrove species dominant area changes in 2016, 2018, 2020 and 2022 based on Sentinel-2 Satellite Imagery processing, and to analyze the dynamic changes based on geospatial analysis. The method used in this study is divided into two: satellite imagery data processing and field survey. The result showed that the area of mangrove species in Timbulsloko and Bedono increased from 2016 to 2022. In 2016 the area of mangroves was 140.04 ha, 159.57 ha in 2018, 171.05 ha in 2020, and 234.8 ha in 2022. The use of Sentinel 2 Satellite Imagery to map the distribution of mangrove species dominant produce overall accuracy of 84.62%. The mangrove species with the highest area are *Avicennia marina* followed by *Avicennia alba*, *Rhizophora apiculata*, and *Rhizophora mucronate.* The increase in this area of mangroves in this area is due to natural additions and artificial additions due to mangrove planting conservation by several parties and the awareness of the local residents to protect mangroves.

Introduction

Indonesia has a very wide area of mangroves. According to Arbiastutie *et al.* (2021), Indonesia has the largest mangrove ecosystem worldwide, contributing about 27% of the world total mangrove forests, which cover 16 million hectares. Mangrove forests in Indonesia are widespread, one of which is in the villages of Timbulsloko and Bedono, Demak, Central Java. Mangrove forests in this area change every time, caused by several factors namely tidal flood (Rudiarto *et al.,* 2020), massive erosion, land subsidence (Muskananfola *et al.,* 2020), industrial pollution, and physical coastal damage (Purnomo *et al.*, 2020).

Phenomena of erosion and flooding in this area have destroyed villages, fish ponds, and the economy of local communities. The disaster awakened the local community to plant mangroves. The mangrove ecosystem has an integral role in the success of the planting program (Irsadi *et al.*, 2019). Mangrove rehabilitation is needed to restore the mangrove ecosystem (Cemaron *et al.,* 2018). According to Damastuti and de Groot (2017), since 1990, mangroves have been planted in Sriwulan, Bedono, Timbulsloko, and Surodadi, increasing the mangrove area from 7.5 ha to 240 ha. The existence of mangrove planting and natural disasters that occurred in this region caused the area of mangrove forests change over the time. Calculation of changes in mangrove area is very important to determine the condition of the mangrove ecosystem which has very broad benefits in coastal areas.

Remote sensing has been widely used to map mangroves since it has advantages over field measurements. The advantages of remote sensing include lower costs, better accuracy, simpler

* Corresponding author.
Email address: zahrasafira1999@gmail.com

p-ISSN 2089-7790; e-ISSN 2502-6194
Received 14 June 2023; Received in revised form 07 July 2023; Accepted 02 August 2023
Available online 31 August 2023

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 2, Page 216-222

repeatability, and a wider field of view than traditional methods in the field (Pham *et al.*, 2019). Various data of the mangrove ecosystem can be extracted from remote sensing data obtained by a variety of sensors through the application of different classification approaches (Maurya *et al.*, 2021).

Mapping of changes in mangrove area has been carried out before, but these studies only focused on mangrove area in general, not on mangrove species. Mapping mangroves per species has many challenges (Kuenzer *et al.*, 2011), this is because individual mangroves live in groups and the individual size is smaller than the resolution of satellite imagery. Therefore, this study will take the dominant species that represent the satellite imagery shooting area. This study uses Sentinel 2 Satellite Imagery to distinguish dominant mangrove species and calculate the area for each year. According to Xia *et al.* (2020), Landsat and Sentinel satellite images can provide better spectral and textural information for separating mangrove species based on the kind of vegetation they represent. Therefore, it is important to conduct this study to analyze the dynamics of mangrove area and mangrove species dominant area changes in 2016, 2018, 2020 and 2022 based on Sentinel-2 Satellite Imagery processing, and to analyze the dynamic changes based on geospatial analysis

Materials and Methods

Location and time of research

This research site is Timbulsloko and Bedono villages, Sayung district, Demak region, Central Java (Figure 1). Timbulsloko Village is directly adjacent to Bedono Village. These two villages have the largest mangrove areas compared to the other villages in Sayung District, Demak. This research was conducted from October 2022 to May 2023.

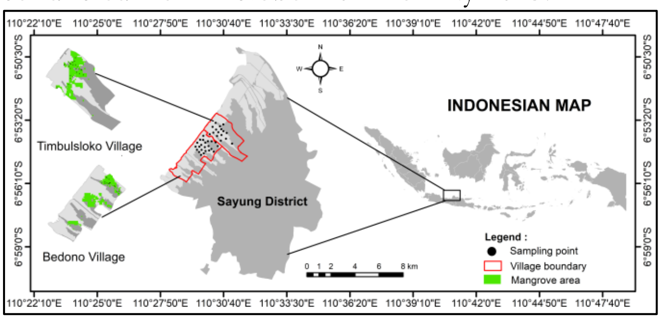

Figure 1. Maps showing the location (red square), the green color representative the mangrove area.

Materials

The data used in this research were primary data and secondary data. The primary data was taken from the field, namely data of species mangrove. The secondary data obtained from the processing of Sentinel-2 Satellite Imagery (recorded on 2 August 2016, 11 October 2018, 31 August 2020, and 11 August 2022) downloaded from USGS. The equipment used in this research were Global Positioning System type Garmin 65s, transect quadratic, mapping software, and camera.

Methods

The methods of this research divided into two, namely the satellite imagery data processing method and the field survey method. The satellite imagery data was used to determine the area of mangrove species dominant, while the survey method was used to take the dominant species in the field that used as classification and accuracy test.

Mangrove distribution data was obtained by performing radiometric correction, geometric correction, image cropping, masking, digital image classification, calculation of mangrove and mangrove dominant area, and accuracy assessment. Radiometric correction aims to restore image pixel values to their original values, carried out using the Dark Object Subtraction (DOS) method (Helmi *et al.*, 2018). The geometric correction aims to improve the position of the data so that it matches the position on the earth's surface using the linear polynomial rectification method using three control points.

Image cropping aims to limit the research area. Digital image classification was conducted twice, the first was conducted to classify between mangroves and non-mangrove, the second was conducted to classify between mangrove species using ArcMap 10.4 software. Image sharpening with a false-color composite (combination of band 6, 5, and 4) was conducted in this study to see the different color of mangrove and non-mangrove. Classification of mangroves and non - mangrove was conducted with supervised classification with the maximum likelihood approach. According to Aulia *et al.* (2022), this method can compare and calculates the average diversity value between existing classes by assuming a normal spectral distribution for each characteristic when performing parameter classification. As many as 30 mangrove species data in the field were used as training data to separate the dominant mangrove species.

Data collection in the field was conducted using a purposive sampling method. Data collection was conducted at 43 points using a quadratic transect. The distribution of the sampling points is shown in Figure 1. At each point a 10m x 10m square transect was laid out, then identified and counted the number of mangrove vegetation each species. Furthermore, the dominant mangrove species that represents one transect was determined. The use of a quadratic transect measuring 10m x 10m was chosen because the Sentinel 2 Satellite Image has a resolution of 10m x 10m. Data collection was only conducted on mangroves with a trunk diameter of ≥ 5 cm.

A total of 30 points were used to classify dominant mangrove species, and 13 points were used to accuracy assessment. Calculation of mangrove area using Sentinel 2 Satellite Imagery was carried out using ArcMap software. Calculation of changes in mangrove area and mangrove species dominant area was carried out with overlay methods for each year. Then an accuracy test was carried out to find out how much accuracy the data from Sentinel 2 satellite imagery with the data obtained in the field.

Data analysis

The data obtained were described quantitatively. While the accuracy assessment was carried out with error matrix value between dominant mangrove species data obtained in the field and dominant mangrove species data obtained based on Sentinel 2 Satellite Imagery data. The error matrix is the most common method and is often used to determine the accuracy of remote sensing image classification, such as land cover (Comber *et al.,* 2012). The error matrix was calculated by calculating the values of user accuracy, producer accuracy, and overall accuracy.

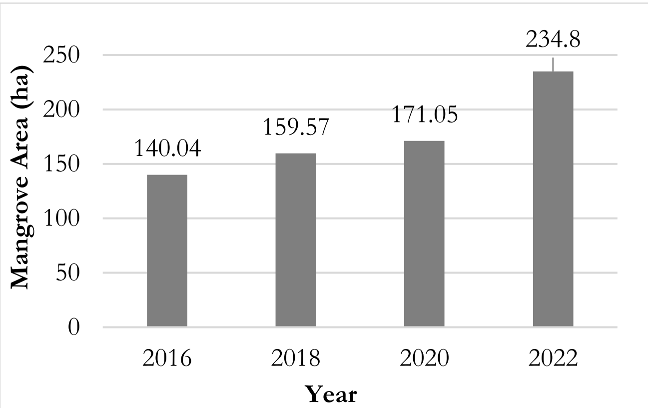

Figure 2. Mangrove area changes in Timbulsloko and Bedono.

Results

Mangrove area changes in Timbulsloko and Bedono Villages

Calculation of the area of mangrove forests in Timbulsloko and Bedono Villages was carried out by processing Sentinel 2 Satellite Imagery. The results showed that the area of mangroves in Timbulsloko and Bedono Villages has increased from 2016, 2018, 2020, and 2020. In 2016 the area of mangroves was 140.04, in 2018 was 159.57, in 2020 was 171.05, and in 2022 was 234.8 (Figure 2).

In 2018 there was an additional area of mangroves by 19.53 ha, in 2020 there was an additional area of 11.48 ha, in 2022 there was an additional area of 63.75 ha (Figure 3). In Figure 3, yellow color represented the mangrove area in 2016, orange color represented the additional area of mangrove in 2018, light green color represented the additional area of mangrove in 2020, and dark green represent the additional area of mangrove in 2022.

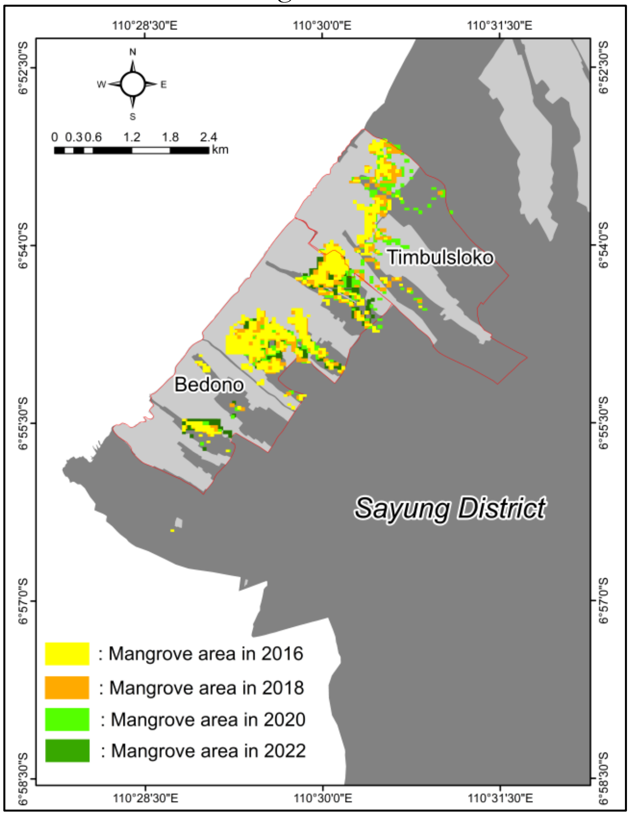

Figure 3. The changes of mangrove area in Timbulsloko and Bedono Villages.

Mangrove species dominant area changes in Timbulsloko and Bedono Villages

The results of identifying the mangrove species in the field at 43 points found several mangrove species, namely *Avicennia alba, Avicennia marina, Rhizophora mucronata*, and *Rhizophora apiculata* (Table 1). The distribution of the mangrove species dominant is shown in Figure 4. Mangrove species dominant represented the most dominant mangrove species with the highest number in a transect.

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 2, Page 216-222

Table 1. Mangrove species dominant in Timbulsloko and Bedono Villages.

No	Longitude	Latitude	Species Dominant
1	110.507854	-6.88984	*A. marina*
2	110.508464	-6.88928	*A. marina*
3	110.506043	-6.88973	*R. mucronata*
4	110.506067	-6.89157	*A. marina*
5	110.50947	-6.89411	*A. alba*
6	110.509195	-6.89264	*R. mucronata*
7	110.504426	-6.89064	*A. alba*
8	110.504016	-6.89095	*R. mucronata*
9	110.506609	-6.89026	*A. marina*
10	110.507921	-6.89087	*A. marina*
11	110.508952	-6.89088	*A. marina*
12	110.512435	-6.89534	*A. marina*
13	110.51074	-6.89467	*R. mucronata*
14	110.511654	-6.89321	*R. mucronata*
15	110.510474	-6.89262	*R. mucronata*
16	110.511426	-6.8929	*A. marina*
17	110.509856	-6.89202	*R. apiculata*
18	110.507737	-6.89625	*A. marina*
19	110.508904	-6.88782	*A. marina*
20	110.50694	-6.89061	*R. mucronata*
21	110.50673	-6.89553	*A. marina*
22	110.506715	-6.89682	*A. marina*
23	110.505861	-6.89942	*A. marina*
24	110.50072	-6.90217	*R. mucronata*
25	110.500011	-6.90363	*A. marina*
26	110.500935	-6.90107	*A. marina*
27	110.499986	-6.90393	*A. marina*
28	110.500793	-6.90045	*A. marina*
29	110.505861	-6.89942	*A. marina*
30	110.499296	-6.904775	*A. marina*
31	110.497757	-6.905331	*A. marina*
32	110.507942	-6.891381	*A. marina*
33	110.500358	-6.902751	*R. apiculata*
34	110.506362	-6.909471	*R. mucronata*
35	110.500737	-6.900272	*R. mucronata*
36	110.506438	-6.91037	*A. marina*
37	110.501438	-6.900438	*R. mucronata*
38	110.504145	-6.906708	*A. marina*
39	110.499336	-6.905451	*A. marina*
40	110.499294	-6.904776	*R. apiculata*
41	110.500298	-6.905209	*A. marina*
42	110.500942	-6.905713	*A. marina*
43	110.501505	-6.905236	*A. marina*
44	110.502009	-6.905098	*R. apiculata*

The results of Sentinel 2 Satellite Imagery processing showed that in 2016 *A. alba* species had an area of 30.36 ha, *A. marina* was 58.7 ha, *R. mucronata* was 22.3, and *R. apiculata* was 28.7. In 2018, *A. alba* had an area of 37.8 ha, *A. marina* was 60.4 ha, *R. mucronata* was 26.4, and *R. apiculata* was 34.9. In 2020 *A. alba* species had an area of 39.6 ha, *A. marina* was 64.9 ha, *R. mucronata* was 29.2, and *R. apiculata* was 37.4. In 2022 *A. alba* species had an area of 48.3 ha, *A. marina* was 77.6 ha, *R. mucronata* was 45.1, *R. apiculata* was 63.7 (Figure 5).

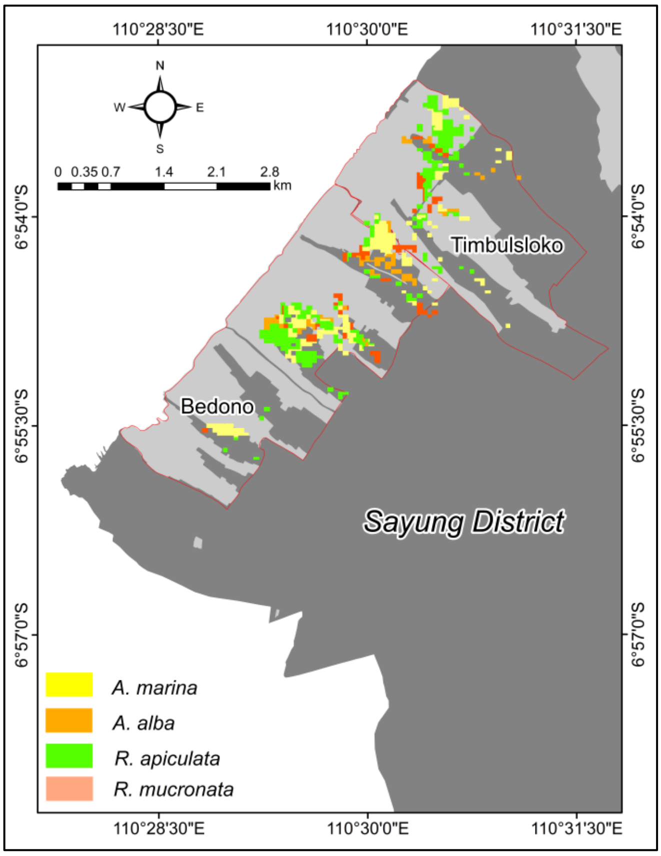

Figure 4. The distribution of the mangrove species dominant in 2022.

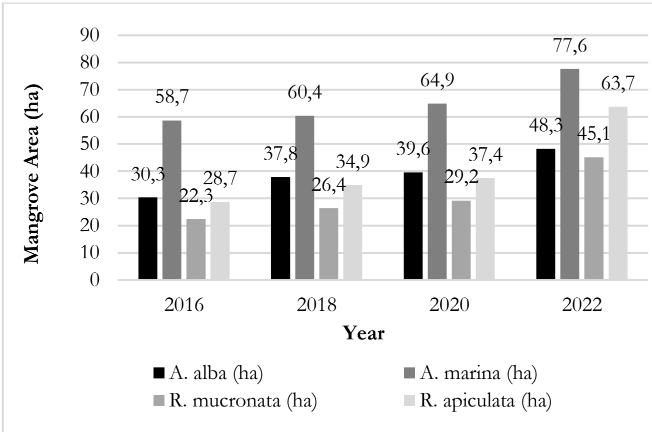

Figure 5. Mangrove area changes in Timbulsloko and Bedono.

The area of A. *alba* species increased by 7.5 ha in 2018, 1.8 ha in 2020, and 8.7 ha in 2022. The area of A. *marina* species increased by 1.7 ha in 2018, 4.5 ha in 2020, 12.7 ha in 2022. The area of R. *mucronata* species increased by 4.1 ha, 2.8 ha in 2018, and 15.9 ha in 2022. The R. *apiculata* species increased 6.2 ha, 2.5 ha in 2020, and 26.3 ha in 2022 (Figure 6).

Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan
Volume 12, Number 2, Page 216-222

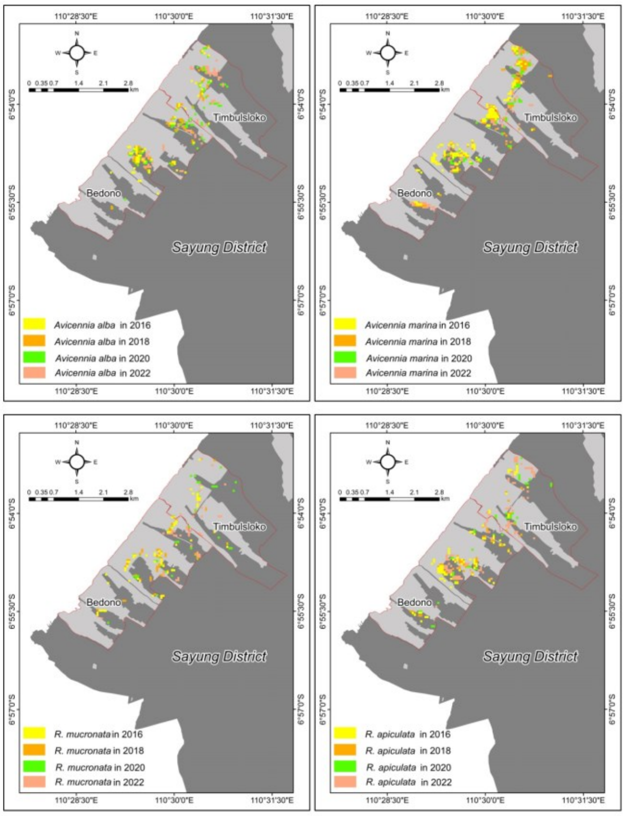

Figure 6. The changes of *A. alba*, *A. marina, R. Mucronata*, and *R. apiculata* area in Timbulsloko and Bedono Villages.

The use of Sentinel 2 Satellite Imagery to map the distribution and area of mangrove species dominant obtained overall accuracy of 84.62% (Table 2).

Table 2. Accuracy assessment of mangrove species dominant based on sentinel 2 satellite imagery and field survey data.

Survey	Sentinel 2 Data *A. marina*	*A. alba*	*R. mucronata*	*R. apiculata*	User Accuracy (%)
A. marina	4	1	0	0	80
A. alba	0	2	0	0	100
R. mucronata	0	0	4	1	80
R. apiculata	0	0	0	1	100
Producer Accuracy (%)	100	66.67	100	50.00	13
Overall Accuracy (%)			84.62		

Discussion

Mangrove area changes in Timbulsloko and Bedono Villages

The Timbulsloko and Bedono Villages have very natural mangrove forest areas, but in 1980 the mangrove forest in these areas were converted into ponds. This conversion causes the area of mangrove forests to decrease and results in various natural disasters. According to Damastuti and de Groot (2017), various mangrove rehabilitation efforts have been conducted in Timbulsloko and Bedono villages since the 1990s, initiated by different actors (e.g., the community, the government, and NGOs).

Based on the Sentinel 2 Satellite Imagery processing, the mangrove forests in Timbulsloko and Bedono Villages experienced an increase in area in 2016, 2018, 2020, and 2022. The increase in area in these two areas was due to mangrove planting carried out by several parties.

In Figure 2, it can be seen that there has been an increase in the area of mangroves from 2016 to 2022, the largest mangrove area increase was from 2020 to 2022. The increase in mangrove areas in recent years has provided benefits for the people at the research location, both ecological and economic benefits. According to Damastuti and de Groot (2019), the mangrove-rehabilitated areas around these villages have seen increased economic activity. Ecologically, mangrove forests have a function as feeding ground, spawning ground and as a nursery ground for biota living around mangroves (Su *et al.,* 2021).

Mangrove forests in the study area have a very important role, considering that this area often experiences tidal flooding and land subsidence. Mangrove ecosystems can act as a wave barrier, sediment retaining system, and can absorb wave energy (Handayani *et al.,* 2021). Mangroves can reduce the intensity of hazards along the land edge by dampening waves, capturing sediment, and forming land, mangrove forest play an important role in protecting the coastline (Spalding *et al.,* 2014). Mangrove forests have various benefits that are important for protecting the research area, this reason has made people to start planting mangroves in this area.

Mangrove Species Dominant area changes in Timbulsloko and Bedono Villages

Mangrove species found in the study area include *Avicennia alba, Avicennia marina, Rhizophora mucronata*, and *Rhizophora apiculata*. Based on the area calculation for each year of observation in Figure 5, it can be seen that *Avicennia marina* has the highest mangrove area, followed by *Avicennia alba, Rhizophora apiculata,* and *Rhizophora mucronata*. *Avicennia marina* is a native species in this area.

The large area of *Avicennia marina* is because this species is a pioneer species that can survive high salinity and can live well in areas that are frequently traversed by tides (Sabri *et al*., 2018), this type of mangrove is also not widely used by the community so it can grow well, meanwhile the other species of mangrove widely used by the community. *Avicennia marina* also has a good adaptation system to metal pollution in the environment. Based on data collection in the field, the research area has a salinity ranging from 30-32 ppt, with water areas polluted by pollution from industries around the area. According to Azizah *et al*. (2021), *Avicennia marina* has a mechanism for absorption of heavy metal elements with the rhizofiltration system by the root which does not poison the body.

In each year of observation, the four mangrove species have increased in these area. The highest addition occurred in the species *Rhizophora apiculata* which occurred from 2020 to 2022, this addition occurred due to natural and artificial factors. The natural factor that resulted in the high addition of this species was because the species from Rhizophoraceae had a very high growth speed and had very good adaptability (Saddhe *et al*., 2018). The artificial factor that resulted in the high increase in the area of this species was because most of the mangrove planting carried out in the villages of Bedono and Timbulsloko used mangroves of the Rhizopora species. The use of Rhizophora species for planting mangroves is because this species has the ability to grow faster.

Utilization of Sentinel 2 Satellite Imagery to map mangrove area and mangrove species dominant area has been widely used and produces very good accuracy. In this study, the use of remote sensing to map the area of mangrove species dominant obtained overall accuracy of 84.62%. The results of this accuracy test show that the use of remote sensing to map the area and distribution of mangroves can be used properly. Chen (2020) conducted research about mangrove area mapping with Sentinel 2 imagery and obtained an accuracy of 90.47%, Ghorbanian *et al*. (2021) obtained an accuracy of 93.23%, Jia *et al*. (2019) obtained an accuracy of 97%.

Differences accuracy in each study can be caused by differences in location and time of data collection. According to Ayustina *et al*. (2018), the high accuracy of using remote sensing for mapping is due to the time interval between the date of satellite imagery capture and data collection in the field which is too close so not much changes occur. Meanwhile, the low value of accuracy can be caused by an error in taking points using GPS. GPS errors result in incorrect classifications because the location in the field does not match the location in the satellite imagery.

Conclusion

The area of mangrove forest and mangrove species in Timbulsloko and Bedono Villages has increased from 2016, 2018, 2020 and 2022. In 2016 the area of mangroves was 140.04, in 2018 was 159.57, in 2020 was 171.05, and in 2022 was 234.8. The increasing area also occurred for each species, the species that had the highest area is *Avicennia marina* followed by *Avicennia alba, Rhizophora apiculata*, and *Rhizophora mucronata*. The use of Sentinel 2 Satellite Imagery to map the distribution of dominant mangrove species produced an overall accuracy of 84.62%. The increase in mangrove area and mangrove species dominance is caused by natural and artificial factors due to planting from various sources.

Acknowledgments

The authors would like to extend appreciation to the Rijksdienst voor Ondernemend Nederland for funding this research with contract number 839-03/UN7.D2/KS/X/2022 and Center for Coastal Rehabilitation and Disaster Mitigation Studies (CoREM) Diponegoro University who has provided facilities during the research.

References

Arbiastutie, Y., D. Farah, Marsiani. 2021. Short communication: ethnobotanical and ecological studies of medicinal plants in a mangrove forest in Mempawah District, West Kalimantan, Indonesia. BIODIVERSITAS, 22(6): 3164-3170.

Aulia, Z.S., R.R. Hidayat, Amron. 2022. Carbon sink estimation of mangrove vegetation using remote sensing in Segara Anakan, Cilacap. Jurnal Ilmiah Perikanan dan Kelautan, 14(1): 130–141.

Ayustina, R., *et al.* 2018. Classification of shallow water seabed profile based on Landsat 8 imagery and in-situ data. Case study in Gili Matra Island Lombok, Indonesia. E3S Web of Conferences, 47 (04002): 1-12.

Azizah, D., *et al.* 2021. Index of environmental pollution and adaptation of Avicennia marina around the ex-bauxite mining area in Bintan Island. IOP Conf. Series: Earth and Environmental Science, 967 (012016).

Cemaron, C., L.B. Hutley, D.A. Friess, B. Brown. 2018. Community structure dynamics and carbon stock change of rehabilitated mangrove forests in Sulawesi, Indonesia. Ecological Applications, 0(0): 1–18.

Chen, N. 2022. Mapping mangrove in Dongzhaigang, China using Sentinel-2 imagery. Journal of Applied Remote Sensing, 14(1).

Comber, A., E. Fisher, C. Brunsdon, A. Khmag. 2012. Spatial analysis of remote sensing image classification accuracy. Remote Sensing of Environment, 127: 237–246.

Damastuti, E., and R. de Groot. 2017. Effectiveness of community-based mangrove management for sustainable resource use and livelihood support: A case study of four villages in Central Java, Indonesia. Journal of Environmental Management, 203:510-521.

Damastuti, E., and R. de Groot. 2019. Participatory ecosystem service mapping to enhance community-based mangrove rehabilitation and management in Demak, Indonesia. Regional Environmental Change, 19:65–78.

Ghorbanian, A., S. Zaghian, R.M. Asiyabi, M. Amani, A. Mohammadzadeh, S. Jamali. 2021. Mangrove ecosystem mapping using Sentinel-1 and Sentinel-2 satellite images and random forest algorithm in Google Earth Engine. 2021. Remote Sensing,13 (2565): 1-18.

Handayani, S., L. Adrianto, I.W. Nurjaya, D.G. Bengen, Y. Wardiatno. 2021. Strategies for optimizing mangrove ecosystem management in the rehabilitation area of Sayung coastal zone, Demak Regency, Central Java. Journal of Natural Resources and Environmental Management, 11(3): 387-396.

Helmi, M., *et al.* 2018. Rehabilitation priority area assessment on death coral using cell based modeling approach at Parang Islands. 2018. International Journal of Civil Engineering and Technology (IJCIET), 9(11): 2949-2961.

Irsadi, A., S. Anggoro, T.R Soeprobowati. 2019. Environmental factors supporting mangrove ecosystem in Semarang-Demak Coastal Area. E3S Web of Conferences, 125.

Jia, M., Z. Wang, C. Wang, D. Mao, Y.A. Zhang. 2019. New vegetation index to detect periodically submerged mangrove forest using single-tide Sentinel-2 Imagery. Remote Sensing, 11 (2043): 1-17.

Su. J., D.A. Friess, A.A. Gasparatos. 2021. A meta-analysis of the ecological and economic outcomes of mangrove restoration. Nature ommunication, 12(5050): 1-13.

Kuenzer, C., A. Bluemel, S. Gebhardt, T.V. Quoc, S. Dech. 2021. Remote sensing of mangrove ecosystems: a review. Remote Sensing, 3: 878-928.

Maurya, K., S. Mahajan, N. Chaube. 2021. Remote sensing techniques: mapping and monitoring of mangrove ecosystem - a review. Complex & Intelligent Systems, 7: 2797–2818.

Muskananfola, M.R., Supriharyono, S. Febrianto. 2020. Spatio-temporal analysis of shoreline change along the coast of Sayung Demak, Indonesia using Digital Shoreline Analysis System. Regional Studies in Marine Science, 34, 101060.

Pham, T.D., N. Yokoya, D.T. Bui, K. Yoshino, A.D. Friess. 2019. Remote sensing approaches for monitoring mangrove species, structure, and biomass: opportunities and challenges. Remote Sensing, 11(230): 1-24.

Purnomo, P.W., N. Afiati, O.E. Jati. 2020. Abundance and diversity of fish larvae and juveniles in mangrove, estuary, and erosion zone on the west coast of Demak Regency. AACL Bioflux, 13(5): 3126-3134.

Rudiarto, I., H. Rengganis, A. Sarasadi, E. Caesar. 2020. The effectiveness of strategy adaptations on tidal flood in the coastal areas of Sayung, Demak, Central Java, Indonesia. IOP Conf. Series: Earth and Environmental Science, 448, 012090. doi:10.1088/1755-1315/448/1/012090

Sabri, D.M., S.A. El-Hussieny, N. Elnwhisy. 2018. Genotypic variations of mangrove (*Avicennia marina*) in Nabq Protectorate, South Sinai, Egypt. International Journal of Agriculture & Biology, 20: 637–646.

Sadhe, A.A., M.R. Malvankar, K. Kumar. 2018. Selection of reference genes for quantitative real-time PCR analysis in halophytic plant Rhizophora apiculate. PeerJ, 6: e5226.

Spalding M., A. McIvor, F.H. Tonneijck, S. Tol, P. van Eijk. 2014. Mangroves for coastal defence: guidelines for coastal managers & policy makers. Wetlands International and The Nature Conservancy, Cambridge.

Xia, J., N. Yokoya, T.D. Pham. 2020. Probabilistic mangrove species mapping with multiple-source remote-sensing datasets using label distribution learning in Xuan Thuy National Park, Vietnam. Remote Sensing, 12 (3834): 1-17.

How to cite this paper:
Aulia, Z.S., R. Pribadi, M. Helmi. 2022. Dynamics of Mangrove Species Dominant Area Changes in Timbulsloko and Bedono, Demak. Depik Jurnal Ilmu-Ilmu Perairan, Pesisir dan Perikanan, 12(2): 216-222.