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Mangrove Land Mapping and the Potential for Bivalve Diversity with Remote Sensing in the Pulau Dua Nature Reserve (As an Initial Study for the Development of Class X High School Ecosystem Biology Subconcept Learning Devices)

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Abstrak

Bivalvia merupakan hewan invertebrata yang memiliki tingkat keanekaragaman tinggi dan sumber hayati laut yang memiliki nilai ekonomi yang cukup penting. Penelitian ini dilakukan pada November tahun 2021, bertujuan untuk mengetahui keanekaragaman bivalvia, pemetaan lahan manrove dan potensi keanekaragaman bivalvia, hubungan hasil analisis keberadaan air terhadap keanekaragamanan bivalvia di Cagar alam Pulau Dua dan implikasi hasil penelitian dalam bidang kependidikan. Metode yang digunakan adalah metode jelajah untuk mengetahui keanekaragaman bivalvia dan metode penginderaan jauh untuk memetakan daerah potensi keanekaragaman bivalvia di Cagar Alam Pulau Dua. Hasil pengamatan didapatkan bahwa keanekaragaman bivalvia di Cagar Alam Pulau Dua termasuk kedalam kategori keanekaragaman sedang dengan nilai 1,085. Hasil hubungan keanekaragaman bivalvia dengan MNDWI tergolong memiliki hubungan kuat yaitu dengan nilai korelasi koefisien (r) adalah 0,668. Pada Cagar Alam Pulau Dua didapatkan daerah yang berpotensi tinggi memiliki keanekaragaman bivalvia terdapat pada titik koordinat 106,198956 6,018374. Hasil penelitian ini selanjutnya dilakukan analisis materi pada KD 3.10 dan KD 4.10 kelas X SMA kesekolah.

Kata Kunci: *Bivalvia, Cagar Alam Pulau Dua, Keanekaragaman, Mangrove dan Penginderaan Jauh*

Abstract

Bivalvia is an invertebrate animal that has a high level of diversity and a marine biological resource that has significant economic value. This research was conducted in November 2021, aiming to determine bivalve diversity, mapping of manrove land and the potential for bivalve diversity, the relationship between the results of analysis of the presence of water on bivalves diversity in the Pulau Dua Nature Reserve and the implications of research results in the field of education. The method used is the roaming method to determine bivalves diversity and remote sensing methods to map areas of potential bivalve diversity in Pulau Dua Nature Reserve. The results of observations found that the diversity of bivalves in Pulau Dua Nature Reserve was included in the medium diversity category with a value of 1.085. The results of the relationship between bivalve diversity and MNDWI are classified as having a strong relationship, namely the correlation coefficient (r) is 0.668. In the Pulau Dua Nature Reserve, it was found that areas with a high potential for bivalve diversity were found at coordinates 106.198956 6.018374. The results of this research were then carried out to analyze the material at KD 3.10 and KD 4.10 for class X SMA at school.

***Keywords**: Bivalves, Pulau Dua Nature Reserve, Diversity, Mangroves and Remote Sensing*

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Introduction

Pulau Dua Nature Reserve is located in the Sawah Luhur Area, Kasemen District, Serang City. Pulau Dua was designated as a Nature Reserve area through the decree of the minister of forestry number 253/Kpts-II/1984 dated 24 December 1984 and was determined in accordance with the decree of the minister of forestry of the Republic of Indonesia number: Sk. 3107/Menhut-VII/KUH/2014, dated April 25 2014. The Dua Island Nature Reserve area has an area of 32.85 hectares (Nurwati, 2018). The Pulau Dua Nature Reserve is a wetland area and conservation area which has a distinctive characteristic, namely that it is a place where birds live, both migratory and local birds and has another characteristic, namely the mangrove ecosystem (Takandjandji & Kwatrina, 2011).

Mangrove forest is one of the ecosystems of mangrove plants whose life grows mostly on the beach. Usually the growth of mangrove trees is influenced by tides so that the mangrove ecosystem is always flooded with water (Supriharyono, 2009). The mangrove ecosystem is said to be one of the ecosystems that has high productivity compared to other ecosystems because mangroves have a high potential for decomposition of organic matter compared to other ecosystems. The organic material produced by mangroves is an important ecological link for living creatures that live in mangrove waters and one of the invertebrate groups that live in mangrove forest waters is bivalves (Suryono, 2016).

Bivalvia is an invertebrate animal that has a high level of diversity and a marine biological resource that has significant economic value. the distribution area of bivalves is very wide, covering almost all Indonesian waters, which are overgrown with mangrove forests, which can be used as breeding grounds for bivalves (Dahuri, 2003). Factors that greatly influence the amount of diversity of bivalves are pressure factors and changes in the ecosystem environment occupied by these bivalves ((Michael, 1995) in (Darojah, 2005)). The relationship between decreased diversity and mangrove damage can be used as a very important factor to determine the condition of diversity in this ecosystem. If there is damage to the mangroves, it will affect the diversity of the bivalves that live in the mangrove ecosystem because this diversity with the mangrove ecosystem has a close relationship, namely the mangrove ecosystem as a place to live and foraging for bivalves.

Mapping areas of potential diversity in mangrove lands can be usedsatellite imagery with remote sensing methods. Satellite imagery is remote sensing digital imagery obtained from a recording system via satellite sensors. Remote sensing is a methodto get information about knowing and determining the object to be studied without direct contact with the target or object to be studied (Irawan & Malau, 2016). Remote sensing can identify mangrove areasusing chlorophyll-a and living habitat from mangroves located in tidal areas (Vo et al., 2013). This remote sensing has many advantages, namely that it can map large areas in a short time, the information obtained from Landsat images depicts the earth's surface objectively. Remote sensing has relatively high spatial resolution so that it is able to represent the earth's surface and objects that cover that surface (Atmoko & Sidiyasa, 2007).

The development of teaching materials conceptually and closely related to understanding natural environmental aspects is very necessary because of the development of the world of education in the era of revolution 4.0 (Dikti Diknas, 2008). With the above demands, it is hoped that the results of this research can help in the field of education, where the results of this research will later be related to ecological material in the sub-concept of ecosystem components in class interactions that take place in it from various sources and can be implemented as an initial study of the development of learning toolsbiology sub-

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concept of ecosystem components for class X high school to help students understand ecological learning material.

Research on bivalve diversity has been carried out by (Alimito et al., 2021) and (Ditian et al., 2021). Alimoto's research results (2021) explained that the diversity of bivalves at this place was classified as moderate and the types obtained were 8 families, 9 genera and 9 species, while the research results of (Ditian et al., 2021) explained that the diversity of bivalves at the research location was also classified as moderate and the order of bivalves obtained are Arcoida, Veneroida and so on. Until now, no one has conducted research regarding mapping studies of potential bivalve diversity areas using remote sensing in the Pulau Dua Nature Reserve. Based on the background above, the aim of this research is to find outmapping of mangrove land and the potential for bivalve diversity using remote sensing in the Pulau Dua nature reserve (as an initial study for developing biology learning tools for the ecosystem sub-concept for class X SMA).

Method

The method used is the exploration method to determine the diversity of bivalves and the remote sensing method to map areas of potential bivalve diversity in the Pulau Dua Nature Reserve. This research was conducted at the Pulau Dua Nature Reserve located in Banten Bay, including to Sawah Luhur Village, Kasemen District, Serang City. Geographically, the two islands are located at 106°1138" - 106°1314" East Longitude and 6°115" - 6°125" South Latitude. The research was conducted from November 2021 to December 2021.

The tools used in this research are a laptop (to operate the GEE), a camera (tool for documentation)and google earth engine,Knife (to pry bivalves attached to rocks or mangrove roots), pH meter (to measure water pH), Thermometer (to measure water temperature), Refactometer (to measure salinity), GPS (to determine coordinates), Bucket (to measure pelecypoda container), net (to catch pelecypods), Identification book (to identify pelecypods)and the research materials, namelyStationery (to record the results of specimens obtained and other data), plastic clips (for Bivalvia containers), paper labels (to provide information)and a map of the mangrove island nature reserve of Kelapa Dua.

This data analysis includes:

1. MNDWI data calculation analysis

MNDWI (Modified Normalized Difference Water Index) is an index used to measure the wetness level of an area using remote sensing (Xu, 2006). MNDWI has the following formula:

$$MNDWI = \frac{Green - MIR}{Green + MIR}$$

2. Diversity Index (H)

Diversity is also called species heterogeneity. Diversity shows the richness of species in a community and balance in the distribution of numbers per individual. Diversity index using Shannon Wienner (Dwiono, 2003).

$$H' = -\sum \left(\frac{ni}{N}\right) ln \left(\frac{ni}{N}\right)$$

Information:

H' = Shannon-wienner diversity index
Ni = importance of each species (number of individuals of each species)
N= total importance (total number of all individuals).

The Shannon-Wiener diversity index assessment criteria are grouped into 3 assessment criteria as follows:

H < 1 : Low diversity
1 < H< 3 : Medium diversity
H > 3 : High diversity

3. Uniformity index (E)

Uniformity is calculated using the Evennes uniformity index formula (Krebs, 1989), as follows

$$E = \frac{H'}{H\,max}$$

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Information :
E = uniformity index
H = shannon-winner diversity index
H max = in S
S = number of species discovered

The criteria for the level of uniformity are divided into three:
0 < E < 0.4 = low uniformity
0.4 < E < 0.6 = moderate uniformity
0.6 < E < 1 = high uniformity

4. Dominance index (C)

The Dominance Index is used to determine whether there is a dominant species in the community, using the Simpson dominance index (Krebs, 1989) as follows:

$$C = \Sigma \left(\frac{ni}{N}\right)^2$$

Information :
C = Simpson dominance index
ni = number of individuals of species I
N = number of individuals of all species

The dominance index value ranges between 0-1

Dominance index criteria, namely:
C approaches 0 (C < 0.5) = no type dominates
C is close to 1 (C > 0.5) = there is a type that dominates
(Odum, 1971)

5. Relationship between mangrove vegetation and bivalve diversity

Y = a + bX

Information :
Y = diversity of bivalves
X = Mangrove vegetation
a = Constant
b = Coefficient

Results and Discussion

Species found in the Pulau Dua Serang Banten Nature Reserve

Observations that have been carried out in the Pulau Dua Nature Reserve to determine the mapping of potential bivalve diversity areas, obtained 3 orders namely the Arcoida order, Anismorya order and the Venerida order.The bivalve species that have been found in the Pulau Dua Serang Banten Nature Reserve can be seen in Table 1.

Table 1. Species Found in the Pulau Dua Nature Reserve

No	Order	Species		Amount individual
		Scientific name	Region name	
1	Arcoida Order	*Anadara antiquata*	Feather Clams	23
2	Order of Anisomrya	*Perna viridis*	Green Shells	17
3	Order of the Venerida	*Polymesoda erosa*	Scallops	16

Anadara antiquata is the most common species found in the Pulau Dua Nature Reserve area and comes from the Arcoida order with 23 individuals, the next species is Perna vidiris which comes from the Anisomrya order with 17 individuals and Polymesoda erosa from the venerida order with 16 individuals. Description and classification of bivalves in Pulau Dua Nature Reserve are as follows:

Order Arcoida

1. *Anadara antiquata*(feather clams)

*Anadara antiquata*or what is often called shellfish is an animal that belongs to the phylum molluskhas characteristics, namely a thick shell and consists of two pieces, both shell pieces are symmetrical, have about 35-40 radialibs in each shell valve, have a white shell covered with periostracum which is brownish to blackish brown, the inner side is white sometimes yellow on the umbonal part and there are fine hairs on the sides of the shell, the flesh is soft and orange in color. This clam has a maximum shell length of 10.5 - 7 cm and the habitat of the Anadara antiquata species usually lives in interdial and sublittorial muddy areas to a depth of 25 meters (Carpenter & Niem, 1998).

Based on the results of observations that have been made in the field, the results

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obtained from morphological observations are that the feather clam has two shells, where on the shell there are 35 radial rib ribs on the shell, it has a brownish white color and fine hairs at the tip of the shell, the shell has a size of 5- 6 cm, from these characteristics it can be concluded that the clams found belong to the Arcoida order. Anandara antiquata is found in muddy substrates in open mangrove zones.

*Anandara antiquata*found in muddy substrates in mangrove areas on the edge of the sea, this type of shellfish is often found in muddy substrates because muddy substrates are rich in organic material which can increase the survival of shellfish, in accordance with the statement by (Irawan & Malau, 2016) in (Sudiyar et al., 2020) stating that the material Organic matter is higher in fine or muddy sediment conditions, less in coarse sediment conditions. Apart from the substrate, there are other factors that affect the growth of bivalves, namely temperature, pH meter, DO meter and water salinity. The results of calculating environmental parameters can be seen in Table 1.

The classification of feather shells is as follows:
Kingdom : Animalia
Phylum : Mollusca
Class : Bivalves
Order : Arcoid
Family : Arcoidea
Genus : Anadara
Species: Anadara antiquata.

Figure 1.*Anadara antiquata*
[Source: personal documentation]

Order of Anisomrya
1. Green mussels

Green mussels (*Perna viridis*) has the characteristics of a shell that is elongated, oval triangular in shape and has a smooth surface with clear growth lines on the outer shell. Green mussels have a dark brownish green shell on the front and bright green on the back and the inner shell is white. This green mussel has a maximum size of 16 to 18 cm (Carpenter & Niem, 1998). Green mussels are "suspension feeders", can move from place to place using their legs and "byssus" threads, live well in waters with a depth range of 1 to 7 meters (Cappenberg, 2008).

Based on the results of observations in the field, it was obtained that the shell was in the shape of an oval triangle, blackish brown and light green at the end of the shell, had a smooth shell texture and was 9 cm in size. From these characteristics it can be concluded that the shells found belonged to the Anisomyria order. Perna viridisfound in muddy substrates in mangrove areas on the seashore where these substrates contain nutrients which are a food source for these bivalves. Apart from the substrate, there are other factors that influence the growth of bivalves, namely temperature, Ph meter, DO meter and water salinity.

The classification of green mussels is as follows:
Kingdom : Animalia
Phylum : Molluscs
Class : Bivalvia
Order : Anisomyria
Family : Mytilidae
Genus : Perna
Species: Perna viridis

Figure 2.Perna viridis.

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[Source: personal documentation]

Order Venerida

1. Shellfish

Clam shells have the characteristics of a round oval shell, thick and slightly inflated. It has the same shell length as its height. The shell color of the kepah clam is greenish yellow for young clams and blackish brown for mature clams and has a size of up to 110 meters. The habitat of this clam usually lives on muddy bottoms, in fresh or brackish waters, in mangrove estuaries and large rivers. This mangrove clam is very tolerant of dry surfaces and can survive with air respiration for several days (Carpenter & Niem, 1998).

Based on the results of observations in the field, it was found that the shells were large and heavy, the shell length was around 10 cm. It is round and oval in shape and has a shell color that is blackish brown. From these characteristics it can be concluded that the shellfish found belongs to the order Venerida. Kepah clams are found in muddy substrates in mangrove forest areas. The location of the mangrove area where the kepah clam was discovered has good conditions, namely an area with dense mangrove trees.thus allowing bivalves to grow by using mangrove litter as food. This is in accordance with the statement by McConnaughey & Zottoli (1983) in (Taqwa, 2010) that fallen leaves, seeds, stems and other parts of mangroves called litter have an important role in producing organic material, where this organic material is the basis of the food chain. Litter from mangrove plants will be deposited on the bottom of the waters and accumulate continuously and will become sediment rich in nutrients, which is a good place for the survival of molluscs. Apart from the substrate, there are other factors that influence the growth of bivalves, namely temperature, Ph meter, DO meter and water salinity

The classification of kepah clams is as follows:

Kingdom : Animalia
Phylum : Mollusca
Class : Bivalvia
Order : Venerida
Family : Cyrenidae
Genus : Polymesoda
Species : Polymesoda erosa

Figure 3.Polymesoda erosa.
[Source: personal documentation]

Environmental parameters at the research location are one of the factors for the existence of bivalves. The following is a table of environmental parameters measured at the research location points:

Table 2. Parameters of the mangrove environment in Pulau Dua Nature Reserve

Location point	Temperature (ºC)	pH	DO (mg/L)	Salinity (ppt)
1 – 2	30	6,6	6,2	35
3 – 4	29	6,2	6.5	35
5 - 7	30	7.3	6,2	33

Based on Table 2, the temperatures obtained from location points 1 - 7 have temperature results ranging from 29ºC - 30ºC. Based on the results of these measurements the temperature obtained is a good temperature for bivalves, according to Parenrenggi (1998) in (Kisman et al., 2016) bivalves can live at temperatures ranging from 28ºC - 31ºC. The pH calculation results at the research location ranged from 6.2 to 7.3, which is a good pH for bivalve life. The optimum pH for bivalves according to (Hasan et al., 2014) in (Kisman et al., 2016), namely the optimum pH for bivalve life ranges from 6 - 9. The salinity obtained at the point of the research location ranges from 33 - 35 ppt, this is in accordance with the opinion of Ritniasih (2007) in (Kisman

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et al., 2016) says that good salinity for bivalves is 5 ppt - 35 ppt. The results of dissolved oxygen (DO) calculations at the study site ranged from 6.2 mg/L - 6.5 mg/L, this is in accordance with Prihatini's statement (1999) in (Kisman et al., 2016) that bivalves can live at oxygen levels ranging from 3 - 12 mg /L. The availability of sufficient dissolved oxygen makes the shellfish's metabolism run well. Based on the results of environmental parameters in Pulau Dua Nature Reserve it can be said that it has good temperature, pH, salinity and oxygen levels for the survival of bivalves.

Index of Diversity (H'), Uniformity (E) and Dominance (C) of Bivalvia found in Pulau Dua Nature Reserve

The results of calculating the diversity index of bivalves found in the Pulau Dua Nature Reserve are classified as moderate, calculation results iThe uniformity index of bivalves is relatively highand the results of calculating the dominance index in the Pulau Dua Nature Reserve show that there are no dominant animals. The table of diversity index results (H'), uniformity (E) and dominance (C) can be seen in Table 3.

Table 3. Diversity index (H'), uniformity (E) and dominance (C)

Species	Diversity Index (H')	Uniformity Index (E)	Dominance Index (C)
Anadara antiquata *Perna viridis* *Polymesoda erosa*	1,085	0.987	0.342
Criteria	Medium diversity	High uniformity	Nobody dominates

The results of the calculation of the diversity index value (H') in the mangrove area of the Pulau Dua Nature Reserve are that it has a diversity index that is classified as moderate, seen in Table 4.3 the index value of bivalve diversity in the Pulau Dua Nature Reserve is 1.085. (Ayunda, 2011) believes that the moderate diversity index value factor is a diversity index which can be said to be a stable distribution of species and communities in an area. From these results, it can be said that the Pulau Dua Nature Reserve Area is still in good condition for the survival of bivalves. Species diversity is not only synonymous with the number of species found, but is also determined by the number of types and the evenness of individuals of each type. The better and more stable a community is, the more diverse the species and biota that live in it (Odum, 1994). this is in line with the results of the calculation of the uniformity index analysis obtained, namely having high uniformity.

The uniformity index (E) obtained in Pulau Dua Nature Reserve is classified as high uniformity with a value of 0.987. According to (Kharisma et al., 2012) this uniformity index describes the ecological balance in a community, where the higher the uniformity value, the better the environmental quality and suitable for bivalve life. From these results it can be said that Pulau Dua Nature Reserve has good environmental conditions for the development of bivalves. The uniformity index value will have a high value if there is no dominance of a particular species, and will have a low value if there is dominance (Odum, 1994).

The results of the dominance index (C) in the Pulau Dua Nature Reserve are valuable 0.342 which means that nothing dominates the area. According to (Odum, 1994) explained that if the dominance index ranges from less than 1, then the dominance in a community in that area is classified as low and indicates that the community structure is in a stable condition. From the results above, it shows that the Pulau Dua Nature Reserve is in a stable condition which is suitable as a habitat for bivalves, namely for finding food and breeding.

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Relationship between the results of the analysis of the presence of water and the diversity of Bivalves in the Pulau Dua Nature Reserve

Research on the relationship of the results of analysis of the presence of water to bivalves in Pulau Dua Nature Reserve using MNDWI value analysis on the Google Earth Engine (GEE) platform. MNDWI is an indexanalysis that analyzes the presence of water or the level of wetness in an area using remote sensing.Various remote sensing studies make MNDWI an important choice for implementing rapid water mapping in large-scale areas.The MNDWI value is determined based on 7 sample coordinate points obtained from the points where bivalves are found. Following are the results of the MNDWI values obtained from satellite imagery:

Table 4. MNDWI values based on location points in Pulau Dua Nature Reserve

Location point	Coordinate point	MNDWI
1	-106.1945 -6.01666	-0.167391300
2	-106.1935 -6.018133	-0.150188311
3	-106.19535 -6.018416	-0.171738326
4	-106.19553 -6.018577	-0.181000054
5	-106.19895 -6.018374	0.134508982
6	-106.19971 -6.018302	0.043478262
7	-106.200337 -6.018189	0.095601171

Based on the results from Table 4. above, it can be seen that at points 1,2,3 and 4 have negative values which means that at that point the location is included in the area that is not a body of water or the area includes vegetation or soil areas and at point 5 , 6 and 7 have a positive value, this means that at that point the location includes areas that include water bodies. At points 1 to 4 bivalves were found on muddy substrates in open mangrove areas while at points 5 to 7 bivalves were found on muddy substrates in open mangrove zones. this is in line with the opinion of (Xu, 2006) who said that the contrast between water and artificial soil MNDWI is greatly magnified by an increase in the reflectance value of water and a decrease in the value of the built land from positive to negative,

As for the pictures the graph of the relationship between MNDWI and bivalves diversity in the Pulau Dua Nature Reserve is as follows:

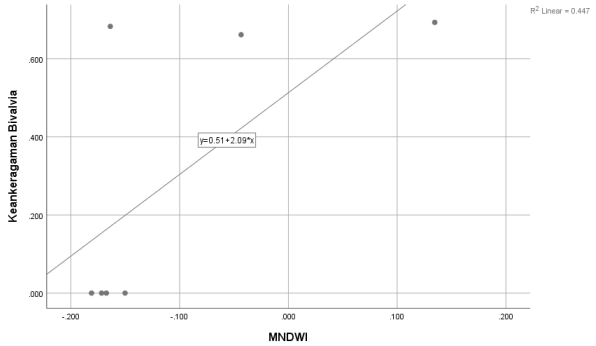

Figure 4. Graph of the Relationship between MNDWI Value and Bivalve Diversity

The results of Figure 4 above are the results of calculations using simple linear regression analysis to determine the relationship between the Y variable, namely bivalve diversity, and the X variable, namely MNDWI in Pulau Dua Nature Reserve. and the results obtained are the results of the equation Y = 0.51+2.09x, showing a positive relationship, where an increase and decrease in the independent variable (X), namely MNDWI, will result in an increase and decrease in the dependent variable (Y), namely bivalve diversity. The R2 results show that 44.7% of bivalve diversity in the Pulau Dua Nature Reserve is influenced by the results of the MNDWI analysis. The strength of the relationship between the results of the MNDWI analysis and diversity is calculated using the correlation coefficient (r) formula.

The results obtained based on the value of r = 0.668 show that the relationship between MNDWI and bivalve diversity has a strong relationship, this shows that bivalves can be found in areas that contain

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water. MNDWI is an analytical index that analyzes the presence of water or the degree of wetting in an area using remote sensing. Bivalves have a relationship with the presence of water related to the living habitat of these bivalves, bivalves are animals that live in fresh water and sea water. Apart from that, the definition of habitat is an area that can fulfill basic population requirements such as the need for water sources, food and shelter (Alikodra, 2002). Bivalves areeats small animals in the waters such as plankton. According to (Heddy & Kurniati, 1994), mangrove bottom soil has the characteristics of always being wet, low oxygen content, rich in organic matter and always saturated with water. The water content in the soil helps mussels obtain food by filtering food suspended in water. If the water content in the soil is low, it will be difficult for mussels to take food, thereby reducing the opportunity to eat and experiencing drought which can result in the death of the bivalves.

Mapping Potential Diversity Areas in the Pulau Dua Nature Reserve

Mapping potential areas for bivalve diversity in the Pulau Dua Nature Reserve using the Google Earth Engine (GEE), the initial stages of GEE are started by using landsat 8 from USGS Landsat 8 Surface Reflectance Tier 1 which has a value of 1 pixel which is 30 x 30 meters. The results of the roaming are in the form of coordinates that will be used on the Google Earth engine as field data and will be analyzed using the MNDWI method. MNDWIis an analytical index that analyzes the presence of water or the degree of wetness in an area using remote sensing.

The following is the mapping of potential bivalve diversity areas:

Figure 5. Map of potential bivalve diversity areas with the MNDWI index

Based on the results of the analysis using the MNDWI method, there are 3 criteria for potential bivalve diversity areas, namely white areas do not have bivalve diversity potential, green areas have the potential for bivalve diversity and red areas have high potential for bivalve diversity. The white area does not have the potential for bivalve diversity, this is because the white area is an area without water content, therefore the area has no potential for bivalve diversity. Pulau Dua Nature Reserve has 5 different vegetation formations namely the Rhizophora formation, the Avicenia formation, the Diospyros Formation, the coastal vegetation formation and the shrub formation. In the eastern white area is the Diospyros formation area,*Diospyrus maritime*.

The green area has the potential for bivalve diversity, this is because the water content in this area was detected and is an area of Rhizophora and Avicenia formations which is a mangrove forest area. The mangrove forest itself is a habitat where bivalves live and from the results of field data in the green areas, one bivalve species was found, namely Polymesoda erosa, therefore the green areas are included in the criteria for areas that have the potential for bivalve diversity. The high potential diversity of bivalves can be found in areas colored red, this is because in these areas the presence of water was detected and the results of field data found 2 species of bivalves, namely Anadara antiquata and Perna viridis. From these results it can be said that the red areas have the potential to

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have a high level of diversity. This area is also an open mangrove zoning area where the open mangrove zoning is kareas that face directly to the sea and have rather hard muddy and sandy soil (Atmoko & Sidiyasa, 2007). Coastal areas are usually very rich in marine biota such as molluscs, one of which is bivalves. So from these results it can be said that the red areas have high potential for bivalve diversity.

The results of field data analysis using the MNDWI (Modified Normalized Difference Water Index) above show that there are 7 locations where bivalves were found (Appendix 8). At location points 1, 2, 3, 4 and 7, light green areas were found, indicating that these areas have the potential for bivalve diversity. Points 5 and 6 have high diversity values and are found in red areas. Red areas indicate that these areas have high potential for bivalve diversity. This proves that the presence of water can affect the diversity of bivalves.

Implementation of Research Results in the Field of Education as Learning Devices

The results of this research will be implemented in the form of an initial study of the development of learning tools on the ecosystem component sub-concept material in the form of an analysis of the biology learning curriculum in accordance with the revised 2013 curriculum. The decrease in KI and KD is in accordance with the objectives of class X biology subjects. The core competencies that must be achieved are core competencies 3 knowledge (understanding, analyzing, and analyzing factual, conceptual and metacognitive knowledge) and core competencies 4 skills (reasoning, processing and studying in concrete and abstract domains related to the development of what is learned at school independently and being able to use methods that are in accordance with scientific principles) (Permendikbud, 2018).

The results of mapping the area of potential bivalve diversity in Pulau Dua CA can be applied to KD 3.10 Analyzing ecosystem components and the interactions between these components and KD 4.10 Presenting work that shows interactions between ecosystem components (food webs, biogeochemical cycles). Based on KD knowledge 3.10 and KD skills 4.10, 4 indicators of competency achievement were created, namely:

Table 5. Analysis of Ecosystem Components Sub-concept Material based on KD 3.10 and KD 4.10 Class X

Basic competencies	Learning Indicators	Facts and Research Results Habitat bivalves	Material	Learning Resources Recommendations
KD 3.10 Analyze ecosystem components and interactions between these components	Determine the general characteristics of bivalves	a. Has a shell (*) b. Has a variety of shell shapes (*) c. Has legs like an axe (**) d. Has eyes and sensing tentacles outside the mantle (**)	General characteristics of bivalves	a. Poster b. Magazine c. Student worksheet
	Explain the type of environment that is the habitat of bivalves based on the results of observations	a. Living immersed in muddy substrates (*) b. Utilizing mangrove litter as food ingredients(*) c. More commonly found in areas with soft silty substrates than sandy mud areas (*)	Bivalve habitats	a. Poster b. Magazine c. Student worksheet

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Basic competencies	**Learning Indicators**	**Facts and Research Results Habitat bivalves**	**Material**	**Learning Resources Recommendations**
	Relate the role of bivalves in life	a. As a component of environmental indicators (**)	The role of the bivalves	a. Poster b. Magazine c. Student worksheet
KD 4.10 Presenting work that shows interactions between ecosystem components (food webs, biogeochemical cycles)	Write a written work regarding the interactions between ecosystem components from the results of observations	a. Mangrove litter as food for bivalves (*) b. birds as bivalve predators (**)	Interaction between ecosystem components	a. Poster

Note: (*) Research data
(**) Data from literature studies

The diversity of bivalves and mangroves is one of the reciprocal relationships that can be studied in ecological learning in the sub-concept of ecosystem componentsnamely regarding the interaction between biotic and abiotic factors in a component. Diversity material can be added to the learning of ecosystem sub-concepts, namely regarding bivalve habitat, the role of bivalves in the mangrove ecosystem, namely as food chain interactions in the mangrove ecosystem. It is hoped that the results of the material analysis can be used as a reference as a medium or learning resource for teachers and students and can be used by future researchers as research related to the development of learning tools. Learning media are tools or materials used to channel communication in the learning process. Media is also a means used to arouse students' learning motivation by providing visual experiences to students (Miftah, 2013).

Material analysis seen in table 4.3 was made based on KD 3.10 which was reduced to 3 learning indicators and KD 4.10 was reduced to 1 learning indicator based on the results of field data and the results of the literature study that had been conducted. Determination of learning indicators can be described as follows:

1. The first learning indicator is to determine the characteristics of bivalves, based on facts from field data and the results of literature studies, it is found that bivalves have general characteristics of bivalves, namely having 2 shells, varying shell shapes, having ax-shaped legs and having sensing tentacles outside the mantle. Based on facts
2. The second learning indicator is explaining the type of environment that is the habitat of bivalves, based on observational facts and the results of literature studies it is found that bivalves live immersed in muddy substrates, utilize mangrove litter as food ingredients and are more commonly found in areas with soft muddy substrates compared to muddy substrate areas sandy.
3. The third learning indicator is linking the role of bivalves to life. Based on the facts from observations and the results of literature studies, it is found that bivalves can act as an indicator component in an ecosystem, especially mangrove ecosystems.

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4. Writing a paper on the interactions between ecosystem components from observations, based on facts and observations, it was found that the interaction of bivalves with mangrove ecosystem components is as a food chain, where bivalves use litter as food and water birds act as bivalve predators.

Learning media recommended by the author for learning indicators are posters, magazines and student worksheets. It is hoped that this learning media can help students make it easier to understand ecological learning material, especially the sub-concept of ecosystems, by making direct observations in the surrounding environment so that learning is more contextual and relevant to everyday life.

Conclusion

Based on the results of research conducted in the Pulau Dua Nature Reserve, it can be concluded that the diversity of bivalves in the Pulau Dua Nature Reserve is included in the medium diversity group with a value of 1,802. Mapping the potential for bivalve diversity in the Pulau Dua Nature Reserve found 3 potentials, namely no potential for bivalve diversity, potential for bivalve diversity and high potential for bivalve diversity. The area with high potential for bivalve diversity is located at coordinates 106.198956 6.018374. Relationship between MNDWI and bivalve diversity based on resultscorrelation coefficient (r) = 0.668 indicates that the relationship between MNDWI and bivalve diversity has a strong relationship.The results of this study are expected to be implemented in biology learning in the mangrove ecosystem sub-concept with KD 3.10 and KD 4.10. Implementation in biology learning can be material analysis.

There is a need for research using other indices to determine the relationship between bivalve diversity and remote sensing in the Pulau Dua Nature Reserve. Future researchers can continue this research by creating media to use as a learning medium for more interesting ecological material.

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