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Regional Case Study

Marine Debris Mitigation Strategy in Supporting the Development of Sustainable Tourism in SEZ Mandalika Lombok

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Abstract

Concerns about increasing marine debris at priority tourist destinations in SEZ Mandalika require a comprehensive mitigation strategy. The purpose of this study is to analyze the characteristics of marine debris on three different types of beaches and to analyze marine debris mitigation strategies. Data collection was conducted by field survey with a transect methode. Marine debris mitigation strategies are identified quantitative SWOT analysis. Characteristics of macro marine debris at Tanjung Aan Beach based on the amount dominated 41% plastic. Meso marine debris is dominated by plastic foam in the form of white cork 48%. In the fishing area, the characteristics of marine debris is dominated type of cloth material 52% in the form of fishing thread and other fabrics. Meso marine debris in the fishing area dominated 45% in the form of white cork flakes. Characteristics of macro marine debris at Batu Berang Beach, it was found that fabric waste dominated 42%. Meso waste in Batu Beach is dominated 60% plastic. The alternative strategy that the highest score (2.99) is the sorting of organic and non-organic waste in various coastal typologies by visitors with the preparation of facilities and infrastructure by the tourism management or village government.

Keywords: Marine debris; mitigation strategy; tourism destination; SEZ Mandalika; SWOT quantitative

1. Introduction

The Mandalika Special Economic Zone (SEZ) is one of the priority tourist destinations with the main potential for marine tourism. SEZ Mandalika will host an international scale event in March 2021 which will bring in local and foreign tourists. The involvement of SEZ Mandalika as the host of international scale events can increase the branding of SEZ Mandalika so that it has the potential to increase the number of visits by local and foreign tourists. The increasing number of tourist visits will lead to more and more diverse tourism activities so it has the potential to generate waste which will have an impact on environmental sustainability.

Marine debris is solid material that is produced and processed persistently which is discarded or left behind in the sea, causing disruption of marine and coastal ecosystems (Löhr et al., 2017). Marine debris consists of various types such as plastic, metal, textile, glass, and rubber. The most dominant marine debris as much as 70% consists of plastic which has characteristics that are difficult to decompose and has the potential to decompose into microplastics which cause death in marine biota (Gall & Thompson, 2015). Various marine organisms consumed by humans as food such as fish, bivalves and crustaceans have been reported to contain microplastics in their intestines (Bråte et al., 2016). Toxins ingested by humans will accumulate and grow in the human body through the process of bioaccumulation and biomagnification (Kelly et al., 2007). Plastic waste floating in the waters acts as a carrier of toxins such as Flatates, Polycyclic Aromatic Hydrocarbons (PAH), Brominated Flame Retardants (BFR), Polychlorine Biphenyls (PCB), Dichloropenytrichloroethane (DDT)(Cole et al., 2011). Marine debris can also form a transport mechanism that can help spread marine organisms and a mechanism for alien species to invade new habitats.Marine debris in the form of debris will reduce tourist visits so that reducing income (Pasternak et al., 2017). Concerns about increasing marine debris generation require comprehensive mitigation strategy efforts so as to minimize negative impacts on aquatic ecosystems and human health.

Several previous studies (Sheavly & Register, 2007) have found solutions for handling marine debris, including explaining that knowledge is the key for people to use and dispose of waste. Education program and enforcement of policies and laws are good practices for preventing marine debris. Preventive, reduction and control measures for marine debris can be carried out by educating the public and industry, compiling data and carrying out continuous marine debris monitoring program, involving relevant stakeholders such as government, business, industry, and related parties, follow-up on the world industry, and implementation of policies and regulations related to marine debris. Research (Pettipas et al., 2016) explains that the recommendations for mitigating marine waste in the form of plastic are strategies for waste management and law enforcement, education, collaboration with various parties, awareness, identification of sources of waste, and increasing monitoring and research of marine waste. (Hartley et al., 2015) explained that marine debris prevention education is very effective for children aged 8 to 13 years. Children who have been given education in the form of posters, artworks, demonstrations, and mini experiments can change their understanding significantly, especially regarding the causes and effects of marine debris, so that children have better perceptions and attitudes toward preventing marine debris.

According to Agamuthu et al. (2019), there are various initiatives to deal with cleaning up marine debris through physical activities such as organizing projects for handling marine debris and cleaning beaches. Efforts to promote marine waste mitigation can be carried out by efficiently managing waste and good practice of 3R actions. The problem of marine debris cannot be solved directly, but requires continuous efforts and synergy between the local, regional and global levels. Blickley et al. (2016) explains that even local policies can be effective for marine debris mitigation strategies. For example, by minimizing the use of plastic, regulations on tobacco-free coastal areas, community-based marine waste reduction and monitoring program, and minimizing loss of fishing gear in water areas. The purpose of this study is to analyze the characteristics of marine debris on three different types of beaches and to analyze marine debris mitigation strategies in supporting the development of sustainable tourism in the Mandalika SEZ. This research has a novelty compared to previous studies that analyze waste generation mitigation strategies based on the characteristics of marine debris on different types of beaches using the quantitative SWOT analysis method.

2. Methods

2.1. Location and Time

The research was conducted from August to September 2022 at Sandy Beaches (Tanjung Aan Beach), Rocky Beaches (Batu Berang Beach), and Fishing Areas (Aan Beach Fishing Areas) (Figure 1).

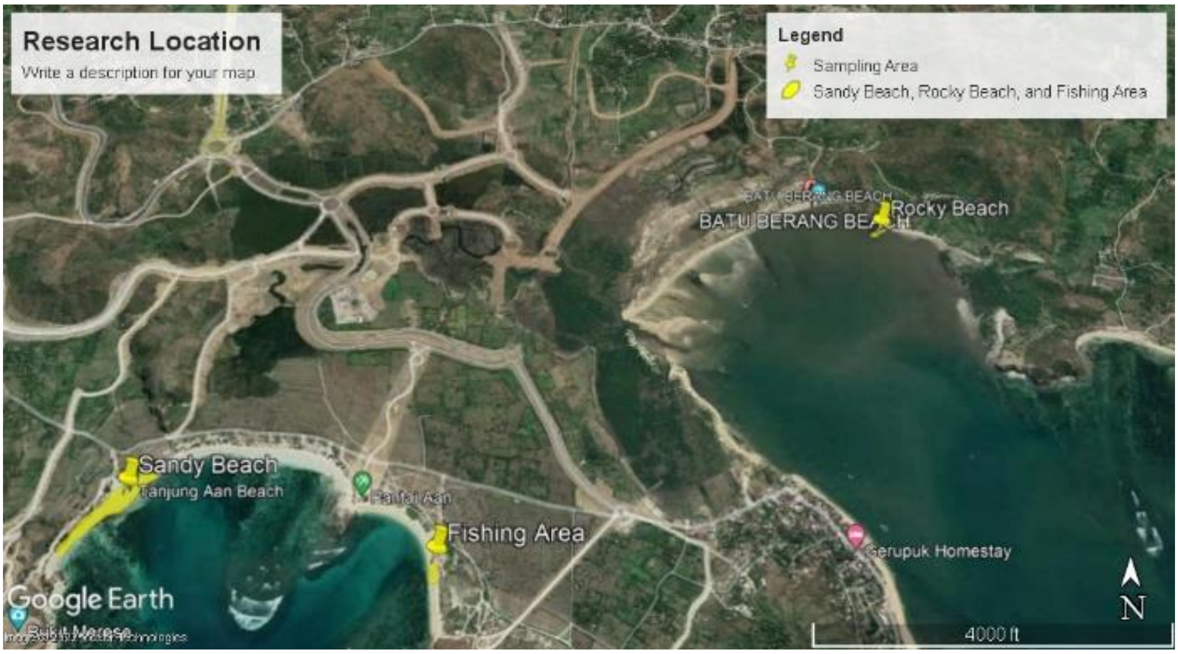

Figure 1. Research location

2.2. Tools and Materials

The tools and materials used in this study:

1. Analytical balance with accuracy of 0.001 gr
2. Olympus camera with Global Positioning System (GPS)
3. Roll meters
4. Garbage sieve (hole diameter 0.5 cm and 2.5 cm)
5. A4 envelope
6. A5 envelope
7. Gloves
8. Masks
9. Barrier stick
10. Stationery (pencils, clip boards, permanent markers, ruler markers, and label paper)
11. Sampling plot strings 5 x 5 and 1 x 1 in meters
12. Data summary form
13. Laptops

2.3. Data Type

The type of data will be collected in this study are the characteristics of marine debris in the form of waste weight (g), amount of waste (item), the percentage per type of waste (%), weight/m2, and density of macro and meso waste (gr/m^2). In formulating a marine debris mitigation strategy, internal factors identified were strengths and weaknesses, and external factors identified were opportunities and threats.

2.4. Data Collection Methode

This research was conducted by field survey using the transect method. The transect method in this research refers to Marine Debris Monitoring Guidelines for the Ministry of Environment and Forestry at 2020. Determining the location for collecting marine debris data by choosing a transect area of at least 100 m long parallel to the coastline with a width following the back boundary of the beach with a width of 5 meters following the tides. The 100 meter long transect area will be divided into 5 lanes with each lane being 20 m apart. Ropes can be used to mark boundaries. Determine sub-transect boxes with a size of 5 x 5 m in each 20 m lane. To simplify and speed up the sampling process, a simple special tool can be made from ropes tied using cable ties at strong angles. The tool measures 5 x 5 meters with a small box measuring 1 x 1 meter which contains 25 pieces. The placement of the sub-transect box can be done randomly which is considered to represent the condition of the beach litter at the selected location. Sub-transect boxes measuring 1 x 1 m are made in each sub-transect box measuring 5 x 5 m so that there are 25 boxes in each 20 m lane. The numbering 1 to 25 in each 1 x 1 m box can be selected by simple random sampling (Figure 2).

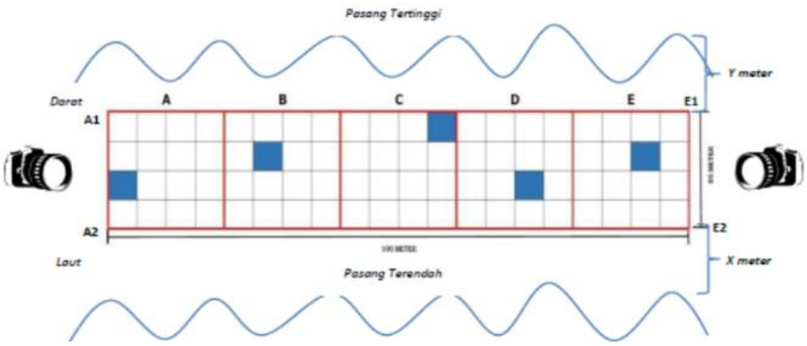

Figure 2. Sampling methods of transect line

Marine debris mitigation strategies are identified using direct interview with tourists by providing a structured list of questions. From the data obtained, all variables will be grouped on the aspects of strengths, weaknesses, opportunities and threats to formulate a marine debris mitigation strategy.

2.5. Data Analysis Method

The waste weight per square meter is the total waste weight per transect box area. Data on the weight of waste per meter square (g/m^2)

$$M = \frac{total\ waste\ weight\ (g)}{long\ (m) x\ wide\ (m)}$$

The percentage of waste composition (%) calculated was the weight of waste per type per total waste in the transect box.

$$Percentage\ (\%) = \frac{x}{\sum Xi}\ x\ 100\%$$

x = waste weight per type.

Waste density (K) is calculated from the amount of waste per transect box area. Waste density data with units of waste amount per type ($(gr)/m^2$).

$$Density = \frac{Amount\ of\ waste\ per\ type}{long\ (m)\ x\ wide\ (m)}$$

Quantitative SWOT analysis is conducted by identifying internal factors (IFE) to determine strengths and weaknesses, then an assessment of external factors (EFE) is conducted to determine threats and opportunities. Internal and external factors are known based on the characteristics of marine debris data and the results of structured interviews with respondents according to their level of importance. After obtaining the importance value of each internal and external factor, it is weighted by paired comparison. The scale used in weighting with paired comparison are:

1. Weight 1 if the horizontal factor indicator is less important than the vertical factor.
2. Weight 2 if the horizontal factor indicator is as important as the vertical factor.
3. Weight 3 if the horizontal factor indicator is more important than the vertical factor.
4. Weight 4 if the horizontal factor indicator is more important than the vertical factor.

The determination of the rating on each variable is multiplied by the rating based on the level of importance to get the weighted score of all strategic factors. If the total IFE and EFE weighting score is below 2.5 it can be stated that the internal factor is weak, but if it is above 2.5 it can be stated that the internal factor is strong. The total score of the IFE and EFE matrices is then mapped in the Internal – External matrix. Mapping the Internal – External Matrix aims to determine the condition of marine debris on different types of beaches in SEZ Mandalika (Figure 3). This position is used as a reference for determining and developing marine debris mitigation strategies.

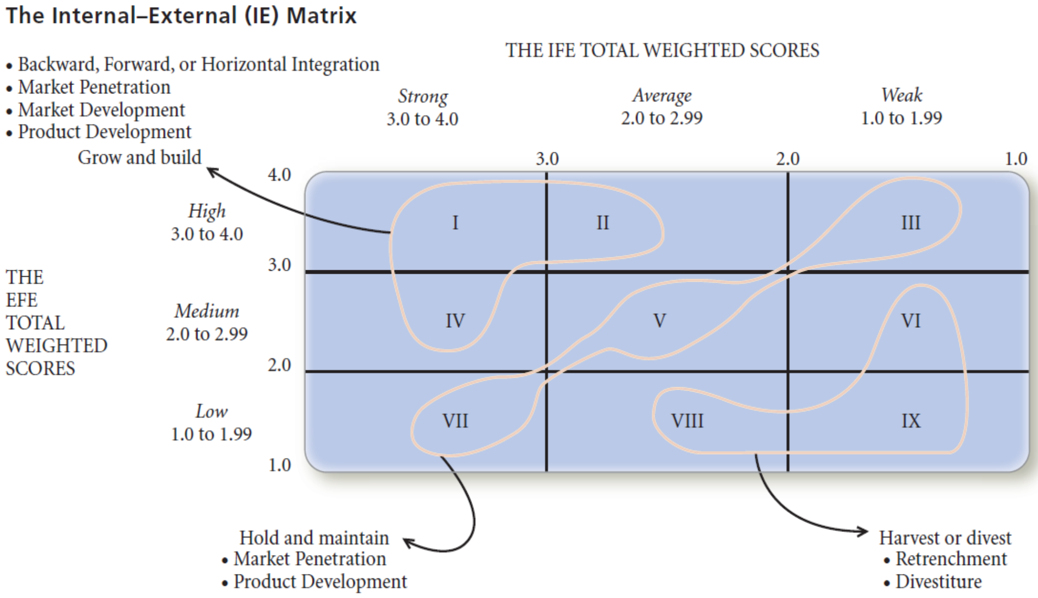

Figure 3. Mapping internal and external matrix

The preparation of the SWOT matrix obtained four strategic steps as follows:

1. SO (Strenght-Opportunities) strategy using internal strengths and taking advantage of external opportunities.
2. ST (Strenght-Threats) strategy using internal strengths and taking advantage of external opportunities.
3. WO (Weakness-Opportunity) strategy using internal strengths and taking advantage of external opportunities.
4. WT (Weakness - Threats) strategy using internal weaknesses and avoiding external threats.

3. Result and Discussion

3.1 Marine Debris Characteristics Based on Beach Type in SEZ Mandalika

Tanjung Aan Beach is a beach with a substrate type of white sand beach with 100% uniformity of the substrate type. Tanjung Aan Beach is used as a place for mass tourism activities, however, in sampling marine debris on sandy beaches, a location far from visitor's activity was chosen. Based on the results of the study, the macro waste at the Sandy Tanjung Aan Beach has an average waste weight of 7.3 gr with an average amount of waste of 1.4 items. Based on the percentage of the amount, the type of plastic material dominates 41%. Based on weight percentage, the amount of rubber has the highest weight of 68% (Figure 4). The types of plastic waste found were bottle caps, straws, spoons, forks, plastic food, clear plastic, toys, drinking glasses, sacks, rope, plastic washing soap, and other plastics. The average weight of macro waste per m^2 was 0.29 gr/m^2 which was dominated by rubber waste of 0.80 gr/m^2. The average density of macro waste is 0.06 $items/m^2$ which is dominated by plastic materials 0.09 $items/m^2$.

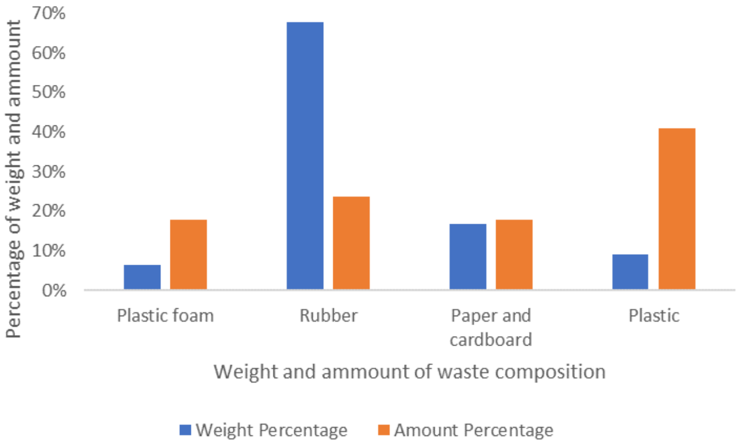

Figure 4. Macro debris in Tanjung Aan beach

Meso waste at Sandy Tanjung Aan Beach has an average waste weight of 0.07 gr with an average amount of waste of 2 items. Based on weight percentage, the type of rubber waste has the highest weight 48%. Based on the percentage of the amount, the type of plastic foam material dominates 30% in the form of white cork (Figure 5). The average weight of meso waste per m² was 0.07 gr/m² which was dominated by 0.18 gr/m² of wood waste. The average density of meso waste is 0.08 items/m² which is dominated by the type of plastic foam material of 0.12 items/m². The dominating amount of plastic marine debris and plastic foam is thought to originate from anthropogenic pressure, namely tourist activities such as swimming, enjoying beach views, and culinary tours. This is in line with research (Agamuthu, 2015) on the East Coast of Peninsular Malaysia, Batu Burok Beach, and Seberang Takir Beach which have sandy substrates that have a high amount of plastic waste compared to other types of beaches. Plastic waste on sandy beaches is above average compared to other types of beaches in the first month of observation. This is because this beach is exposed to stronger currents and tidal influences from the South China Sea. The South China Sea is the busiest shipping lane, so more plastic waste is washed up on sandy substrate beaches. Plastic waste in coastal areas usually enters the sea caused by wind and tides offshore. Plastic waste can also enter through rivers. Garbage particles can move around the oceans via ocean currents, waves and wind (Chassignet et al., 2021). Based on research results, around 5% of unmanaged waste is disposed of directly near the shoreline, 4% is disposed of near the shoreline in medium-sized river basins, and the majority 91% is disposed of in large river basins far from the coastline. Thus, large rivers are the main source of plastic waste from inland areas to the ocean which cannot be ignored (Schmidt et al., 2017).

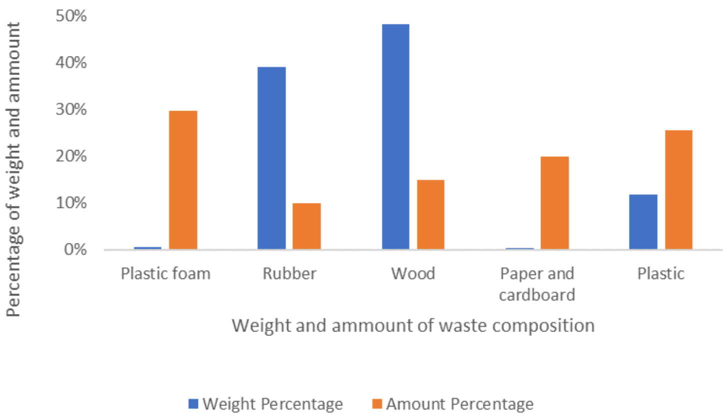

Figure 5. Meso debris in Tanjung Aan beach

Sampling of marine debris was carried out in the Tanjung Aan fishing area. In this fishing area there is a gathering place for fishermen and boats that land. Macro waste in the fishing area has an average waste weight of 9.55 gr with an average amount of 1.94 items. Based on the percentage of the number of types of fabric, it dominates as much as 52% (Figure 6). The most common types of fabric waste are yarn and other fabrics. The threads found were more likely to originate from fishing threads used by fishermen when fishing activity. Based on the results of the study (Unger & Harrison, 2016), (the General Linear Model (GLM) analysis found that there was no significant relationship between marine plastic waste and the proximity of fishing ports. In the analysis of fishing materials, several types of plastic such as fishing boxes, buoys, ropes, nets, and plastic parts are indicated to be correlated between fishing grounds and marine debris. Therefore, the fishing industry accounts for the highest proportion of litter on UK beaches in adjacent fishing grounds. Marine debris can be identified as significantly related to fishing activities. Based on the weight percentage, glass and ceramic types had the highest weight of 84% with the largest weight found in beverage bottles weighing 269.5 gr. The average weight of macro waste per m^2 was 0.38 gr/m^2 which was dominated by glass and ceramic waste of 1.92 gr/m^2. The average density of micro waste is 0.08 $items/m^2$, which is dominated by fabrics, 0.24 $items/m^2$.

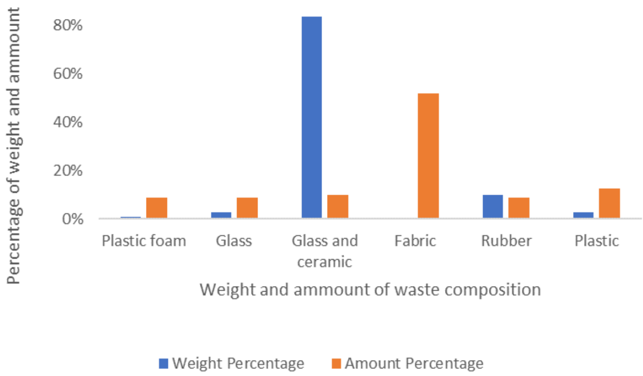

Figure 6. Macro debris in fishing area

Meso waste in the fishing area has an average weight of 0.15 gr with an average number of 2.2 items. Based on the weight percentage, glass and glass waste types have the highest weight 80%. Based on the percentage of the amount, the type of plastic foam material is more dominant, 45% is found in the form of white cork flakes. The average weight of meso waste per m2 was 0.006 gr/m^2 which was dominated by glass and glass waste of 0.0196 gr/m^2. The average density of meso waste is 0.08 $items/m^2$ which is dominated by plastic foam types of 0.16 $items/m^2$. The amount of plastic foam waste is dominant 45% due to anthropogenic activities that produce waste such as food packaging and fish storage cool box.

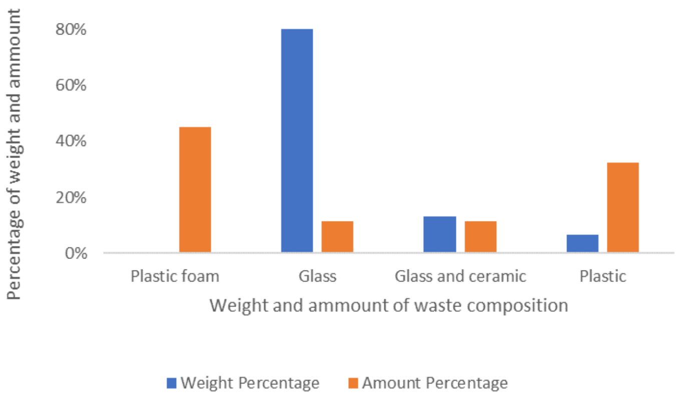

Figure 7. Meso debris in fishing area

Macro waste at Batu Berang Beach has an average weight of 9.71 gr with an average amount of waste of 1.55 items. Based on the weight percentage, the type of rubber with the highest weight was 42%, because it was found that the type of rubber hose was 46.52 gr. Based on the percentage of the amount, the type of plastic dominated 42% (Figure 8). The average weight of macro waste per m^2 was 0.38 gr/m^2 which was dominated by rubber waste of 0.65 gr/m^2. The average density of micro waste is 0.05 items/m^2, which is dominated by plastic 0.06 items/m^2. The amount of plastic waste is dominant 42% due to anthropogenic activities that produce waste such as bottle caps, straws, drinking cups, plastic flakes, bread wrappers, food plastic, candy plastic, chocolate wrappers, toy wrappers, sacks, rope, rope rapia, fiberglass, pampers wrappers, soap wrappers, gallon labels, noodle wrappers, tissue wrappers , plastic bags, fishing nets, and canvas ropes. The rubber waste with the highest weight comes from anthropogenic activities which are found in tires, rubber straps, other rubber, and rubber hoses.

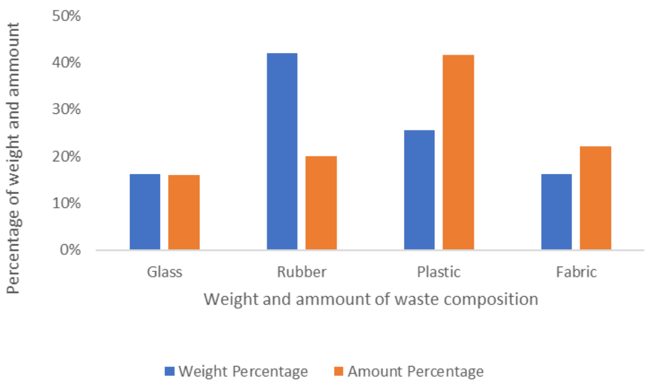

Figure 8. Macro debris in Batu Berang beach

Meso waste at Batu Berang Beach has an average waste weight of 2.85 gr with an average number of 1.8 items. Based on weight percentage, the type of wood waste has the highest weight of 92%. Based on the percentage of the amount, the amount of plastic material is more dominating as much as 60% (Figure 9). The most commonly found plastics are rope, bottle caps, straws, plastic soap, plastic snacks, plastic flakes, sack flakes, fishing lines, fiberglass flakes, plastic packaging, and nets. The average weight of meso waste per m^2 was 0.11 gr/m^2 which was dominated by 0.41 gr/m^2 of wood waste. The average density of meso waste is 0.41 items/m^2 which is dominated by types of wood materials 0.41 items/m^2.

The results of this study are in line with research (Walker et al., 2006) on a rocky beach in Halifax Harbor Scotia which states that the percentage of marine waste is 78% of the type of plastic consisting of B3 waste in the form of pads and condoms, plastic food packaging, styrofoam fragments, bottles and lids, plastic, cloth, soft drink cans, cigarette butts, nylon rope, and fishing nets. Marine debris comes from recreational activities 52%, waste disposal 14%, and shipping and fishing activities 7%. According to research (Thiel et al., 2013), there are no proportional differences in the types of anthropogenic marine debris on sandy beaches, rocky beaches, and sea level. The dominant anthropogenic marine debris is in the form of plastic including plastic bags, plastic wraps, ropes, and hard plastic and soft plastic (> 75%). Styrofoam type has the highest amount on rocky beaches and sandy beaches. The high amount of marine debris is caused by transportation and accumulation activities which are a complex problem in Indonesia, due to ocean-atmospheric circulation, high population of coastal communities, and marine activity. Marine debris is everywhere and crosses boundaries, because it is found in the sea and then carried by currents in various directions (Purba et al., 2019).

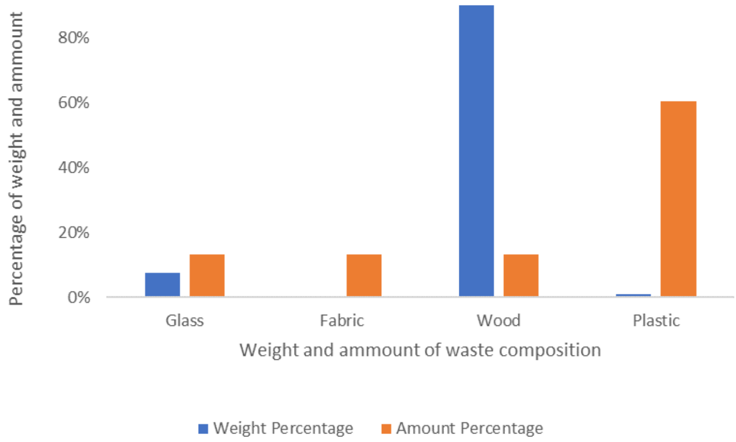

Figure 9. Meso debris in Batu Berang beach

3.2. Mitigation Strategy for Marine Debris in SEZ Mandalika in Supporting Sustainable Tourism

Mitigation strategies for marine debris in supporting sustainable tourism in SEZ Mandalika are analyzed using quantitative SWOT. The quantitative SWOT analysis identifies internal factors including strengths and weaknesses and external factors including opportunities and threats. Aspects of strength in this study as follows:

1. The economic potential of plastic waste 41% based on the percentage of the amount in Aan Beach with a sandy beach typology (S1).
2. The economic potential of rubber waste 68% based on the weight percentage at Aan Beach with a sandy beach typology (S2).
3. The economic potential of cloth waste 52% based on the percentage of the amount in Aan Beach with a typology of fishing spots (S3).
4. The economic potential of glass and ceramic waste 84% based on weight percentage with fishing typology (S4).
5. The economic potential of plastic waste 42% based on the percentage of the amount in Batu Berang Beach with a rocky beach typology (S5).
6. The economic potential of rubber waste 42% by weight in Batu Berang Beach with a rocky beach typology (S6).

Aspects of weakness in this study as follows:

1. Types of marine waste in the form of plastic, rubber, glass and ceramics require a long time to be degraded (W1).
2. The size of the waste tends to vary from meso size (0.5 - 2.5 cm) and macro size (> 5cm) is quite diverse to suit the market (W2).

Aspects of opportunity in this study as follows:

1. 73% of tourist visitors have knowledge about marine debris, types of marine debris, and the largest source of marine debris (O1).
2. The local community already has a mutual cooperation pattern in carrying out clean operations in their respective areas (O2).
3. The village government has prepared facilities and infrastructure to accommodate and transport waste (O3).
4. 57% of tourist visitors have awareness of waste originating from community activities (O4).

Aspects of threats in this study as follows:

1. There are no regulations goverment marine waste management in tourist areas (T1).
2. Tourism activities and fishing activities can produce waste (T2).

After identifying external and internal factors, the next stage is evaluating internal and external strategic factors based on their level of importance as follows (Table 1):

Table 1. The level of important external and internal factors

Symbol (S)	The Level of Impotance
S1	The strength very big
S2	The strength big
S3	The strength big
S4	The strength big
S5	The strength very big
S6	The strength big
W1	The weakness very big
W2	The weakness very big
O1	The opportunity big
O2	The opportunity big
O3	The opportunity big
O4	The opportunity medium
T1	The threats big
T2	The thretas medium

After obtaining the level of importance of each internal and external strategic factor, and then do the weighting as follows (Table 2 and 3):

Table 2. The weighting internal factors

Symbol	S1	S2	S3	S4	S5	S6	W1	W2	Total	Weight
S1		1	1	1	2	1	1	1	8	0.07
S2	3		2	2	3	2	1	1	14	0.12
S3	3	2		2	3	2	1	1	14	0.12
S4	3	2	2		3	2	1	1	14	0.12
S5	2	1	1	1		3	1	1	10	0.08
S6	3	2	2	2	3		1	1	14	0.12
W1	4	3	3	3	4	3		3	23	0.19
W2	4	3	3	3	4	3	1		21	0.18
								Total	118	1.00

Table 3. The weighting external factors

Symbol	O1	O2	O3	O4	T1	T2	Total	Weight
O1		1	2	2	1	1	7	0.11
O2	3		3	3	2	3	14	0.22
O3	2	1		2	1	2	8	0.13
O4	2	1	2		1	1	7	0.11
T1	3	3	2	3		2	13	0.21
T2	3	3	3	3	2		14	0.22
						Total	63	1.00

Based on the weight assessment, internal and external strategic factors can be sorted based on the priority of marine debris mitigation strategies. Strategy ratings can be analyzed with the IFE and EFE matrices (Table 4 and 5). The internal factor matrix is prepared by describing the strengths and weaknesses of the variables by giving weights and ratings to produce a score. The scores obtained from the strengths and weaknesses variables are added up to get the external and internal factor quadrants.

Table 4. Internal factors strategies

Internal Factors Strategic			
Strenght	**Weight**	**Rating**	**Score**
The economic potential of plastic waste 41% based on the percentage of the amount in Aan Beach with a sandy beach typology (S1)	0.07	4	0.27
The economic potential of rubber waste 68% based on the weight percentage at Aan Beach with a sandy beach typology (S2).	0.12	3	0.36
The economic potential of cloth waste 52% based on the percentage of the amount in Aan Beach with a typology of fishing spots (S3)	0.12	3	0.36
The economic potential of glass and ceramic waste 84% based on weight percentage with fishing typology (S4).	0.12	3	0.36
The economic potential of plastic waste 42% based on the percentage of the amount in Batu Berang Beach with a rocky beach typology (S5).	0.08	4	0.34
The economic potential of rubber waste 42% by weight in Batu Berang Beach with a rocky beach typology (S6).	0.12	3	0.36
Weakness			
Types of marine waste in the form of plastic, rubber, glass and ceramics require a long time to be degraded (W1).	0.19	2	0.39
The size of the waste tends to vary from meso size (0.5 - 2.5 cm) and macro size (> 5cm) is quite diverse to suit the market (W2).	0.18	2	0.36
Total	1.00	24.00	2.78

Table 5. External factors strategies

Eksternal Factors Strategic			
Opportunity	**Weight**	**Rating**	**Skor**
73% of tourist visitors have knowledge about marine debris, types of marine debris, and the largest source of marine debris (O1).	0.11	4	0.44
The local community already has a mutual cooperation pattern in carrying out clean operations in their respective areas (O2).	0.22	3	0.67
The village government has prepared facilities and infrastructure to accommodate and transport waste (O3).	0.13	4	0.51
57% of tourist visitors have awareness of waste originating from community activities (O4).	0.11	4	0.44
Threats			
There are no regulations goverment marine waste management in tourist areas (T1).	0.21	4	0.83
Tourism activities and fishing activities can produce waste (T2).	0.22	2	0.44
Total	1.00	21.00	3.33

Based on the IFE and EFE calculations in table 4 and 5, external conditions have a score of 3.3 and internal conditions have a score of 2.78. Based on the total IFE and EFE scores, the condition of marine debris in the Mandalika SEZ is in quadrant II were grow and built (Figure 10).

Figure 10. The quadrant internal and external factors

		Total IFE		
		4.0 Strong 3.0	3.0 Medium 2.0	2.0 Weak 1.0
Total EFE	4.0 Strong 3.0	I	II (Grow and Built)	III
	3.0 Medium 2.0	IV	V	VI
	2.0 Weak 1.0	VII	VII	IX

Alternative strategies are obtained by maximizing strengths and opportunities, maximizing strengths in reducing threats, maximizing opportunities and reducing weaknesses, and minimizing threats and weaknesses. In determining the ranking of alternative strategies, it is based on a quantitative analysis of internal and external factor weighting scores. The ranking order is the sequence of priority strategies in marine debris mitigation that are recommended. The alternative strategy that has the highest score (2.99) is the sorting of organic and non-organic waste in various coastal typologies by visitors with the preparation of facilities and infrastructure by the tourism management or village government. Segregating organic and inorganic waste by visitors is a priority strategy because based on interview results, 73% of visitors already have knowledge about types of marine debris. Waste segregation by visitors can be implemented with education about waste sorting at the entrance to tourist areas by tour managers, installing interpretation boards on waste sorting, and providing waste sorting facilities based on type of waste. The alternative strategy that has the lowest score (1.02) is the sorting of marine debris based on the size required by the market by the local community. Sorting marine debris by local people according to market demand is an alternative strategy with the last priority, because meso-sized marine debris has a very small size to sort and is difficult to adjust to market demand. So that the most effective effort is the prevention of marine debris caused by anthropogenic activities. In detail the priority strategy alternatives are described in the following table 6:

Table 6. The priority strategy alternatives

Code	Alternative Strategy	Influencing Factors	Total Score	Priority Strategy
AS1	Sorting of organic and non-organic waste in various coastal typologies by visitors with the preparation of facilities and infrastructure by the tourism manager or village government	S1 S2 S3 S4 S5 S6 O1 O3	2.99	1
AS2	Sales of inorganic waste in the form of plastic, rubber, cloth, glass and ceramics in various coastal typologies empower local communities and improve the welfare of local communities	S1 S2 S3 S4 S5 S6 O1	2.48	2
AS7	Compilation of regulations government about the management of marine waste in tourist areas so that waste becomes an economic potential	S1 S2 S5 S6 T1	2.15	3
AS5	Education to tourist visitors by local communities regarding the process of waste degradation in nature or that is dumped into the sea	W1 O1 O3 O4	1.79	4
AS4	Empowerment of local people who work as fishermen in reducing cloth waste in the form of fishing thread at fishing grounds	S3 S4 O2	1.38	5

Code	Alternative Strategy	Influencing Factors	Total Score	Priority Strategy
AS3	Empowerment of local communities in forming movement forums in reducing and sorting inorganic waste on sandy beaches	S1 S2 O2	1.29	6
AS8	Make waste management regulations in tourist areas comprehensively, especially in reducing and handling inorganic waste which degrades over a long time	W1 T1	1.22	7
AS6	Sorting marine debris based on the size required by the market by local communities	W2 O2	1.02	8

4. Conclusions

Characteristics of macro marine debris at Tanjung Aan Beach with sandy substrate based on the amount dominated 41% plastic type waste. Meso marine debris is dominated by plastic foam in the form of white cork 48%. In the fishing area, the characteristics of the waste type of cloth material dominated 52% in the form of fishing thread and other fabrics. Meso trash in the fishing area dominated 45% in the form of white cork flakes. Characteristics of macro waste at Batu Berang Beach with rocky substrates, it was found that fabric waste dominated 42%. Meso waste in Batu Beach is dominated by 60% plastic materials. The alternative strategy that has the highest score (2.99) is the sorting of organic and non-organic waste in various coastal typologies by visitors with the preparation of facilities and infrastructure by the tourism manager or village government.

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