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Integrated Model of Coastal Ecosystem Restoration Management on the Tamban Beach, Malang Regency, Indonesia

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Abstract: The novelty of this research shows that addressing climate change in coastal areas not only strengthens public awareness of the dangers of sea level rise but also increases the integration of ecosystem services both in land and seascapes. Coastal areas at the global, national and local levels are experiencing severe degradation. The decline in the number of services provided by coastal ecosystems in Indonesia, such as mangroves, coral reefs, and seagrasses, is due to the intensification of anthropogenic processes. The impact is the increasing intensity of tsunami waves, tidal flooding, and subsidence. This study aimed to create an integrated model for managing biological and ecological restoration of the coastal ecosystem in the coastal area of Tamban in Malang District in the planning process and institutional aspects. The method used for spatial mapping of the Tamban coastal area was unmanned aircraft (UAV). Meanwhile, the Partial Least Square (PLS) was used to determine the public's perception of and response to climate change. To make the best decisions regarding the impacts of climate change, interpretative structural modeling (ISM) was used. The results showed that the local people should participate actively in the planning, monitoring and evaluation process to increase the benefit from coastal ecosystems both in landscape and seascape. The conclusion of this study shows that preventing the impact of climate change must include the community involvement and policy formulations to utilize and restore landscape and seascape ecosystem services.

Keywords: climate change, partial least square, unmanned aerial vehicle, interpretative structural modeling.

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摘要：这项研究的新颖性表明，解决沿海地区的气候变化不仅可以增强公众对海平面上升危险的认识，还可以增加陆地和海洋生态系统服务的整合。全球、国家和地方层面的沿海地区正在经历严重的退化。印度尼西亚沿海生态系统（如红树林、珊瑚礁和海草）提供的服务数量减少是由于人为过程的加剧。其影响是海啸波、潮汐洪水和下沉强度的增加。本研究旨在在规划过程和制度方面创建一个综合模型，用于管理玛琅区坦班沿海地区沿海生态系统的生物和生态恢复。用于坦班沿海地区空间测绘的方法是无人驾驶飞机(无人机)。同时，偏最小二乘法（PLS）被用来确定公众对气候变化的看法和反应。为了对气候变化的影响做出最佳决策，使用了解释性结构模型(主义)。结果表明，当地人民应积极参与规划、监测和评估过程，以增加沿海生态系统在景观和海景方面的收益。本研究的结论表明，防止气候变化的影响必须包括社区参与和政策制定，以利用和恢复景观和海景生态系统服务。

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关键词：气候变化，偏最小二乘，无人机，解释性结构建模。

1. Introduction

According to [1], biodiversity and ecosystem services are declining faster than at any other time in human history. The main drivers of this decline are the loss of ecosystem habitat from unsustainable agricultural activities, deforestation, unsustainable resource use, intensified climate change, and the invasiveness of alien species. Because of the decline in ecosystem services, especially in coastal areas, the supply of fish has decreased from 90% (1974) to 67% (2015).

For this reason, it is recommended by [1] to improve the quality of marine waters from acidity because according to the United Nations, there will be a process of ocean acidity from 100%-150% until 2100. According to [2], marine area is one of the natural capitals, one of which includes the interaction between ecosystems and biotic and abiotic ecosystem processes as a functional unit (coral reef ecosystems, mangrove ecosystems, seagrass ecosystems, etc.).

Ocean waters as the world's economic capital in the future are a very promising asset. However, because of changes in their lower capacity due to anthropogenic processes, their ability as that of economic capital is decreasing.

However, according to [3], the decline in the number of coastal ecosystem services in Indonesia due to land changes shows that development planning does not consider coastal ecosystem services. The coastal area in Malang Regency, especially the mangrove forests on the Tamban coast, is damaged. According to [4], the problem in preserving mangroves is illegal logging activities, considering that mangrove wood has excellent charcoal quality, so it is used as firewood.

According to [5, 6], the economy of the Southeast Asian region is largely based on the exploitation of natural resources, which has led to a rather unsettling conflict between natural resource conservation and economic development. The condition of the coastal ecosystem services in Indonesia, which includes the biodiversity of coastal ecosystems including mangroves, coral reefs, and seaweed, is also increasingly experiencing a decline.

Previous research has shown that efforts to increase awareness and assessment of local communities, including the formulation of policies by various stakeholders, have not been carried out in a more comprehensive manner. According to [7], ecosystem-based adaptation strategies offer a valuable and effective tool for managing the impacts of climate change today. Efforts to maintain and improve coastal systems will also support the sustainable provision of other coastal services, including the provision of food and the maintenance of livelihoods reliant on coastal resources. The results of a study conducted by [8] succeeded in developing a mathematical model to assess the impact of rapid GHG emissions on climate change and coastal ecosystems. The mitigation method used two control strategies: coastal greenbelt and desulfurization. Green belts are considered in coastal areas to reduce GHG concentrations by absorbing environmental carbon dioxide (CO2). Desulfurization is considered in factories and industries to reduce GHG emissions by controlling the release of harmful sulfur compounds.

The results of a literature review [9] related to adaptation to climate change impacts in Small Island Developing States revealed that those states share a common vulnerability to climate change. However, research data on the nature and efficacy of adaptation across the small island developing states are fragmentary. Research documented various adaptation strategies, especially in the form of structural or physical and behavioral changes. However, evaluation of concrete adaptation interventions is lacking; thus, it remains unclear to what extent documented adaptations effectively and sustainably reduce vulnerability and increase resilience.

Based on the results of the literature review as mentioned above, an integrated model related to adaptation to the impacts of climate change that covers local community assessments and responses, areas that need to be avoided and those that do not need to be avoided because of the impacts of climate change need to be identified. Formulation of public policy as a result of research becomes a strategic tool to encourage various stakeholders.

2. Materials and Methods

2.1. Description of the Study Area

Tamban Beach is located in Tambakrejo Village, Sumbermanjing Wetan District, Malang Regency, East Java Province, Indonesia. Tamban Beach is one of the coastal villages and one of the 12 beaches of Tambakrejo Village that have been developed for both the tourism and fisheries sectors. Tamban Beach is a beach that is vulnerable to tidal flooding, abrasion, and even moderate-scale tsunamis. Tidal flooding is a disaster that annually inundates fishers' settlements up to 1.7 km away and 60 families.

This village is at a bay facing directly to the Java Sea. Tamban beach has a population of approximately 200 people. The contours of the land that protrude into the hills make it easier for people to quickly save themselves when a tsunami or tidal flooding strikes. The Malang Regency Government has prepared infrastructure in the form of alarm sirens and appeals to save themselves to guide the public and tourists to temporary evacuation sites in the event of a tsunami and flooding. According to [10], the position of Tamban beach in Tambakrejo village is on the coast of the Indian Ocean. This very strategic position is very vulnerable to tsunamis if coastal protection is not increased by planting mangrove forests. The mangrove forest on the Tamban beach is 15 ha and is managed by the Gunung Pithing Conservation community in coordination with the Tambakrejo Village Head.

Based on [11], Tamban beach is one of the fishery centers in Malang Regency. Fishers on Tamban Beach still use traditional equipment, so the fish catches of fishers on Tamban Beach are still not comparable to the existing marine potential. The number of fishers on Tamban Beach is 189. Of this number, 141 fishers still use rowboats and 48 fishers use motorized fishing boats. The coast of Tamban develops very slowly. This is due to the lack of well-organized Tamban spatial planning, where most population's occupations are fishers. Additionally, the beauty of the beach is also less noticed. In fact, Tamban beach will be used as a foundation for developing marine ecotourism in Tambakrejo Village. This area is often hit by tidal waves, at least three to four times each year. Based on this incident, the Malang Regency government plans to immediately relocate and reorganize the Tambakrejo Fishing Village. The relocation discourse had actually been submitted to the local government in 2000. However, many of the residents of Tamban beach did not want to be relocated.

The program of reallocation of people living along the Tamban coast is very dangerous. According to [12], in 2020, there were 151 tsunami events in Malang Regency, while until March 2021, there were 122 tsunami events. Not an inch of area in Malang Regency is safe from earthquakes and thus, the Malang Regency Regional Disaster Management Agency compiled an earthquake risk map together with the Meteorology and Geophysics Agency to create a tsunami hazard map in the Malang Regency area, including Tamban beach, including conducting disaster mitigation from pre-disaster, during disaster emergency to post-disaster. [13] stated that the potential for earthquakes in the southern part of Java is located in the megathrust zone or large upward fault movement. This is a subduction zone between the Eurasian and Indo-Australian plates that extends for 5,500 kilometers. The potential for a megathrust earthquake with a magnitude of 8.8 in the southern part of Java Island and can trigger a tsunami as high as 20 meters. The Indo-Australian oceanic crust and the Eurasian continental plate are old, formed about 20 million years ago. Thus, they are so easy to break and cause earthquakes. The two Indo-Australian and Eurasian plates continue to move and cause collisions. Historical records show that devastating earthquakes occurred in the megathrust zone in Java and Sumatra in 1699, West Java and Sumatra in 1780, Java, Bali, and Lombok in 1815, Java and Flores in 1820, West Java in 1834, Central Java and East Java in 1840, West Java and Central Java in 1847, and Java and Bali in 1867. A major earthquake occurred in Malang in 1967. As a result, 1,656 buildings were damaged, 23 people died, and 121 people were injured.

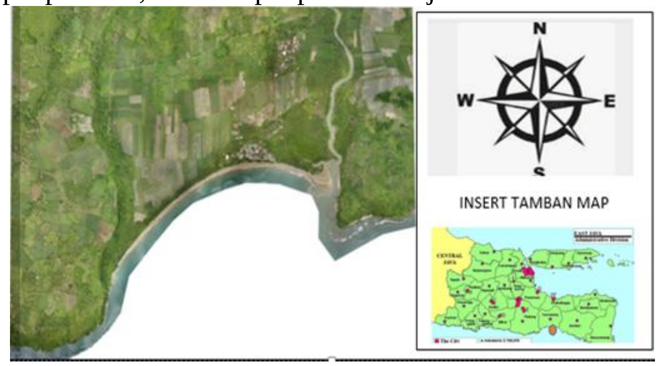

Fig. 1 Map of the research area in Tamban

2.2. Data

The data collected in this study consisted of data obtained from interviews with 51 respondents.

Table 1 List of the respondents

No.	Respondents	Number of the Respondents
1	Local People	30
2	Local Government	10
3	Community Group for coastal ecosystems	11
	Total	51

The measurement of mangrove forest on the Tamban beach in Fig. 2. Station Position can be stated that position Transec 1: (08°25’03.9”S”112°42’51.1E} and position Transec 2: (08°25’37.9” S 112°42’19.1 E), as wll as position Transec 3: (08°25’00.1” S 112°42’52.1 E). The results of the identification of mangrove species at the three stations can be seen in Table 2. In Table 2, it is stated that at stations 1, 2, and 3, Rhizophora species were found. This type of mangrove usually grows on the outside and directly faces the sea, thus directly facing the waves. *Rhizophora apiculata* and *R. mucronata* mangroves grow on mud soil. These species have special and distinctive organs for survival. This condition can distinguish it from other plants that grow on land protected from the influence of salinity. Certain organs are found in these species of plants, whether on the leaves or on the roots of these plants.

Table 2 Mangrove species identification results

No.	Family	Types	Location found
1	Acanthaceae	*Avecenia alba*	Station 1
2	Verbena	*Avecenia Marina*	Stations 1 and 2
3	Rhizophoraceae	*Rhizophora Sp.*	Stations 1, 2 and 3
4	Meliaceae	*Xilocarpus granatum*	Station 2
5	Rhizophoraceae	*Bruguiera gymnorrhiza*	Station 2

Mangrove tourism attractions are presented in the form of activities to enjoy the beauty in the mangrove forest area. This beauty can be enjoyed by walking on the mangrove track on the Tamban beach [4].

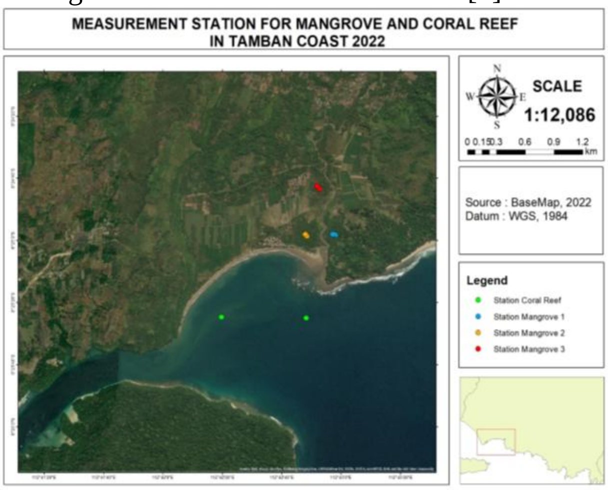

Fig. 2 Map of the mangrove and coral reef measuring stations on the coast of Tamban (2022)

The topography of the Tambakrejo Village is in the form of moderate land, which is about 75 m above the sea level. The soil types in this village are alluvial and lithosol. Alluvial soil can be used as agricultural land because of its relatively high nutrient content. The topographical conditions of the Tamban Coast make it vulnerable to the dangers of tsunami and tidal flooding. Changes in tides, winds, waves, and ocean currents that occur on the coast of Tambakrejo Village are increasing from year to year. The impact of climate change felt by fishers in Tambakrejo Village can be seen from the increase in sea level, where sea water is starting to approach residents' settlements. This can be clearly seen in Tamban Hamlet, where abrasion caused damage to the wave-retaining embankment [15]. The sand of Tamban Beach is clean white along 1,500 meters of stretch and accompanied by stones scattered along the beach. Based on the position of the land slope on the Tamban Beach that can be seen in Fig. 3, the Tamban coast has a slope of 5%-10% from the southwest to the northeast. Meanwhile, the slope of the land from the south to the north ranges from 50%-60%. These conditions show that the slope from land (cliff) to sea (flat) is very prone to flooding. Meanwhile, the height of the inundation from sea to land is prone to tsunami events. Based on the records of tsunami occurrences in the coastal area of Tamban, almost every year, there are 3 (three) tsunamis with an average height of 26–29 meters [14]. Thus, the Tamban beach is very vulnerable to the impacts of climate change. The impact of climate change on the Tamban beach is that the Tamban beach becomes more vulnerable to tsunami hazards, and the area of fishing villages is hit by high tides at least three to four times a year. It was further explained that the impacts of climate change that occurred over the last decade from 1997 to 2017 and have been felt by the respondents are storms and hurricanes, increasingly fierce waves, shift in the location of fishing grounds, decreased number of fish catches in the last decade, the cost of fishing that is becoming more expensive, shift of fish species caught, decreased income due to the reduced number of fish, and many fishers who are getting sick due to climate change.

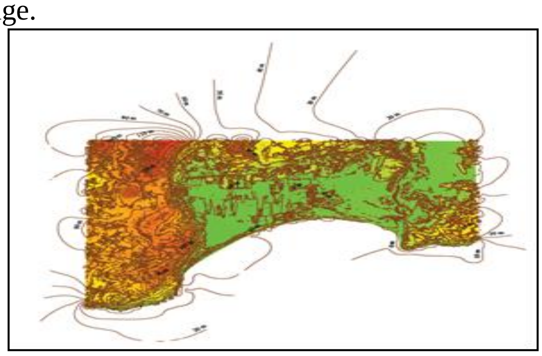

Fig. 3 Contour map of the Tamban coast

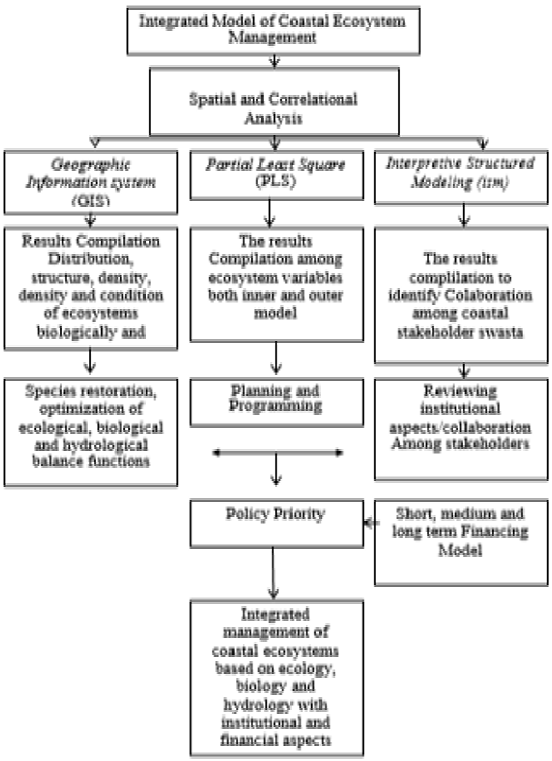

Fig. 4 Flowchart of the research methodology

2.3. Method of Analysis

Data analysis involved three steps: aerial photo mapping using unmanned aerial vehicle (UAV), partial least square (PLS), and interpretative structural modelling (ISM). The combination of the three models produced an integrated model of coastal ecosystem restoration management on the Tamban beach.

2.3.1. UAV Modeling

This unmanned aircraft works with an auto-pilot system, so it can fly while shooting automatically according to the instructions and the planned flight path design. Topographic mapping of the coastal area of Tamban and its surroundings was carried out with an estimated area of 450 hectares using photogrammetric techniques and aerial photo mapping using unmanned aircraft. This work aimed to compile a detailed base map source, namely the availability of orthophoto mosaic and topographic maps at a scale of 1: 20,000, to obtain up-to-date base map and land cover information. The distribution of ground control points is in the form of signal-premarks and it must meet the photogrammetric requirements for making a map of a scale of 1: 20,000. Aerial photography was carried out by taking into account a flying height of 300 m from the average ground level. Besides, the camera used has a minimum resolution of 18 MP and the type of sensor is APS-C with overlap of 80% ± 5% and sidelap of 70% ± 5%. The aerial photo dataset geotagging system uses the PPK (Post Processing Kinematic) method, which uses 2 GNSS- GPS modules which are placed on the ground as a base and on the UAV aircraft as a GPS rover. The projection system used is the Universal Transverse Mercator (UTM) with an elapsoid datum WGS-84 or according to the local coordinate system. The process of generating DEM (digital elevation model) is in the form of digital elevation data for DSM (digital surface model) and DTM (digital terrain model). The results of aerial photography are a collection of photos or aerial photo datasets that are automatically stored in photogrammetry software. The process of identifying the similarity of objects based on the similarity of photo pixel values is to get the coordinates of the binding points in each photo, which results in camera calibration parameters or IO (internal orientation) and EO (external orientation) parameters or camera position at the time of shooting so that it will produce a 3D shape in the model coordinate system.

Fig. 5 Image coverage of the mapping area of the Tamban beach – Malang Regency

2.3.2. PLS Modeling

The unidimensionality of a construct can be evaluated through a measurement model (outer model) using composite reliability and convergent validity by constructing latent variables into a path diagram. By testing the validity and reliability, this research also examines the indicators that are feasible to be continued in the research.

In this study, the variables were mangrove ecosystem assessment (A), coral reef ecosystem assessment (B), seagrass ecosystem assessment (C), climate change assessment (D), damage assessment of mangrove, coral reef, and seagrass ecosystems (E), assessment of disaster management efforts (F), and efforts to develop strategies for managing coastal ecosystems (G), formed using a reflexive indicator type (arrow direction from latent variable to construct). The reason for using reflexive indicators on the variables of mangrove ecosystem assessment (A), coral reef ecosystem assessment (B), seagrass ecosystem assessment (C), climate change assessment (D), assessment of damage to mangrove ecosystems, coral reefs, and seagrass (E), assessment of disaster management efforts (F), and efforts to develop coastal ecosystem management strategies (G) is that the indicators of some of these constructs are a reflection of their constructs (latent variables). This is in accordance that "If an indicator is a reflection of its construct or related to attitudes and personality, it must use reflexive indicators." Because PLS does not assume a certain distribution for parameter estimation, then parametric techniques to test the significance of the parameters are not needed. The PLS evaluation model is based on predictive measurements that have nonparametric properties. The measurement model or outer model with formative indicators does not require evaluation with corvengent and discriminant validity of the indicators and composite reliability for block indicators. This is because the outer model with formative indicators is evaluated on the basis of its substantive content by comparing the relative weight and observing the significance of the weight size. The structural model, or inner model, is evaluated by the percentage of variance explained by the R2 value for the dependent latent construct using the Stone-Geisser Q-square test and the magnitude of the structural path coefficient. The stability of this estimate was evaluated using the t-statistic test obtained through the boostraping procedure.

2.3.3. ISM Modeling

The ISM analysis used PLS results, which showed the relationship between the variables, which said that disaster management efforts (F) have the greatest influence on management efforts (G), where disaster management efforts (F) are significantly influenced by many factors, but the most dominant influences were from:

a) Climate change assessment (D);

b) Coral reef ecosystem assessment (B);

c) Mangrove ecosystem assessment (A);

d) Seagrass ecosystem assessment (C); Because of the absence of seagrass and seaweed fields in the Tamban coastal area, this ecosystem is eliminated.

e) Assessment of ecosystems and climate change that are influenced by anthropogenic processes (E).

SM does not attempt to break down the problem into smaller parts, but rather connects the ideas by building a model of the situation. ISM is at the heart of the interactive management (IM) method, which focuses on the knowledge of a group of participants to obtain accurate results from a valid and relevant process [16].

2.4. Data Measurements

2.4.1. Tamban Coast Profile

The resulting transverse measurements presented in Fig. 6 show the following transverse profiles.

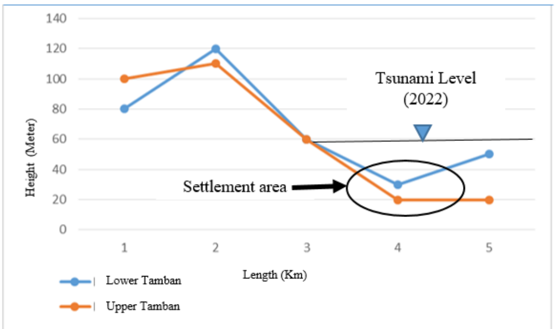

Fig. 6 The transverse profile of the Tamban beach's upper and lower parts

Fig. 6 shows that the measurements are from the north coast to the south, both for the upper Tamban beach position and the lower beach position. The upper and lower parts of the Tamban beach have relatively similar contours; thus, if there is an average sea level rise of 30–60 meters, fishing settlements located on the 10–20 meter contour will be exposed to the danger of tsunami, and fishers and the community will be affected by the tsunami.

2.4.2. Mapping of Inundated Area

Based on the measurements on the UAV map, the area of the Tamban beach is 5,308,114 square meters or equal to 530.8 Ha. The inundation area reaches 3,333,481 square meters or 333.3 Ha, with an inundated area of 62.7%. Fig. 7 shows that the tsunami event really endangered the lives of the people living along the Tamban coastal area. The area near the Tamban beach, both in the upper and lower Tamban coastal zones, shows that the beach "bodyguard," namely the mangrove forest, has been severely damaged so that the mangrove forest in the Tamban Beach area is unable to withstand high waves.

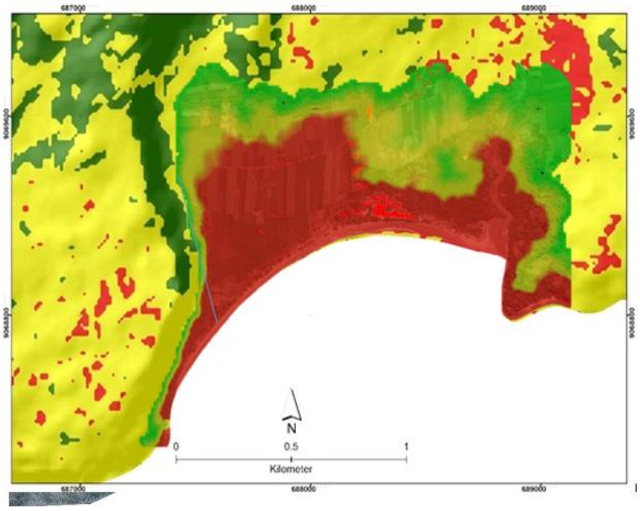

Fig. 7 Map of the Tamban coastal area that was inundated by tsunami

2.4.3. Measurement of the Mangrove and Coral Reef

2.4.3.1. Measurement of Mangrove Data

Research on mangrove ecosystems and coral reefs on the Tamban coast was conducted to determine the extent to which their service capabilities protect the Tamban coast from the danger of a tsunami. Mangrove forests with high density can function as protective devices for coastal areas by functioning as dampers for waves, wind, and storms. The path of mangrove vegetation along the coast is a form of defense that reduces the strength or energy of waves (including tsunamis) [20]. Therefore, the coastal defense system in the form of mangrove vegetation paths is a very appropriate protection fortress.

The density of mangrove forests can be seen in Table 3 as follows:

Table 3 Relative density of mangrove forests on the Tamban coast

Species	**Relative Density of Mangrove Forests**								
	Trees			**Sapling**			**Seedling**		
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Avicenia Alba	633.33	0	0	166.67	0	0	0	0	0
Avecenia marina	1333.33	666.67	0	833.33	233.33	0	0	0	0
Rhizopora sp.	366.67	166.67	1933.33	200	266.67	1800	0	0	0
Xilocarpus granatum	0	800	0	0	166.67	0	0	0	0
Bruguiera gymnorrhiza	0	1133.33	0	0	100	0	0	0	0

Notes: S1 - Station 1, S2 - Station 2, S3 - Station 3

The importance value index is the sum of the values of the relative density of species (RDi), relative frequency of species (RFi), and relative density of species (RCi).

INP = RDi + RFi + RCi

The importance of a species ranges from 0% - 300%. This importance value provides an overview of the influence or role of a mangrove plant species in a mangrove community.

Table 4 The importance value index

Species	Importance Value Index								
	Trees			Sapling			Seedling		
	S1	S2	S3	S1	S2	S3	S1	S2	S3
Avicenia Alba	56.87	0	0	15.88	0	0	3,17	0	0
Avecenia marina	103.59	67.08	0	60.01	20.06	0	4.76	0	0
Rhizopora sp.	33.58	9.78	183,15	18.96	18.10	114.7	3.17	0	0
Xilocarpus granatum	0	62.20	0	0	18.45	0	0	0	0
Bruguiera gymnorrhiza	0	93.03	0	0	10.44	0	0	0	0

Table 5 Mangrove ecological index

Station	H' (Uniformity Index)	E (Diversity Index)	C (Dominance)
1	0.76	1.11	0.51
2	1.32	1.90	0.29
3	0.34	0.49	0.28

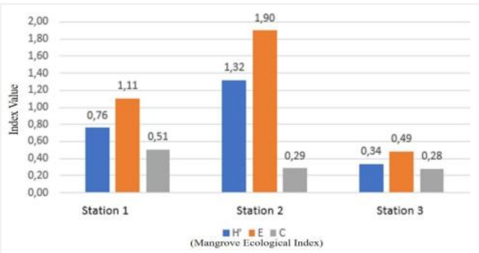

Fig. 8 Mangrove ecological index

2.4.3.2. Measurement of Coral Reef

Coral reef coverage measurements were carried out at two stations, and the results are presented in Fig. 9.

Table 6 Position of coral reef measurement station in Tamban waters

No.	Name of the Station	Position	Depth (meter)
1.	Station 1	08°24’53.6” S 112°42’55.1” E	5
2.	Station 2	08°25’38.1” S 112°42’17.5” E	7

To calculate coral coverage, the percentage of live coral coverage was calculated based on the equation below [19].

Ni = Li/L × 100%

where:

Ni - percentage of coral lifeform type – i coverage;

Li - the length of the ith coral lifeform (m);

L - total length of line transect (m).

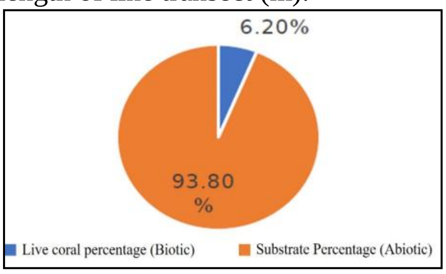

Fig. 9 Percentage of live coral coverage by category in pond water stations (2022)

The percentage of coral reefs at Station 1 is shown in Fig. 10. The condition of coral reefs at Station 1 is classified as atrocious. This refers to the criteria given by [18]. The percentage of substrate cover is divided into four categories: damaged (0% - 25%), moderate (26% - 50%), good (51% - 75%), and excellent (76% - 100%).

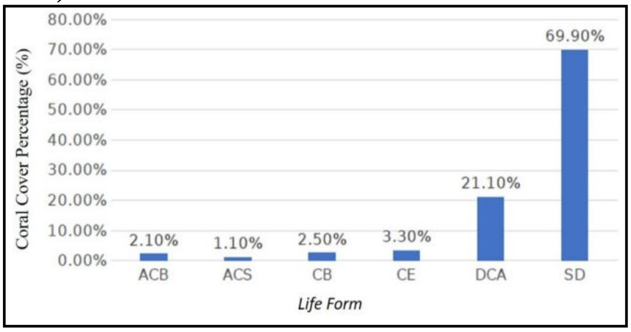

Fig. 10 Percentage of substrate coverage at Station 1 of Tamban waters (2022)

Table 7 Mortality index at Station 1

Total Percentage of Dead Coral (DC) Coverage	Total Percentage of Live Coral (LC) Coverage	Mortality Index (MI)
938	62	0.938

Therefore, MI = $\frac{DC}{DC+LC} = \frac{938}{938+62}$ = 0.938

Table 8 Mortality index at Station 2

Total Percentage of Dead Coral (DC) Coverage	Total Percentage of Live Coral (LC) Coverage	Mortality Index (MI)
90	910	0.91

Therefore, MI = $\frac{DC}{DC+LC} = \frac{90}{910+90}$ = 0.91

The coral mortality index (MI) obtained at Station 1 was 0.938, which indicates a high mortality rate of coral. The mortality index (MI) of coral obtained at station 2 was 0.91, indicating that the mortality rate of coral was high. A mortality index value close to 0.0 indicates that almost no coral mortality was found, while a value close to 1.0 indicates a significant change from live coral to dead coral.

Table 9 Coral index at Station 1

Life Form	Number of species	Pi	ln Pi	Pi * ln Pi
ACB	2	0.4	0.91629	-0.36652
ACS	2	0.4	0.91629	-0.36652
ACT	1	0.2	1.60944	-0.32189
Total	5	0.2	1.60944	-0.32189

Table 10 Coral ecological index at Station 1

H'	1.054920168
H' Max	1.098612289
E	0.960229718
C	0,36

Table 11 Coral index at Station 2

Life Form	Number of species	Pi	ln Pi	Pi * ln Pi
ACB	1	0.166667	1.79176	-0.29863
ACS	1	0.166667	1.79176	-0.29863
CB	2	0.333333	1.09861	-0.3662
CS	2	0.333333	1.09861	-0.3662
Total	6			

Table 12 Coral ecological index at Station 2

H'	1.329661349
H' Max	1.386294361
E	0.959147917
C	0.28

2.4.4. Water Quality Measurement

The measurement of water quality was carried out at 2 observation stations. The parameters observed in this study were temperature, pH, salinity, and dissolved oxygen (DO). These are critical parameters for coral reef life. Geographically, temperature can limit the distribution of corals. Meanwhile, salinity is an important factor for the spread of marine organisms. pH affects the resistance of organisms because a low pH interferes with the absorption of dissolved oxygen by these organisms.

Table 13 Water quality data obtained from measurements at Stations 1 and 2

	Temperature	pH	Salinity	DO
Station 1	28.3 °	8	33 ppt	7.4 mg/L
Station 2	28.3 °	8	25 ppt	6.8 mg/L

Temperature measurement in both station 1 and station 2 obtained a result of 28.3°C. This means that in Tamban waters, the temperature is still relatively good for fish growth. The optimal temperature for fish growth is in the temperature range of 25–30°C. The pH value at both Stations 1 and 2 was 8, meaning that Tamban waters with an average pH of 8 are still suitable for fish growth.

The salinity measurement in Tamban waters showed 33 ppt at station 1 and 25 at Station 2. This means that the salinity in Tamban waters is in the normal range. Dissolved oxygen (DO) at station 1 was 7.4 mg/l and DO at station 2 was 6.8 mg/l. Therefore, the DO in Tamban waters is in the normal range.

2.4.5. Partial Least Squares (PLS)

Based on the distribution of questionnaires to 51 respondents, the characteristics of 51 respondents were obtained. The average age of the respondents was 41.7 years. Based on the percentage by gender, male respondents were 52.9%, while female respondents were 47.1%. A total of 37.3% of the respondents were high school graduates. The occupations of 35.3% of respondents are fishers, while 29.4% of respondents are farmers. Income per month for non-fixed income is 39.2%, and income is less than 1 million/month as much as 29.4%. In terms of income, 31 respondents filled in income data, and it can be seen that the average respondent had an income of IDR 2,116,129.03 with the smallest income being IDR 500,000, - and the largest income being IDR 25,000. 000.

Since PLS does not assume a specific distribution for parameter estimation, a parametric technique to test the significance of the parameters is not required. The PLS evaluation model is based on predictive measurements that have nonparametric properties. The structural or inner model is evaluated by the percentage of variance explained by the R2 value for the dependent latent construct using the Stone-Geisser Q-square test and the magnitude of the structural path coefficient. The stability of this estimate was evaluated using a test with t-statistic obtained through the bootstrapping procedure. Table 14 is the basis for preparing the structural models.

Table 14 Sub-variables of the model

Symbols	Variable Item
	Sub-Variables of Mangrove Ecosystems
A1	The community considers that mangroves are very beneficial for the Tamban Hamlet community both for community protection from disasters as well as for food security and protection of marine life;
A2	The community considers that the mangrove forest on the Tamban coast is currently experiencing quite serious damage;
A3	The community considers that the mangrove forest on the Tamban coast must be protected and not destroyed;
A4	The community considers Pokmaswa Tambaan Indah is very active in protecting mangroves from damage;
A5	The community considers that the mangrove forest on the Tamban coast must be protected and not destroyed;
A6	The community considers Pokmaswass Tambaan Indah is very active in protecting mangroves from damage;
A7	The community considers that the mangrove forest on the Tamban coast can be used as an alternative source of food;
A8	The community considers that the regency government does not care about the damage to mangrove forests;
A9	The community considers that, until now, the community has not cared to overcome the damage to mangrove forests;

A10	The community considers that, until now, they do not know the function and role of the mangrove forest in the protection the Tamban Beach.
	Sub-Variables of Coral Reef Ecosystems
B1	The community considers that coral reefs are very beneficial for the Tamban Hamlet community both for community protection from disasters as well as for food security and protection of marine life;
B2	The community considers that the coral reefs on the Tamban beach are currently experiencing quite serious damage;
B3	The community considers that the coral reefs on the Tamban beach must be protected and undamaged;
B4	The community considers Pokmaswa Tambaan Indah is very active in protecting coral reefs from damage;
B5	The community considers that the coral reefs on the Tamban beach must be protected and undamaged;
B6	The community considers Pokmaswass Tambaan Indah is very active in protecting coral reefs from damage;
B7	The community considers that the coral reefs on the Tamban beach can be used as an alternate source of food;
B8	The community considers that the regency government does not care about the damage to coral reefs;
B9	The community considers that, until now, the community has not cared to overcome the damage to coral reefs;
B10	The community considers that, until now, the community does not know the function and role of coral reefs in the protection of Tamban Beach;
	Sub-Variables of Seagrass Ecosystems
C1	The community considers that seagrass is very beneficial for the people of Tamban Hamlet, for protecting the community from disasters, food security, and protection of marine biota;
C2	The community considers that seagrass on Tamban Beach is currently experiencing serious damage;
C3	The community considers that seagrass on Tamban Beach must be protected and undamaged;
C4	The community considers that the Tambaan Indah Pokmaswas is very active in protecting seagrasses from damage;
C5	The community considers that seagrass on the beach must be protected and undamaged;
C6	The community considers Pokmaswass Tambaan Indah is very active in protecting seagrasses from damage;
C7	The community considers the seagrass on Tamban beach can be used as an alternative source of food;
C8	The community considers that the regency government does not care about the damage to the seagrass;
C9	The community considers that, until now, the community has not cared to overcome the damage to the seagrass;
C10	The community considers that, until now, the community does not know the function and role of seagrass in the protection of Tamban Beach.
	Sub-Variables of Impact Climate Change
D1	The community considers that Tamban Beach often experiences tidal flooding caused by high sea waves;
D2	The community considers that the temperature in Tamban Beach is getting hotter over time;
D3	The community assesses that almost every year, the Tamban Fishing Village is flooded;
D4	The community considers that the reallocation of people who are always inundated by water needs to be carried out by the government;
D5	The community considers that mangroves and coral reefs can withstand inundation and flooding;
D6	The community considered that the impact of the tsunami was the loss of coastal land due to abrasion;
D7	The community considers that big waves are continuously eroding the land;
D8	The community considers that the big waves will make the community lose their land;
D9	The community considers that big waves will make fishing communities lose their boats;
D10	People think that extreme weather (sudden changes in environmental conditions) makes people panic;
D11	People think that big waves always occur on Tamban Beach;
D12	People think that climate change always happens unpredictably.
	Sub-Varibles of Assessment of Damaged Mangrove, Coral Reef, and Seagrass
E1	The community considers that mangroves, coral reefs, and seagrasses are coastal ecosystems that can provide benefits for people's livelihoods;
E2	The community considers that mangroves, coral reefs, and seagrasses can;
E3	The community considers that the damage to mangroves, coral reefs, and seagrasses is caused by irresponsible human activities;
E4	The community considers that the damage to mangroves, coral reefs, and seagrass causes high waves to be unstoppable;
E5	The community does not understand that coastal ecosystems (mangroves, coral reefs, seagrasses) provide protection to the Tamban beach, including the life of fishers;
E6	The community considers that past human activities have caused damage to mangroves, coral reefs, and seagrasses;
E7	The community considers that there are no longer fishers who use bombs made with potassium nitrate to catch fish;
E8	The community considers that there are no longer people who cut down mangrove trees for their needs;
E9	The community considers that seagrass meadow is currently shrinking because the land is used for mooring boats or for other purposes;
E10	The community considers that the potential of coastal ecosystems can be used for marine ecotourism;
E11	The community considers that human activities such as the construction of settlements, roads, bridges, and buildings are increasing on the Tamban beach;
E12	The community considers that one of the causes of disaster on the Tamban beach is community activities that do not take the use of mangroves, coral reefs, and seagrass into consideration.
	Sub-Variables to Develop Strategies for Managing Coastal Ecosystems
F1	The community considers the need for relocation of residents whose houses are flooded;
F2	The community considers that the local government should make policies for relocating flood-affected communities;
F3	The community considers that there is a need for awareness from the flooded community to want to be reallocated to a safer place;
F4	The community considers that the government must make a policy regarding the use of land that is safe for the community in the future so that they are safer from the tsunami disaster;
F5	The community considers that there are high tides 3 to 4 times a year and it needs to be anticipated by the Malang Regency Regional Disaster Management Agency (BPBD) and the local government to avoid loss of life and property;
F6	The community considers that the local government should have procedures as a response when the community is hit by a

	natural disaster;
F7	The community views that the Malang Regency government and the village government must provide counseling about disasters;
F8	The community considers that there is a need for assistance by the government for victims of natural disasters;
F9	The community considers that the community must try to avoid the disaster area, if the wave height is still on land;
F10	The community considers that the government does not have guidelines regarding disaster-affected communities;
F11	The community, after a disaster, was assisted by the police, army, and local government officials to buy materials and learn skills to help their homes recover from the disaster;
F12	Many social organizations/NGOs came to help the community during a disaster on Tamban Beach.
	Sub-Variables of Efforts to Develop a Strategy for Managing Coastal Ecosystems
G1	The community considers that mangroves, coral reefs, and seagrasses must be preserved by both the government and community;
G2	The community should propose to the government to make the Tamban beach area a conservation area;
G3	The community considers that the management of coastal ecosystems must be based on the values of local wisdom;
G4	The community considers that the government provides a way for the community to seek other sources of income that do not damage coastal ecosystems (mangroves, coral reefs, and seagrasses).
G5	The community considers that there is a need to strengthen the Pokmaswas institution, both in terms of institution and funding;
G6	The community considers that the government should provide funding assistance for Pokmaswa to operationally monitor the existence of coastal ecosystems (mangroves, coral reefs, and seagrasses);
G7	The community believes that the village government should include a mangrove, coral reef, and seagrass recovery plan in its development plan;
G8	The community thinks that there is a need for guidelines for the restoration of coastal ecosystems on the Tamban coast provided by the government;
G0	The community considers that the role of universities in providing input to climate change on the Tamban coast is critical;
G10	The community considers that the existence of the community on the Tamban Beach cannot be separated from the life of mangroves, coral reefs and seagrasses;
G11	The community considers that the design of the Tamban coastal layout is critical for sustainable development.

2.4.5.1. Convergent Validity

Table 15 shows that the convergent validity can be tested based on the assessment of the outer loading coefficient and the average variance extracted (AVE) value. Table 15 shows outer loading value of the mangrove ecosystem assessment variable (A).

Table 15 Convergent validity

	Original Sample (O)	**Sample Mean (M)**	**Standard Deviation (STDEV)**	**t-statistic (|O/STDEV|)**	**p-values**
A.1 <- Mangrove Ecosystem Assessment (A)	0.890	0.889	0.022	39.736	0.000
A.2 <- Mangrove Ecosystem Assessment (A)	0.827	0.828	0.034	24.623	0.000
A.3 <- Mangrove Ecosystem Assessment (A)	0.847	0.846	0.036	23.784	0.000
A.4 <- Mangrove Ecosystem Assessment (A)	0.734	0.729	0.059	12.504	0.000
A.5 <- Mangrove Ecosystem Assessment (A)	0.828	0.830	0.032	25.912	0.000
A.6 <- Mangrove Ecosystem Assessment (A)	0.884	0.881	0.026	34.313	0.000
A.7 <- Mangrove Ecosystem Assessment (A)	0.766	0.764	0.053	14.398	0.000
A.8 <- Mangrove Ecosystem Assessment (A)	0.912	0.912	0.024	37.300	0.000
A.9 <- Mangrove Ecosystem Assessment (A)	0.900	0.899	0.030	30.021	0.000
A.10 <- Mangrove Ecosystem Assessment (A)	0.893	0.891	0.028	31.613	0.000

2.4.5.2. Discriminant Validity

Another method to observe the value of discriminant validity is to assess the validity of the constructs based on the AVE value, where a model is considered good if the AVE of each construct is greater than 0.5.

Table 16 Average variance extracted (AVE)

Construct Variable	**Average Variance Extracted (AVE)**
Mangrove Ecosystem Assessment (A)	0.722
Coral Reef Ecosystem Assessment (B)	0.825
Seagrass Ecosystem Assessment (C)	0.779
Climate Change Assessment (D)	0.809
Anthropogenic Activities (E)	0.764
Disaster management efforts (F)	0.820
Management efforts (G)	0.727

2.4.5.3. Structural Analysis Results Model (Inner Model)

The output of the structural model (inner model) after the bootstrap calculation process with 500 repetitions can be seen in Fig. 11.

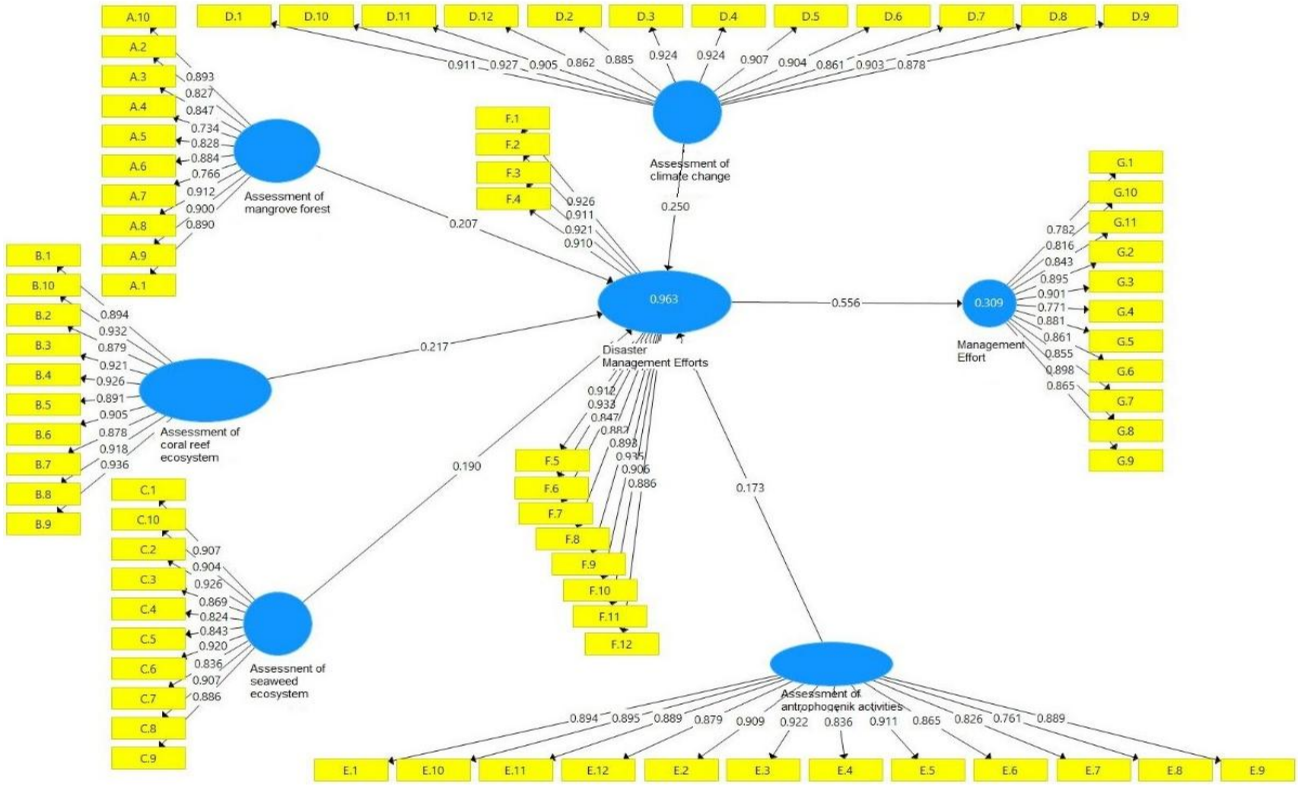

Fig 11 Path diagram (path analysis) for PLS output results

Based on the above model, it can be concluded that disaster management efforts (F) have the greatest influence on management efforts (G), where disaster management efforts (F) are significantly influenced by many factors, but mostly influenced by:

a) Climate change assessment (D);
b) Coral reef ecosystem assessment (B);
c) Mangrove ecosystem assessment (A);
d) Seagrass ecosystem assessment (C);
e) Anthropogenic activities (E).

2.4.6. ISM

Based on the conclusions obtained from the PLS analysis, the following objectives were formulated:

1. Disaster management efforts in Tamban waters also pay attention to the phenomenon of increasing climate change;
2. Disaster management efforts in Tamban waters also pay attention to the increase in the occurrence of damage to coral reef ecosystems;
3. Disaster management efforts in Tamban waters also pay attention to the increase in the occurrence of damage to the mangrove ecosystem;
4. Disaster management efforts in Tamban waters also pay attention to the increase in anthropogenic activities.

3. Results

3.1. Mangrove Analysis

Mangrove forests can reduce the run-up of tsunamis. Mangrove forest with a thickness of 600 meters to 1 km can reduce about 80% of wave tsunami to a run-up height of 10 meters. Table 3 above shows that the density of mangrove forest at station 1 is higher than that at other stations. Meanwhile, station 2 has very low density. Therefore, the Tamban coast is vulnerable to tsunami. Based on the results of the study, there were five types of mangrove species found at the research site. The mangroves at the research site are relatively still in good condition with density value based on the growth category as follows: tree stage at station 1 with a density of 366.67 – 1333.33 Ind/Ha and sapling stage at station 2 with a density of 100–833.33 Ind/Ha.

Based on observations made in the field, there are 3 data collection stations based on the main zone. Station 1 represents highly exposed mangroves and is the zone closest to or directly facing the waters. Station 2 represents the central mangrove forest, which is the zone in the middle between the sea and the land. Station 3 represents the wave-exposed mangrove forest, which is the outermost zone close to the water.

The importance of a species ranges from 0% - 300%. This importance value provides an overview of the influence or role of a mangrove plant species in a mangrove community. According to Table 4 above, the IVI value shows that at station 1, the largest IVI value, which was 1: 33.58% - 103.59%, was in the tree group; IVI value at station 2 was 9.78% -93.03% and IVI value at S3 was 183.15%. Meanwhile, the IVI value in the Belta group at Station 1 ranged from 15.88 - 60.01%, at Station 2 ranged between 18.10% - 20.06% while at Station 3 was 114.7%. Therefore, the role of mangroves on the Tamban coast is critical to prevent tsunami. Table 5 shows that analysis of the structure of the mangrove community at 3 observation stations includes the diversity index (H'), evenness index/uniformity index (E) and dominance index (D). The diversity index of mangrove communities found in the three research stations was classified as varied (low – moderate), ranging from 0.34 to 1.32. This indicates that the mangrove vegetation community in the coastal area of Tamban is in a stable condition (based on environmental parameters and substrate support), although there is still competition between species for nutrients and nutrient space [17]. If the diversity index is less than 1, it is included in the low category. The highest diversity index, namely, 1.32 (medium category), was found at station 2, then followed by station 3 with 0.34 (medium category). When it was compared with Stations 1 and 2, the value of mangrove community diversity at Station 3 was included in the category of low - medium. This is presumably because several research locations tend to experience damage and degradation of the aquatic environment so that it impacts the existence and diversity of species mangroves around the Tamban coastal area. Fig. 8 shows a graph of the mangrove ecological index.

3.2. Coral Reef Analysis

Based on the results of observations and measurements, coral reefs in these waters are dominated by sand (SD) with a substrate coverage percentage of 61.80%, Dead Coral Algae (DCA) with a substrate coverage percentage of 32.00%, Acropora Submassive (ACS) with a substrate coverage percentage of 3.20%, Acropora Tabulate (ACT) with a substrate coverage percentage of 1.50%, and Acropora Branching (ACB) with a substrate coverage percentage of 1.50%. The low percentage of substrate coverage is caused by high human activity at this location.

The mortality index was used to determine the ratio of coral mortality. This index determines the magnitude of the change from live coral to dead coral. A mortality index value close to 0.0 indicates almost no coral mortality, while a value close to 1.0 indicates a significant change from live coral to dead coral.

The diversity index can be interpreted as a systematic depiction that describes the community structure and can facilitate the process of analyzing information about the number of organisms. The diversity index shows the number of different taxa, species providing specific diversity, and genus providing generic diversity. If the diversity index is in the medium category, the number of individuals of each form of coral growth in a community is in a relatively good condition. The diversity index at station I at a depth of 5 meters had a value of 1,054 and was included in the medium category. The diversity index at station 2 at a depth of 7 meters had a value of 1,791 and was included in the medium category.

The uniformity index value is based on the certain criteria. If E is < 0.4, then the uniformity is low, if E is = 0.4 - 0.6 then the uniformity is moderate, and if E is > 0.6, then the uniformity is high. The uniformity index at station 1 at a depth of 5 meters had a value of 0.960, included in the high uniformity category. The uniformity index at station 2 at a depth of 7 meters had a value of 0.959 and it was included in the category of high uniformity and stable community.

The dominance index (C) was used to see the level of dominance of certain biota groups. The dominance index value at station I at a depth of 5 meters had a value of 0.36, which is included in the low category. At station 2 at a depth of 7 m, the dominance index had a value of 0.277, which is categorized as low. At each observation station, it can be seen that there is no dominant coral species. This shows that the waters can still support coral life, so that no competition causes certain species to dominate.

3.3. Analysis of PLS

A reflexive indicator has a correlation with the measured variable if it has a loading factor coefficient of > 0.7. The outer loading value of 0.6 is considered sufficient.

The same condition applies to the assessment of indicator items for variable (B). The 10 indicators had an outer loading greater than 0.7 with p-values < 0.05, so it can be concluded that the 10 indicators of the coral reef ecosystem assessment variable (B) met convergent validity, meaning that it is good in measuring the coral reef ecosystem assessment variable (B). The B.9 indicator was known to have the largest outer loading, which was 0.936, and the B.7 indicator had the smallest outer loading, which was 0.878.

The 10 indicators of the Seagrass Ecosystem Assessment (C) variable were known to have an outer loading greater than 0.7 with p-values < 0.05, so it can be concluded that the 10 indicators of the seagrass ecosystem assessment (C) variable met convergent validity, meaning that it is good in measuring the seagrass ecosystem assessment variable (C). The C.2 indicator was known to have the largest outer loading, which was 0.926, and the C.4 indicator had the smallest outer loading, which was 0.824. Further, the outer loading of the 12 indicators of the climate change assessment variable (D) was greater than 0.7 with p-values < 0.05, so it can be concluded that the 12 indicators of the climate change assessment variable (D) met convergent validity, meaning that it is good in measuring the climate change assessment variable (D). The D.10 indicator was known to have the largest outer loading, which was 0.927, and the D.7 indicator had the smallest outer loading, which was 0.861. The outer loading variable of the 12 indicators of the assessment of damage to the mangrove, coral reef, and seagrass ecosystems (E) was greater than 0.7 with p-values < 0.05, so it can be concluded that the 12 indicators of the variable consisted of the assessment of damage to the mangrove, coral reef, and seagrass ecosystems (E) and met convergent validity, meaning that it is good in measuring the variables of the assessment of damage to mangrove, coral reef, and seagrass ecosystems (E). The E.5 indicator was known to have the largest outer loading, which was 0.911, and the E.8 indicator had the smallest outer loading, which was 0.761. Outer loading of the 12 indicators of the assessment variable of disaster management efforts (F) was greater than 0.7 with p-values being < 0.05, so it can be concluded that the 12 indicators of the assessment variable of disaster management (F) fulfilled convergent validity, meaning that it is good in measuring the assessment variable of disaster management efforts (F). The F.10 indicator was known to have the largest outer loading, which was 0.935, and the F.7 indicator had the smallest outer loading, which was 0.847.

The outer loading of the 11 indicators of the variable of the efforts to develop a strategy for managing coastal ecosystems (G) was greater than 0.7 with p-values being < 0.05, so it can be concluded that the 11 indicators of the variable of the efforts to develop a management strategy. The coastal ecosystem (G) met convergent validity, meaning that it is good at measuring variables. Of the indicators of the variable of efforts to develop strategies for managing coastal ecosystems (G), the G.3 indicator was known to have the largest outer loading, which was 0.901, and the G.4 indicator had the smallest outer loading, which was 0.771.

3.4. ISM Analysis

The ISM analysis built a strategy based on the PLS results as follows:

1. Disaster management efforts in Tamban waters also pay attention to the phenomenon of increasing climate change;
2. Disaster management efforts in Tamban waters also pay attention to the increase in the occurrence of damage to coral reef ecosystems;
3. Disaster management efforts in Tamban waters also pay attention to the increase of mangrove damaged; increase in the occurrence of damage to the Mangrove ecosystem;
4. Disaster management efforts in Tamban waters also pay attention to the increase in anthropogenic activities.

Driver Power-Dependence Matrix (DP-D Matrix) is made on the basis of various objectives classified into four sectors: autonomous, dependent, linkage, and independent (ADLI) based on power drivers and dependencies (driver power and dependence).

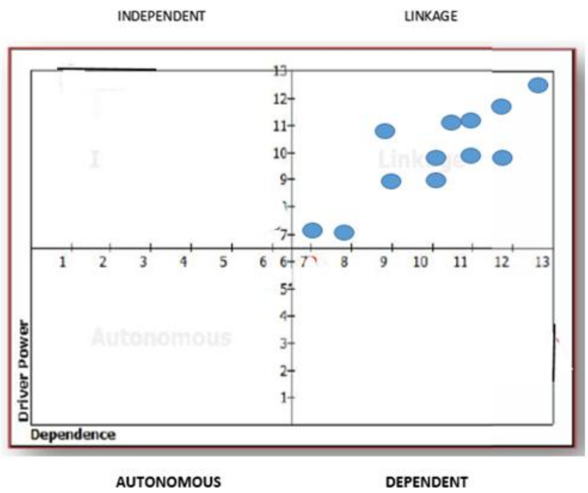

Fig. 12 Driver power-dependence matrix (DP-D matrix)

4. Discussion

Based on UAV analysis, the topography of Tamban Beach has made it very vulnerable to sea level rise. The inundation area reaches 333.3 Ha. The effect of the mangrove significance index indicates that *Avecenia marina* is the most dominant on the east coast of Tamban in the stages of trees, sapling, and seedling. However, the mangrove forests in the west have a very low density percentage. The results of the identification of the existence of mangrove species on the Tamban beach showed that there are differences in the species and conditions of mangroves at each observation station. Observations of environmental conditions based on the temperature range parameters showed almost the same temperature at the two observation stations, namely, 28.3^{o}C. The salinity at the two observation stations ranged from 25 - 33 ppm, while the existing substrate was in the form of sand and mud. Under a range of environmental conditions, mangroves can grow well.

According to the Decree of the Minister of the Environment of 2001, the standard criteria for the percentage of live coral reef include “bad” (0%-24.9%), “moderate” (25%-49.9%), “good” (50%-74.9%), and “excellent” (75%-100%). The results of field measurements showed that coral reefs that dominate the coral reef coast are sand (SD) with a substrate coverage percentage of 61.80%, Dead Coral Algae (DCA) with a substrate coverage percentage of 32.00%, Acropora Submassive (ACS) with a substrate coverage percentage of 3.20%, Acropora Tabulate (ACT) with a substrate coverage percentage of 1.50%, and Acropora Branching (ACB) with a substrate cover percentage of 1.50%. Thus, the presence of coral reefs at the Tamban Beach location is very low in the percentage of substrate coverage. This is due to the high human activity at the Tamban Beach location.

The 12 indicators tested in PLS showed that all variables should get attention. These variables are related to the assessment of damage to mangrove ecosystems and coral reefs, assessment of disaster management, efforts to develop coastal ecosystem management strategies, and variables to develop strategies and manage coastal ecosystems [21]. The relationship between objectives and strategies in the ISM analysis can be seen in Table 17. The table shows the direction of countermeasures, starting from the planning, preparing an action plan, to the monitoring and evaluation.

Table 17 Relationships between objectives and strategies

No.	Objective	Strategy
1.	Disaster management efforts in Tamban waters also pay attention to the phenomenon of increasing climate change.	a).Management of ecological disasters, such as the occurrence of tsunamis, high tides and flooding (tidal flooding), extreme temperature rises, droughts, and El Nino, needs to be organized; b). Increasing the community's resilience in accepting disaster risks; c). Developing stages of disaster management, which include prevention and mitigation; preparedness; emergency management, recovery and action plans that may have implications for disaster risk reduction. d). The institution that manages the emergency, which, in this case, is the Regional BNPB, should prepare in such a way to face an even greater disaster in the coastal waters of Tamban; e). Policy makers in the Malang Regency Government, scientists, and health researchers must collaboratively develop adaptive strategies;
2.	Disaster management efforts in Tamban waters also pay attention to the increase in the occurrence of damage to coral reef ecosystems.	a). Coral reef conservation and restoration policies have become demands and needs that must be met as a harmonization of the economic needs of the community and the desire to continue to preserve existing coral reef resources for the future generations; b). The conservation of coral reef areas uses a zoning system with the division of four zones that can be developed within the aquatic conservation area: core zone, sustainable fisheries zone, usage zone, and other zones. c). Management using artificial coral reefs based on institutional approach strengthening;
3.	Disaster management efforts in Tamban waters also pay attention to the increase in the occurrence of damage to the mangrove ecosystem.	a). Mangrove restoration and conservation policies have become demands and needs that must be met as a form of harmonization of the economic needs of the community and the desire to continue to preserve existing mangrove resources for the future generations; b). The conservation of mangrove areas uses a zoning system with the division of four zones that can be developed within the aquatic conservation area: core zone, sustainable fisheries zone, usage zone, and other zones. c). Management of mangrove forest areas based on institutional approach strengthening;
4.	Disaster management efforts in Tamban waters also pay attention to the increase in anthropogenic activities.	a) The policy of conservation and restoration of coastal ecosystems in the coastal waters of Tamban has become a demand and need that must be met as a harmonization of the economic needs of the community and the desire to continue to preserve existing coral reef resources for the future generations; b). The policy of granting permits to control spatial planning is a must on the Tamban beach; c). Coastal land management must pay attention to the relationship between the landscape and the seascape based on the strengthening of the institutional approach;

5. Conclusion

The main findings of this study indicate that the area of increase due to sea level rise caused by the tsunami is increasingly widespread. It is estimated that the inundation area is based on measurements on the UAV map, the area of the Tamban beach is 5,308,114 square meters or equal to 530.8 Ha. The inundation area reaches 3,333,481 square meters or 333.3 Ha, with an inundation area of 62.7%. The inundation area is very likely to increase from 62.7% to more than that. This is because the anthropogenic process runs very intensively. The construction of housing and the establishment of stalls and kiosks along the Tamban beach are progressing quickly and the construction process is expected to continue intensively. The expansion of this inundation will continue to increase over time. This means that the number of people who will be affected by the tsunami is increasing. Thus, it is necessary to move the location of settlements and places of business.

The results of research [19] regarding the study of the travel time of the fastest tsunami waves to the research area showed that the magnitude of the earthquake was 8.6 in the 0.2 min with a maximum tsunami height of 3.0034 m; 2.0144 m; 1.7030 m and tsunami inundation of 36.3 ha; 21.3 ha; 17, 1 ha in a row. The longest travel time in coastal areas is at 68.8 min; 67.8; 67.7 with the smallest maximum height value of 0.0420 m; 0.0184 m; 0.0189 m. Regarding the effect of variation in magnitude and source point on altitude, travel time and inundation of tsunami waves in Pesisir Selatan Regency, West Sumatra, the results of the study do not suggest any intensive treatment for tsunami-affected communities. Tsunami modeling is carried out as a reference or provides an overview in knowing the distribution of tsunami waves from the earthquake source, the time of propagation of the waves (travel time) and the height of the tsunami (run up) that can pass through the affected area. Therefore, it is necessary to model tsunami inundation and tsunami wave travel time to mitigate the tsunami disaster in Pesisir Selatan Regency.

The implication of the results of this study is the formulation of policy inputs for the local government of Malang Regency to immediately take action to relocate residents who have been and will be affected by the tsunami. The relocation of residents to areas safe from the tsunami disaster needs to be handled immediately by taking into account the spatial zoning. The implication of these findings is that it needs to be considered in the formulation of local government policies of Malang Regency in the formulation of long- and medium-term policies. The allocation of time and financing should consider whether the sources of financing come from the Regional Revenue and Expenditure Budget or from the central government budget.

Transferring people from areas very dangerous from the tsunami disaster to safe areas protects the community from tsunami disasters and tidal flooding. Based on the results of this study, local governments have the legal power to conduct gradual and sustainable relocation. However, this policy will be constrained by political will and the availability of funds to move people to safer areas. In 2012, the Malang district government already had an agenda to relocate the coastal communities of Tamban, but the agenda for relocating the community was still unclear, especially regarding where and how the community would be relocated. As a result, until 2022 there is no clarity regarding the transfer of people to safer places. Meanwhile, the tsunami and tidal floods are still ongoing.

Based on the facts and analysis of this research data, the displacement of the population to areas safer from the reach of tsunami inundation allows avoiding tidal flooding. A safe area on the Tamban coast is in an area that is + 10 Km from the coast to the west or northwest with a hilly contour height. Meanwhile, areas that are considered very dangerous need to be restored to coastal areas by planting mangroves that are in accordance with their habitat. Thus, there are two recovery targets: the restoration of the coastal area along the Tamban coast and the determination of a safe area for residence and place of business to be free from tsunami and tidal flooding.

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