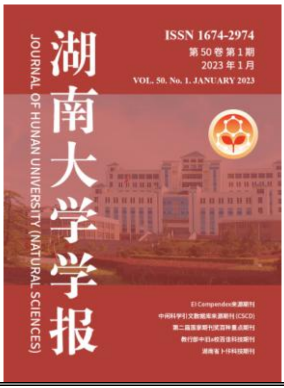


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# Coastal Ecosystem Assessment with an Integrated Approach to Land and Seascape Coastal Ecosystems for Conservation: A Case Study of the Pulo Doro Coast, Malang Regency

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**Abstract:** This research starts from the phenomenon of climate change and increasing land subsidence in the coastal areas. Disasters that often occur due to climate change and subsidence result in the destruction of coastal communities' property, loss of life, agricultural land cannot produce optimally, and tsunamis, tidal floods, and liquefaction are increasingly common. If the incident is not addressed, it will lead to a more severe disaster, and the lives of coastal communities will be threatened. This research aims to assess the condition of coastal ecosystems, both coastal ecosystems, landscapes and seascapes, which are then assessed for the level of usage (economic), conservation (ecology), and the value of local wisdom (social). The method used includes three models: geographic information system (GIS), partial least square (PLS), and total economic value (TEV). GIS is used to assess the presence of landscapes and seascapes. PLS is used to assess public opinion and assessment of the existence of coastal ecosystems. TEV is used to assess the economy. The results of the study show that there are still many Pulo Doro beaches that have not been intervened by anthropogenic processes. The condition of the coastal ecosystem is still intact, although natural processes have begun stressing the coastal area due to the increasing wave height. The results of the PLS show that the community values the landscape as 0.753, the seascape assessment as 0.666, the assessment of the relationship between the landscape and the seascape as 0.841, the assessment of the condition of the Pulo Doro Coastal as 0.693, and efforts to develop a Pulo Doro coastal ecosystem management strategy 0.766. The results of the TEV calculation show that both the landscape and seascape show that the economic value is still not exploited much. The results of this study found a model for managing the coast based on landscape and seascape approaches.

**Keywords:** seascape, landscape, geographic information system, partial least square, total economic value.

# 沿海生态系统评估与陆地和海洋景观沿海生态系统保护的综合方法：玛琅摄政普洛多罗海岸的案例研究

**摘要**：这项研究从气候变化和沿海地区地面沉降增加的现象开始。由于气候变化和沉降而经

常发生的灾害导致沿海社区的财产遭到破坏，生命损失，农田无法最佳生产，海啸，潮汐洪水和液化现象越来越普遍。如果不解决这一事件，将导致更严重的灾难，沿海社区的生命将受到威胁。本研究旨在评估沿海生态系统的状况，包括沿海生态系统、景观和海景，然后评估其使用水平（经济）、保护（生态）和当地智慧（社会）的价值。使用的方法包括三个模型：地理信息系统（地理信息系统）、偏最小二乘法（求助）和总经济价值（TEV）。地理信息系统用于评估景观和海景的存在。求助用于评估公众舆论和评估沿海生态系统的存在。TEV用于评估经济。研究结果表明，仍有许多普洛多罗海滩没有受到人为过程的干预。沿海生态系统的状况仍然完好，尽管由于波高的增加，自然过程已经开始对沿海地区造成压力。求助结果显示，社区对景观的评价为0.753，对海景的评价为0.666，对景观与海景关系的评价为0.841，对普洛多罗海岸状况的评价为0.693，努力程度制定普洛多罗沿海生态系统管理战略0.766。TEV计算结果表明，景观和海景都表明经济价值仍未被充分利用。这项研究的结果发现了一个基于景观和海景方法的海岸管理模型。

**关键词**：海景、景观、地理信息系统、偏最小二乘法、总经济价值。

# 1. Introduction

The coastal area is an area adjacent to the coastline with an increasingly dense concentration of human population, as well as the development of settlements, and increasing socio-economic activities [1, 2]. According to [3], many coastal urban areas are experiencing land subsidence due to the urbanization process and the increasingly rapid population growth living in coastal areas. Coastal areas are threatened with sinking due to land subsidence and sea level rise. Furthermore, [4] mentions that in several regions of the world, the real and costly damage caused by coastal subsidence caused by anthropogenic processes has prompted concerted efforts to contain groundwater subsidence. The impact is the increasing vulnerability of the coast (vulnerability) due to sea level rise and subsidence. Coastal areas suffer from disasters such as tsunamis, tidal flooding below sea level, and increased land subsidence [5].

Coastal processes and natural ecosystems are significantly affected by changes in geographic scale, time, and duration that vary widely. If this is combined to create a biologically productive coastal system and conditions that are vulnerable to additional pressures resulting from human activities, then the issue of economic and social sustainability of human development is vulnerable to natural and artificial hazards. This is due to our poor understanding of the dynamics of land-sea interactions, coastal processes, and human influences that are not planned and managed properly, resulting in the degradation of the coastal environment.

The vulnerability of coastal areas also occurs due to climate change causing sea level rise, which is caused by the complex interaction of components of the physical environment of the coastal area, increased storm surge, erosion, and flooding [6, 7]. This study aims to assess the condition of coastal ecosystems, coastal ecosystems, landscapes, and seascapes for conservation, by using GIS, PLS, and environmental economic analysis approaches, where the urgency of the research is based on the threat of environmental change and subsidence of the land surface on the coast that impact the environment. to people's lives at this time and in the future [8]. This disaster condition occurs in almost all coastal areas in this hemisphere. To anticipate such a disaster, a research was conducted using a case study at Pulo Doro Beach, Malang Regency.

# 2. Materials and Methods

### 2.1. General Description

This study is located in Pulodoro Beach, Donomulyo District, Malang Regency. The research location map can be seen in Fig. 1. The criteria used for selecting the research area are based on the fact that the area has not been intervened by human activities. This area is influenced by natural factors, so this area is very suitable to be used as a base line data to assess the potential both in the landscape and in the seascape.


Fig. 1 Pulodoro Beach, Donomulyo District, Malang Regency (Sources from map of Malang Regency)

## 2.2. Materials

The methods used in this research are geographic information system (GIS), partial least square (PLS) analysis, and economic valuation. The variables that will be observed/measured in this study include spatial, landscape and seascape variables, and disasters.

The flowchart of this research is described below.

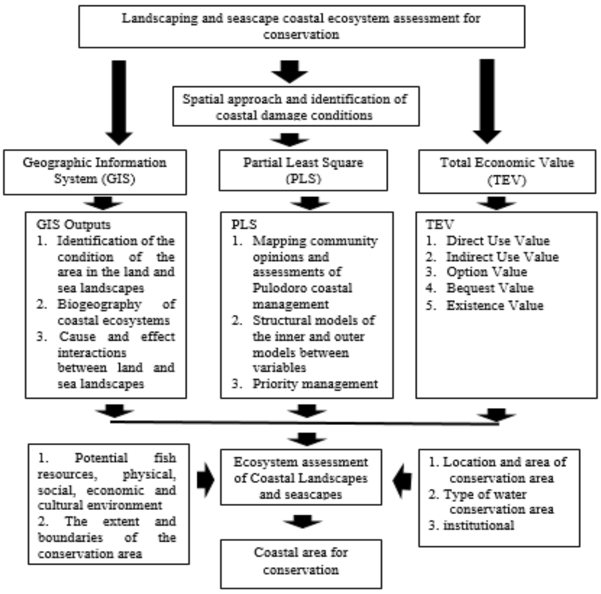


Fig. 2 Methodology flowchart

The results of seascape data processing consist of several parameters which are described in the following explanation.

### *2.2.1. Seascape*

#### *2.2.1.1. Beach Slope*

The results of processing the coastal slope data obtained are that the slope class of the Pulo Doro beach slope is flat to sloping. The percentage of the slope of the transect 1 coast ranged from a slope of 0.11%-13.89%. Transect 2 has a slope percentage of 2.67%-32.96% with a flat to steep beach slope class. The slope to the steepness of the Pulo Doro beach is caused by: the quality and quantity of wave attack as well as the volume and velocity of erosion are not very large, so that sediment transport is stable between accretion and erosion. Additionally, the base material is stable due to the presence of a base current that is not so strong.

#### *2.2.1.2. Babakan Unity of Bantol*

The Pulo Doro Coast is a series of Babakan Bantol, including several beaches in the vicinity, namely Weden Ciut Beach, Pulodoro Beach, Kedung Celeng Beach, Bantol Beach, Seling Kates Beach, and Weden Ombo Beach. Based on the landscape and seascape maps in Babakan Bantol, it can be seen that there are ecosystems in the form of coral reefs (pink), seagrass (fading green), open land (light green), hills, and associated coastal forest (dark green).

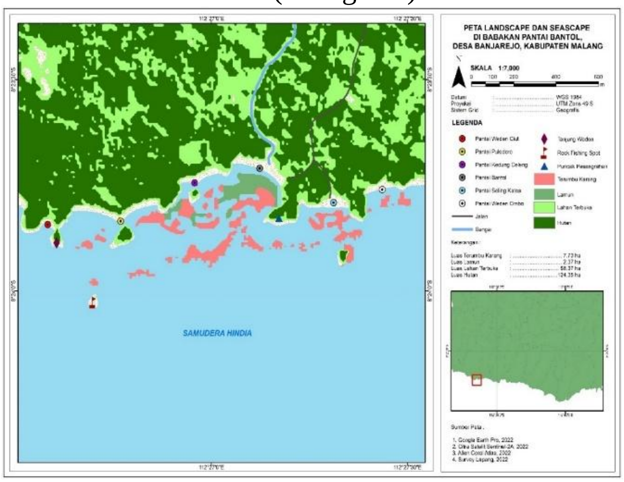


Fig. 3 Bantol landscape and seascape map (Malang Regency map, 2019)

#### *2.2.1.3. Coral Reef Ecosystem Condition*

The Line Intercept Transect (LIT) method was used to estimate the coral cover and the cover of benthic communities living with corals. Measurements of coral reef conditions in Pulo Doro waters were carried out at Stations 1, 2, and 3, as shown in Fig. 1. These measurements include: measurement of coral reef cover and substrate conditions.

Table 1 Coral reef measurement location

| No. | Location | Longitude | Latitude |
|---|---|---|---|
| 1. | Station 1 | 112.4456°E | 8.3973°S |
| 2. | Station 2 | 112.4449°E | 8.3971°S |
| 3. | Station 3 | 112.4442°E | 8.3971°S |
| 4. | Pulodoro Coast | 112.4461°E | 8.3972° S |

The percentage of coral cover using the Line Intercept Transect (LIT) method with a transect length of 50 m at Station 1 is in the poor category with an average biotic percentage of 12.46% and an average abiotic percentage of 87.54%.

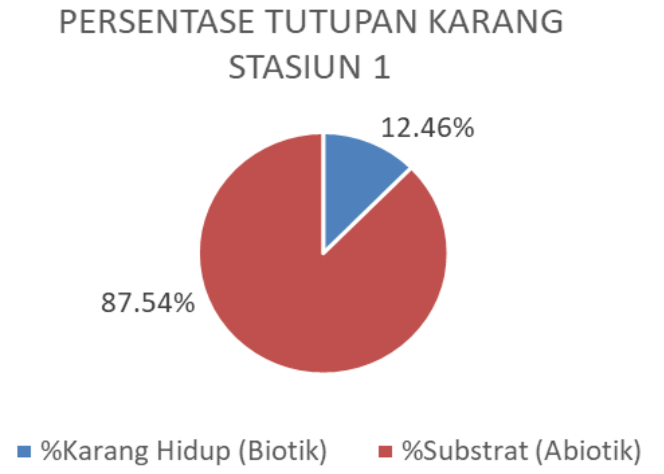


Fig. 3 The percentage of coral cover at Station 1

According to [16], the condition of live coral cover is categorized as damaged if it ranges from 0%-25%. The percentage of substrate cover at station 2 was in the poor category with an average biotic percentage of 17.88% and an average abiotic percentage of 82.12%. Station 3 was in poor category with an average biotic percentage of 18,74% and an average abiotic percentage of 81,26%.

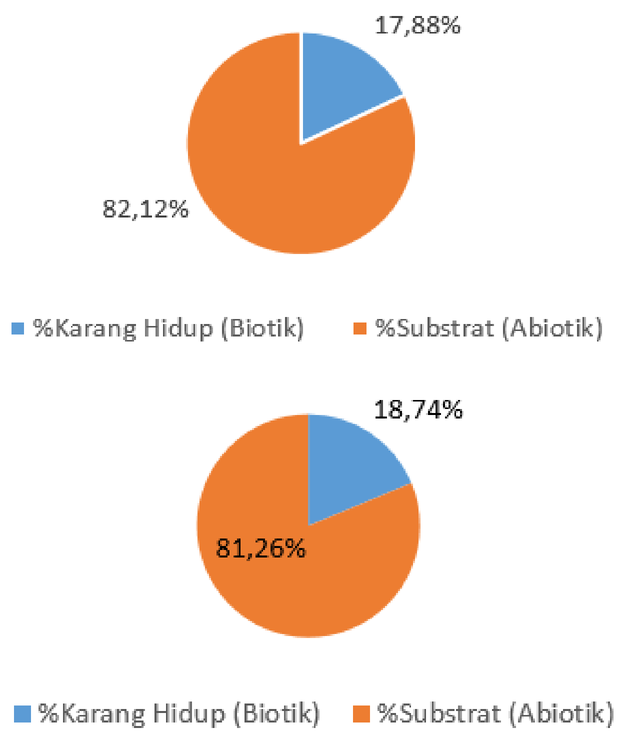


Fig. 4 The percentage of substrat cover at Stations 2 and 3

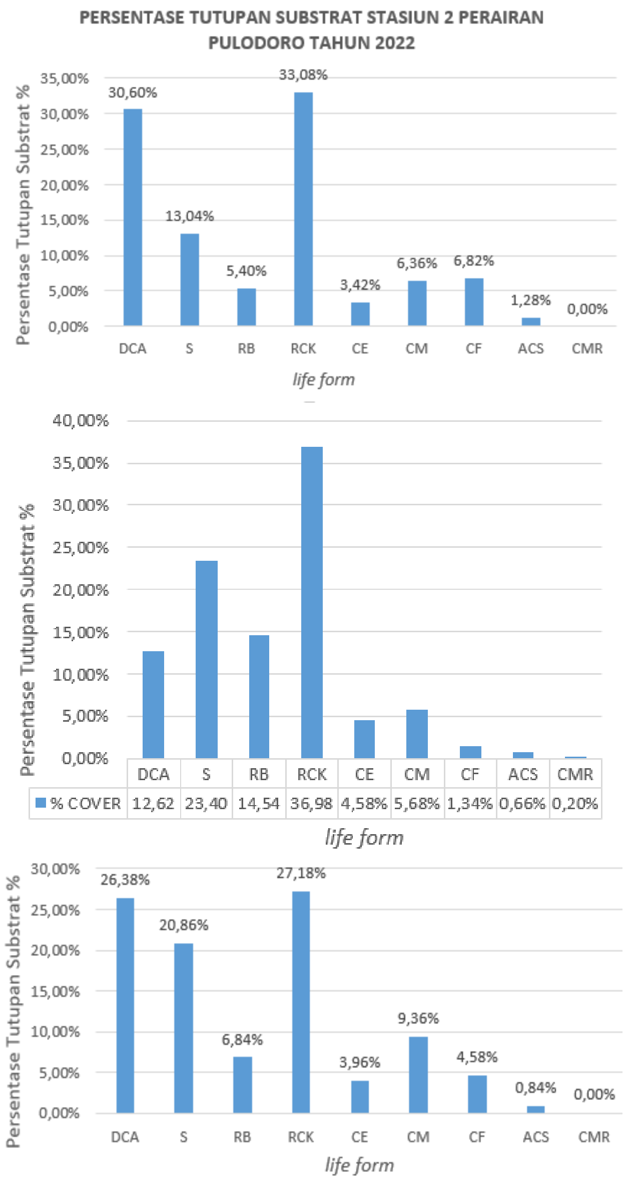


Fig. 5 The percentage of coral cover at Stations 1, 2, and 3 (Developed by the authors)

Table 2 Percentage of substrate cover at each measurement station (Developed by the authors)

| | Station 1 | Station 2 | Station 3 |
|---|---|---|---|
| RCK (%) | 36,98 | 33,08 | 27.18 |
| DCA (%) | 12,62 | 30,60 | 26,38 |
| S (%) | 23,40 | 13,04 | 20,86 |
| RB(%) | 14,54 | 5,40 | 6,84 |
| CE (%) | 4,58 | 3,42 | 3,96 |
| CM (%) | 5,68 | 6,36 | 9,36 |
| CF (%) | 1,34 | 6,82 | 4,58 |
| ACS (%) | 0,66 | 1,28 | 0,84 |
| CMR (%) | 0,20 | 0 | 0 |

*Notes:* RCK - rock, DCA - dead coral algae, S - sand, RB - rubble, CE - coral encrusting, CM - coral massive, CF - coral foliose, ACS - Acropora submassive, CMR - coral mushroom

### *2.2.1.4. Diversity, Uniformity, and Dominance Index*

The results of the calculation of the diversity index, uniformity, and coral dominance at three stations can be seen in the following table.

Table 3 Diversity, uniformity, and dominance indices at Stations 1, 2, and 3 (Developed by the authors)

| Station 1 | CE | CM | CF | ACS | CMR | Total |
|---|---|---|---|---|---|---|
| Number of Species | 12 | 10 | 3 | 2 | 1 | 28 |
| PI | 0.428571 | 0.357143 | 0.107143 | 0.071429 | 0.035714 | |
| LnPI | -8.8473 | -1.02962 | -2.23359 | -263906 | -3.3322 | |
| PI x LnPI | -0.36313 | -0.36772 | -0.23931 | -0.1885 | -0.11901 | |
| **Station 2** | **CE** | **CM** | **CF** | **ACS** | **CMR** | **Total** |
| Number of Species | 12 | 11 | 11 | 3 | 0 | 37 |
| PI | 0.324324 | 0.297297 | 0.297297 | 0.081081 | 0 | |
| LnPI | -1.12601 | -1.21302 | -1.21302 | -2.51231 | 0 | |
| PI x LnPI | -0.36519 | - 0.3606 | - 0.3606 | -0.2037 | 0 | |
| **Station 3** | **CE** | **CM** | **CF** | **ACS** | **CMR** | **Total** |
| Number of Species | 11 | 10 | 9 | 2 | 0 | 32 |
| PI | 0.34375 | 0.3125 | 0,28125 | 0.0624 | 0 | 0 |
| LnPI | -1.06784 | -1.16315 | -1.26851 | -2.77259 | 0 | 0 |
| PI x LnPI | -0.33670 | -0.36348 | -0.35677 | -0.17329 | 0 | 0 |

Table 4 Equilibrium index, H' max, maximum diversity index, and dominance index (Developed by the authors)

| Index nama | Station (each depth 1–2 m) | | |
|---|---|---|---|
| | **Station 1** | **Station 2** | **Station 3** |
| H’ (Spesies Equilibrium) | 1.277 (Medium) | 1.290 (medium) | 0.893 (Low) |
| H’ max (Index Uniformity species) | 1.609 | 1.609 | 1.609 |
| E (Diversity Index) | 0,793 (High Diversity) | 0,801 (High Diversity and Stable Community) | 0,555 (Medium Diversityand Sta ble community) |
| C (Dominance Index) | 0.329 (Low Category) | 0.288 (Low Category) | 0.180 (Low category) |

*Notes:* If E < 0.4, the uniformity is low; if E = 0.4 – 0.6, uniformity is medium; if E > 0.6, the uniformity is high [15]

At each observation station, it can be seen that there is no dominant coral species. This shows that the waters still can support coral life so that no competition causes certain species to be dominant.

*2.2.1.5. Hydrooceanographic Measurement Results*

The results of hydrooceanographic measurements include currents, tides, and waves according to available secondary data. The current is the movement of water that causes a horizontal mass transfer of water. Not only horizontally, but also ocean currents cause vertically of water mass transfer.

Tides and tides are a phenomenon of the movement of rising or falling sea levels periodically caused by certain factors. The tides will occur alternately according to the period or the factors that influence each. The following is the value of the tidal harmonic component at Pulodoro Beach.

Table 5 Results of the tidal data processing (Developed by the authors)

| | $S_o$ | $M_2$ | $S_2$ | $N_2$ | $K_1$ |
|---|---|---|---|---|---|
| A $_{Cm}$ | 0.04 | 27 | 9 | 23 | 24 |
| $g^o$ | | -3 | -92 | 268 | 281 |
| | $O_1$ | $M_4$ | $MS_4$ | $K_2$ | $P_1$ |
| A $_{Cm}$ | 7 | 0.3 | 00 | 2.4 | 8 |
| $g^o$ | 377 | 154 | 191 | -92 | 281 |

With the tidal components above, the type of tide can be determined through the calculation of the Formzahl value. The final result of tidal processing is the tidal harmonic constant that can be used to find the Formzahl number. The Formzahl (F) value is obtained by dividing the sum of the amplitudes of the O1 and K1 components by the sum of the amplitudes of the M2 and S2 components using the data in Table 5, the F value can be calculated:

$$F = \frac{(O1+K1)}{(M2+S2)}$$

$$F = \frac{(7+24)}{(27+9)} = 0.861$$

Based on the calculation results of tidal data processing in the waters of Pulodoro Beach in June 2022 using the admiralty method, the resulting Formzahl number is 0.861 so that it is included in the mixed tidal type category with the double type being more prominent (Condong Ganda). means that in a day there are two high tides and two low tides. Wave observations at Pulodoro Beach, Malang Regency were carried out 3 times in June 2022. The data obtained were in the form of data on average wave heights and their period. The results obtained are wave height I = 1.2 m, wave height II = 1.23 m, and wave height III = 1.18 m, so it has an average wave height of 1,203 m. The wave period was measured 3 times, namely I = 8.2 seconds, II = 7.9 seconds, and III = 7.5 seconds, so the average wave period was 7.87 seconds.

*2.2.2. Landscape*

*2.2.2.1. Coastal Vegetation Observation Results*

Measurement of coastal vegetation can be seen in Table 6.

Table 6 Density of beach vegetation (Developed by the authors)

| Station | The type of vegetation | Individual | Density (Ind/ha) | Total |
|---|---|---|---|---|
| Station 1 | Ketapang (Terminalia Cettapa) | 14 | 1400 | 202400 |
| | Palem-paleman | 10 | 1000 | |
| | Butun (Baringtonia Asiatica) | 22 | 2200 | |
| | Pandan laut (pandanus Tectorius) | 7 | 700 | |
| | Rumput laut (Spinifex) | 1415 | 141500 | |
| | Katang-katang (Lpomoea pes Caprae) | 556 | 55600 | |
| Station 2 | Butun (Baringtonia Asiatica) | 116 | 11600 | 491800 |
| | Rumput-rumputan | 4764 | 476400 | |
| | Pandan Laut (pandanus | 29 | 2900 | |

| | | | | |
|---|---|---|---|---|
| | Tectorius) | | | |
| | Kampis Cina (Hernandia nymphaeifolia) | 2 | 200 | |
| | Ketapang (Terminallia Cettapa) | 7 | 700 | |
| Station 3 | Ketapang (Terminallia Cettapa) | 10 | 1000 | 212500 |
| | Waru (*Hibiscus tiliaceus*) | 17 | 1700 | |
| | Rumput-rumputan | 2040 | 204000 | |
| | Butun (Baringtonia Asiatica) | 24 | 2400 | |
| | Pandan Laut (pandanus Tectorius) | 34 | 3400 | |

*2.2.2.2. Hill*

Hills are forms of coastal landscape systems that exist because of morphogenetic processes and conditions that occurred in the past. Thus, the hill is a form of land with certain characteristics spatially. Hill is a typology that occurs due to dynamics caused by energy from within the earth (endogenous) and energy from outside the earth (exogenous). It will produce a different typology as well. On the coast of Pulo Doro, the hill is a barrier between land and sea, which is included in the landscape category.

## 3. Results and Discussion

### 3.1. GIS Results

Based on Fig. 6, the landscape area consists of hill area, beach sand area, and coastal forest area, whereas the seascape area consists of the association of vegetation forest area, coral reef area, and intertidal region. Furthermore, it can be calculated that each of the used should have a percentage.

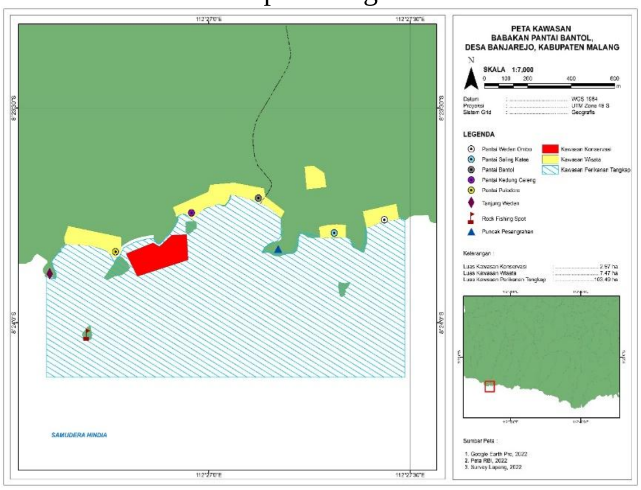


Fig. 6 Results of the GIS map related to the percentage of land use (Developed by the authors)

### 3.2. PLS Variables and Calculation

A set of variables that concern the relationship between one variable and another variable. The variables are structured as follows:

Table 7 A set of landscape and seascape variables for PLS analysis (Developed by the authors)

| **Variables of Landscape and seascape** | | | |
|---|---|---|---|
| **No.** | **A (Landscape assessment variable)** | **B (Seascape assessment variables)** | **C (Assessment variables between landscape and seascape)** |
| 1. | The landscape is well maintained, and no one has used it yet | The quality of the sea has not been much influenced by land | Human activities have a major impact on coastal quality |
| 2. | Resources have not been exploited | The waves affect the shoreline | Marine and land activities have a big impact on the coast |
| 3. | Land vegetation needs conservation | The coastline is affected by landuse | Determination of the area as a conservation area |
| 4. | The Pulo Doro area is suitable for tourist areas | Coral reefs are threatened | Designation of important areas for multi-purpose |
| 5. | Maintaining marine conservation | Coral reef mining affects abrasion | There is a very close relationship between landscape and seascape |
| 6. | Damage to the landscape will affect sea waters | Mangrove vegetation cannot grow properly | Need clarity on the determina tion of the area |
| 7. | Landscape must be conserved | Ocean waves and tides are a threat | Coastal areas have become an alternative as a source of food |
| 8 | The local government plans to use Pulo Doro for ecotourism | The malang regency government does not really care about coastal damage | There is no plan for the use of space for the Pulo Doro coastal area |
| 9. | Coastal use impacts land use | Damage to coastal areas has not occurred | Pulo doro potential for beach tourism |
| 10. | Economic potential has not been exploited | The dynamics of the high seas affect the coast | Communities around Pulo Doro do not yet know the function and role of coral reefs |
| 11. | - | - | - |
| 12. | - | - | - |
| **No.** | **D (Variables for assessing climate change)** | **E (Pulo Doro condition assessment variables)** | **F (Efforts to strategize variables)** |
| 1 | Tidal floods often occur because the waves are high | The Pulo Doro coast has not been much intervened by community activities | Stakeholder collaboration to improve welfare |
| 2 | The ambient temperature is getting hotter | Marine activities have not been widely used | Make a conservation area and business |
| 3 | Flooded almost every year | Need to be a conservation area | Land use based on local wisdom |
| 4 | In order for the economic potential to | High waves cause shoreline changes | Use but not destroy |

| | | | |
|---|---|---|---|
| | develop, tourism is needed | | |
| 5 | Ecosystem services are still optimal | Pulo Doro's potential is unknown | Village institutions are strengthened |
| 6 | The tsunami is not yet signi ficant | Avoid land-use change | Allocation of funding from the government for supervision |
| 7 | Rolling waves will erode the shoreline | Avoiding coastal land-use conflicts | Pulo Doro coastal conser vation must be included in the planning of the local government |
| 8 | The subsidence has not happened yet | Supervision of land use must be strict | The local government must develop disaster guidelines in Pulo Doro |
| 9 | Big waves harm fishing boats | The use of space must be in accordance with its designation | The importance of the role of universities being involved in the preparation of spatial guidelines |
| 10 | Climate change makes people worry about their safety | Regulating the usage of Pulo Doro's potential to become an ecotourism area | The role of the village government is critical |
| 11 | Big waves are driving factors for changing the quality of the coastal environment | Multipurpose use affects the existence of the coast of Pulo Doro | The village government should prepare coastal spatial planning |
| 12 | Climate change is unpredi table | Successful management with collaboration | - |

PLS calculations include the calculation of Discriminant Validity, Composite reliability, construct reliability, structural model testing, structural analysis results, direct and indirect effects and measurements of Goodness of fit [9-11]. The results of the discriminant validity test in this study indicate that each variable has a higher indicator than the other correlation indicators. Besides, another method used to see the discriminant validity value is to assess the validity of the construct based on the AVE value. The result shows that each construct value is greater than 0.5. Based on the results, the output shows that the AVE value for each construct is greater than 0.5; therefore, it can be concluded that each construct is a good model, so that all constructs in the estimated model meet the criteria of discriminant validity. To assess the construct variable with composite reliability, it shows that all the construct variables have a value above 0.940. This means that all constructs are greater than 0.70, so the measurement model or outer model with reflexive indicators has a very high level of validation.

Construct reliability is based on Cronbach's alpha value is good if the value is above 0.70. The calculation results show that Cronbach's alpha for all variables is above 0.90, so the model in this study has met the construct reliability. The test of the structural model (Inner Model) is based on the calculation that the R-square for all variables is 0.750, which means that the assessment of all variables is affected by the Climate Change Assessment of 75.3%. Other 24.7% are influenced by other factors. The goodness of fit in PLS can be seen from the value of Q2. The higher R2, the more the model fits the data. A Q-Square value greater than 0 (zero) indicates that the model has predictive relevance, while a Q-Square value less than 0 (zero) indicates that the model lacks predictive relevance [16]. The calculation results can be seen in the value of $Q^2$:

Value $Q^2 = 1 – (1 – R21) (1-R22) (1 – R23) …. (1 – R 2n) = 1 - (1–0.753) (1–0.666) (1–0.841) (1–0.693) (1–0.766) = 1- 0.000941 = 0.999059 = 99.91\%$

In this research model, the Q-square ($Q^2$) value generated in the overall model equation is 99.91%, which is very high, so this means that the structural model has very high predictive relevance, and the model is getting better and feasible to be used in the prediction [12].

Based on the above, the output of the structural model (inner model) after the bootstrap calculation process 500 times can be seen in the following figure.

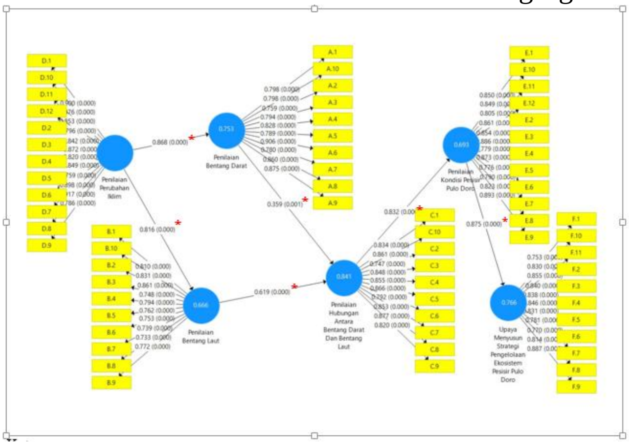

Fig. 7 Path analysis for PLS analysis (Developed by the authors)
*Notes:* * Significant effect; blue circle - construct variable; yellow box – indicator; numbers outside the sign () - loading factor coefficient; number in the sign () - p-value; the number inside the blue circle - R-square

Thus, the direct effect of exogenous variables on endogenous variables shows the magnitude of the direct effect of exogenous variables on endogenous variables without involving mediating variables. The estimation results of the inner model show that the direct effect for all variables has a p value above 0.000, which is smaller than an alpha of 0.05. Meanwhile, the indirect effect of exogenous variables on endogenous variables shows that this indirect effect shows the magnitude of the direct effect of exogenous variables on endogenous variables.

Measurement of Goodness Of Fit based on the calculation of the GOF value obtained a value of 0.7123 (GoF large) using the formula below.

$$OF = \sqrt{Communality\ x\ R^2}$$

$$GOF = \sqrt{(0.682)x\ (0.744)} = 0.7123$$

This means that the PLS model made has a high ability to explain empirical data, so the overall prediction of the model is quite good.

## 3.3. Total Economic Value (TEV) of Landscape and Seascape

### *3.3.1. Direct Use for Landscape and Seascape*

According to [13, 14], the economic assessment of coastal resources follows the principle of calculating the direct use value, indirect use value, option value, and existence value. The following is a table of direct use values of landscape and seascape based on the results of the TEV analysis.

Tabel 8 Direct use values for landscape and seascape (Developed by the authors)

| No. | The type of Direct Use Value Landscape and Seascape | IDR/Year | % |
|---|---|---|---|
| | *Landscape* | | |
| 1. | The direct use value for coastal vegetation (Pandan Laut, *Baringtonia asiatica, Terminalia cettapa, Hibiscus tiliaceus*) with a width of 80% of the costal Pulo Doro is 50% x 11.871 ha x Rp. 4.500 | 26.709.750 | 1,29 |
| 2. | Direct use value for hard shell with estimation per plot per 300 m$^2$ x Rp. 2500 | 750.000 | 0,04 |
| 3. | Direct use value for wood coastal vegetation with assumption (75% from 11.871 ha) * 6.500 | 57.871.125 | 2,79 |
| 4. | Direct use value for a hill with a width of 40% of the total beach area of Pulo Doro (40% x 11.871 ha = 8.903 ha x Rp. 15.000) | 133.548.750 | 6,44 |
| 5. | Direct use value for coastal sand unsunk in tide (20%*11.871) x 5.000 | 11.871.000 | 0,57 |
| 6. | Direct use value for aesthetics to use tourism (40/100*11.871) x 10.000 | 47.484.000 | 2,29 |
| | *Seascape* | | |
| 7. | Direct use value for coral reefs with a width of 20% (11.871 ha * Rp. 45.000 | 106.839.000 | 5,15 |
| 8. | Direct use value for fish 1,5 tons or 1500 kg x Rp. 7.000/kg | 10.500.000 | 0,51 |
| 9. | Direct use value for sea urchins 2000/kg * 2000/kg | 4.000.000 | 0,19 |
| 10 | Direct use value for sand coast with tide (40/100 x 11.871 ha x Rp. 30.000) | 142.452.000 | 6,87 |
| 11 | Direct use value for mangrove forests 1 ha = Rp. 250.000 x (30/100 * 11.871) | 890.325.000 | 42,94 |
| 12 | Direct use value for batimety below 2 meters (60/100*11.871) 50.000 | 356.130.000 | 17,18 |
| 13 | Direct use value for ecotourism (diving ecotou) (60/100*11.871) * 40.000 | 284.904.000 | 13,74 |
| | Total direct use value for landscape and seascape | 2.073.386.625 | 100 |

### *3.3.2. Indirect Use Value*

The following is a table of indirect use values of landscape and seascape based on the results of the TEV analysis (assuming Pulo Doro coastal area of 11,871 Ha) [13].

Table 9 Indirect use value (Developed by the authors)

| No. | The Type of Indirect Use Value for Landscape and Seascape | Rp/Year | % |
|---|---|---|---|
| | *Landscape* | | |
| 1. | The indirect use value of coastal vegetation is 20% x 11.871 ha x Rp. 2.500 | 5.935.500 | 0,32 |
| 2. | Indirect use value of hills to reduce tsunami flooding 40% x 11.871 x Rp. 15.000 | 71.226.000 | 3,86 |
| 3. | Indirect use value for coastal use for “Children Play Ground” 40% x 11.871 x Rp. 200.000 | 949.680.000 | 0,05 |
| | *Seascape* | | |
| 1. | Indirect use value of coastal association vegetation (30 % x 11.871) x Rp. 350.000 | 1.246.455.000 | 67,49 |
| 2. | Direct use value of the beach (20 % x 11.871) x Rp. 200.000 | 474.840.000 | 25,71 |
| 3. | Aesthetic direct use value for tourism to the naked eye (40/100*11.871) x 10.000 | 47.484.000 | 2,57 |
| | Total | 1.846.890.180 | 100 |

### *3.3.3. Option Value*

The following is a table of option values for landscape and seascape based on the results of the TEV analysis.

Table 10 Option value (Developed by the authors)

| No. | | Rp/Year | % |
|---|---|---|---|
| | *Landscape* | | |
| 1. | Option value for coastal vegetation options is 20% x 11.871 ha x Rp. 221.490 (US$ 15) | 525.861.558 | 10,1 |
| 2. | Option value of hills to reduce tsunami flooding 40% x 11.871 x Rp. 300.000 | 1.424.520.000 | 27 |
| 3. | Option value on coastal beach choice value for “Children Play Ground” 40% x 11.871 x Rp. 250.000 | 1.187.100.000 | 22,76 |
| | *Seascape* | | |
| 1. | Option value of vegetation forest association to prevent Tsunami (30% x 11.871) x Rp. 250.000 | 890.325.000 | 17,1 |
| 2. | Option value of the coast (20% x 11.871) x Rp. 400.000 | 949.680.000 | 18,21 |
| 3. | Option value of aesthetics for tourism (40/100*11.871) x 50.000 | 237.420.000 | 5 |
| | Total | 5.214.906.558 | 100 |

*3.3.4. Bequest Value*

The following is a table of the bequest value of landscape and seascape based on the results of the TEV analysis.

Table 11 Bequest value of landscape and seascape (Developed by the authors)

| WTP i (Rp per year) | Respondents | WTP (per year) | % |
|---|---|---|---|
| 2.000 | 10 | 20.000 | 13,70 |
| 4.000 | 8 | 32.000 | 21,92 |
| 6.000 | 6 | 36.000 | 24,66 |
| 8.000 | 2 | 16.000 | 10,96 |
| 10.000 | 3 | 30.000 | 20,55 |
| 12.000 | 1 | 12.000 | 8,22 |
| Total | 30 | 146.000 | 100 |
| RwP | 2.190.000 | | |
| % r | 0,50 | | |
| Respondents who are willing to pay (r) | 15 | | |
| Twp = Rwp x P | 32.850.000 | Total Value Willingness to pay (Rp/year) | |
| Tnp = %r x Twp | 16.425.000 | Total Value paid (Rp/year) | |
| Ts = Twp – Tnp | 16.425.000 | Total consumer surplus (Rp/year) | |

The results showed that there was a consumer surplus from the willingness to pay for the existence of vegetation association forests of Rp. 16,425,000 per year. 50% of the 30 respondents behave as free riders, namely people who enjoy and use landscape and seascape resources without making sacrifices. The free rider community expressed their unwillingness to pay for the existence of landscape and seascape resources due to low economic capacity, so they chose to enjoy landscape and seascape resources without having to incur any costs.

*3.3.5. TEV Calculation Discussion*

The following is the TEV of landscape and seascape based on the result of the TEV analysis.

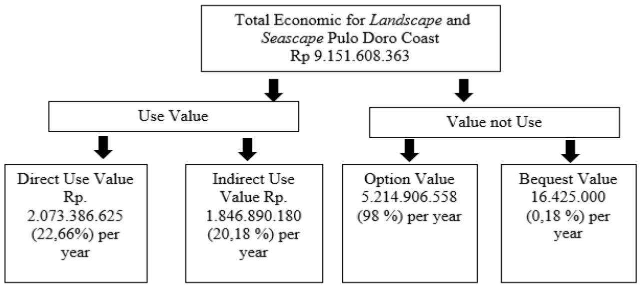


Fig. 8 Pulo Doro TEV calculation with landscape and seascape approach (Developed by the authors)

### 3.4. Pulo Doro Coast Management Strategy

Based on the grouping of areas mentioned above, it is recommended that the Pulo Doro coastal area be a tourism-conservation area. Conservation-tourism areas are designated for "sight-seeing" activities for which the percentage is as follows:

Table 12 Percentage of grouping of landscape and seascape areas

| No. | Grouping of Landscape and Seascape | Procentage | Longitude | Latitude |
|---|---|---|---|---|
| 1. | Landscape Area | 65 | | |
| | Hill area | 10 | 112.447.044-8.398201 | |
| | Beach sand area | 30 | 112.446579-8.397321 | |
| | Coastal forest area | 25 | 112.447695-8.396897 | |
| 2. | Seascape Area | 35 | | |
| | Association Vegetation Forest Area | 5 | 112.447961-8.397043 | |
| | Coral Reef Area | 20 | 112.449089-8.396588 | |
| | Intertidal Area | 10 | 112.449089-8.397562 | |

Based on the table above, using a more rational composition of use and usage, the selected values in the form of landscape areas that need to be optimized for use are hills, coastal vegetation, and coastal land. Meanwhile, the seascape area includes association forest, beaches, and aesthetic values that need to be maintained because they have a greater choice value compared to the value of direct and indirect use. Additionally, to prevent irrational exploration, it is necessary to establish conservation areas that include landscape areas that include coastal sand areas and coastal forest areas. These two types of areas are central to protecting the coast from flooding caused by the tsunami. As for the seascape area that needs to be protected, it includes coral reefs and association forest areas, although mangrove forests do not grow in this area. The determination of the landscape and seascape areas still considers economic, social, and ecological aspects. Thus, a new and more systematic approach to exploiting and protecting ecosystems from degradation due to anthropogenic processes and climate change can be seen in the figure below:

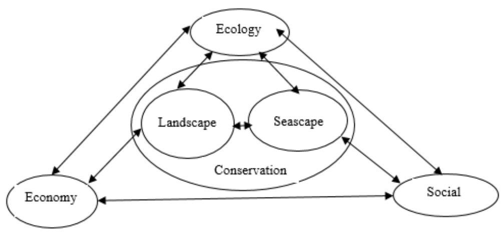


Fig. 9 Model determination of conservation areas using landscape and seascape approaches (Developed by the authors)

## 4. Conclusion

Based on the findings above, it can be concluded as follows:

a) Management of coastal areas is carried out using a landscape and seascape approach based on spatial planning, behavior and public perception and assessing Total Economic Value (TEV);

b) The potential of coastal resources that need to be used, protected, and conserved based on the approach of using direct, indirect resource values, benefit values, and existence values based on spatial use planning;

c) The coastal area management model is based on landscape and seascape conservation, which refers to the total economic value (TEV) approach by considering the direct and indirect relationships, as well as the value of benefits and the value of existence. The results obtained are then reassessed with economic, ecological, and social aspects;

d) Determination of the management of coastal areas should be based on legal aspects in the form of regional regulations (perda) issued by the Regional Head and become input and consideration in the strategic plan (renstra) of the regional development priority medium-term program (PJM);

e) The implementation of coastal area management that already has a legal basis must be accompanied by law enforcement by the civil service police unit with the community to supervise so that there is no violation of the law;

f) Specification limitation of application of the results the specification limits for the implementation of these results lie in the local government's willingness to designate this area as a conservation area. Otherwise, the potential of this area will be exploited by human activities;

g) The effectiveness of the research results will provide insight to local governments, communities, and business actors that the coast of Pulo Doro must be conserved. This is to prevent the degradation of the coastal environment.

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