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Environmental Impact Assessment of Tourism Development in Marine Protected Areas: A Case Study of Tioman Island Marine Park

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ABSTRACT. The purpose of this study is to assess the impact on tourism activities in Tioman Island Marine Park by using Life Cycle Assessment theory. This assessment is capable of providing new insights into environmental impact and offering benefits to the policy makers in planning and monitoring tourism activities in protected areas. The results of each assessment case indicated that transportation to/from the island, accommodation, snorkeling activities, and waterfall trekking activities leave negative impacts on human health, ecosystem quality and resources. Transportation cases showed the highest impact on the park environment (339.46 Pt). In addition, the impact of accommodation cases was at 111.81 Pt, at about 20.08% of the total impact. The advantages of Life Cycle Assessment method include it offers a rational and comprehensive approach to evaluate the environmental impacts in every stage of a product's system. However, some limitations were also found in the approach. Problems can arise from the decision making in identifying input-output to determining products' life cycle process or system boundary. Future studies are recommended to identify damage assessments on other tourist sub-systems such as caterer, souvenirs and second tier supplier.

Keywords: Tourism, Protected areas, Environmental impact, Ecosystem quality.

INTRODUCTION

According to the International Union for Conservation of Nature (IUCN), if a marine area meets the definition of a Protected Area as given in the 2008 Guidelines, then it can be a Marine Protected Area (MPA) (Day et al., 2019). The definition of MPA is "a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values." (Day et al., 2019). Marine Parks have been established since the 1980s by the Department of Fisheries Malaysia (DoFM). With approximately 3,600 km of coral reef areas, the primary objective of Marine parks is to protect coral reef ecosystems from fishing and other harmful activities to ensure a sustainable development of marine biodiversity (Islam et al., 2017; Islam, Noh, Yew, & Mohd Noh, 2013). Marine Park is a cate of Marine Protected Areas (IUCN, 2013). Marine Parks usually allow for tourism recreational activities such as boating, diving, and snorkelling. One similarity between Marine Parks and National Parks in Malaysia is both are used by the community and they often have facilities such as chalets, resorts, restaurants, souvenir shops and tea stalls to encourage their use (Islam et al. 2017, 2013).

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Tourism inside Marine Parks can be considered as a strategy for reducing conflicts between conservation policy and community development in the protected areas. With the establishment of tourism activities that focus more on flora and fauna within the communities' surrounding living areas, such restrictions can be compensated by the founding of Marine Parks. Local communities can earn income through the tourism activities, and they can inculcate a sense of pride in their environment, which motivates them to help in conserving it. The willingness of communities to participate in tourism industry can also enrich the quality of tourism experience because the local can bring their traditional knowledge and culture into the mix (Curran et al,, 2004; Laurance et al., 2012; Zhang et al., 2022)

However, the establishment of Marine Parks in Malaysia is legally forced on the community as opposed through a referendum as in other surrounding countries such as Indonesia, Philippines, Vietnam, Cambodia, and Sri Lanka. This result in the lack of cooperation and coordination among the policy makers, business providers and communities. A conflict might transpire between policy makers and tourism stakeholders due to the difference in interest and value in terms of how they view the MPAs (Curran, 2004; Laurance et al., 2012, Zhang et al., 2022)

In Malaysia, the growth and engagement of tourism sector inside Marine Parks has led to a conflict of interest between tourism development and the conservation objective (Konig et al., 2007; Reef Check Malaysia, 2017) With the increasing number of tourist each year, Marine Parks is facing issues of over limit carrying capacity and large tourism ecological footprint (Rice, Baird, & Eaton, 2012; Patterson, McDonald, & Hardy, 2017; Reef Check Malaysia, 2017). The excess of water use, sewage and waste products has resulted in failed waste management by Marine Parks' administrative bodies in Malaysia which are usually located in small islands with limited land and clean water. Rapid tourism development can put pressure on the Marine Parks as their ecosystem is vulnerable and easily disturbed (Rice, Baird, & Eaton, 2012; Konig et al., 2007; Patterson et al., 2017; Reef Check Malaysia, 2017).

Marine Parks are vulnerable entities because of their remote location, limited resources, high dependency on imported goods, high incurring transportation costs, and susceptibility to natural disasters (Brookfield, 1990; Barrientos, 2010; Adrianto & Matsuda, 2004; MEA, 2005; Vogiatzakis et al., 2008; Haensch et al., 2022). Global processes (such as climate change and the associated sea level rise), regional processes (pollutions due to developments in tourism activity), and local processes (environmental and resource degradation as impacts of population growth) also contribute to tamper with the sustainability of Marine Parks (Pelling & Uitto, 2001; Barrientos, 2010; Adrianto & Matsuda, 2004; Farhan & Lim, 2011, 2012; Haensch et al., 2022).

Some of the detrimental effects of tourism toward Marine Parks' sustainability are related to marine pollution resulting from tourist wastage, excursion boats and ferries (*i.e.* fuel, chemicals, and litter) and disturbance/destruction of aquatic life (Davenport & Davenport, 2006; Sanchez-Quiles & Tovar-Sanchez, 2015). In recent decades, several composite indexes have emerged to quantify the impacts of tourism on the environment. However, most of the research in this area are based on qualitative judgement because environmental impacts triggered by tourism activities are not easy to quantify. It is important to carry out quantitative research in this area as information on environmental loads is important for stakeholders inside the Marine Parks. With quantifiable data, the problem can be identified more directly, and strategies can be executed effectively.

Hence, the Life Cycle Assessment (LCA) approach was applied in this research to establish an inventory of the environmental loads of island tourism inside a Marine Park, to figure out the environmental loads, and to quantify these loads in terms of per tourist per trip basis. Since tourism is a composite product, when tourists begin a trip, the life cycle of the "tourism product" starts, and when tourists end their trip, the life cycle of the "tourism product" ends. Accordingly, every sector of the whole trip, including transportation, accommodation, and recreation activity is considered, and the environmental loads of the whole trip can be inventoried under such an approach. Using LCA in the case of tourism, a more thorough and thorough investigation of the environmental effects of particular activities is conducted in order to enhance the environmental performance of particular phases or processes (Castellani et al., 2012). As a result, LCA is a very useful method for evaluating both direct and indirect carbon emissions from the tourism industry as well as the socioeconomic and environmental impacts brought about by this industry (Herrero et al., 2022).

METHODOLOGY

Case Study Site: Tioman Island Marine Park

Tioman Island Marine Park was gazetted as a Marine Park in 1994 under the Fisheries Act 1985 biodiversity (Islam et al. 2017, 2013) . The island has received international recognitions for its beautiful beaches and world-renowned coral reef habitats which thrive in the area (Hanafiah, Jamaluddin, & Zulkifly, 2013; Latif & Omar, 2012). Figure 1 shows the arrival of tourists on the island from the year 2012-2016.

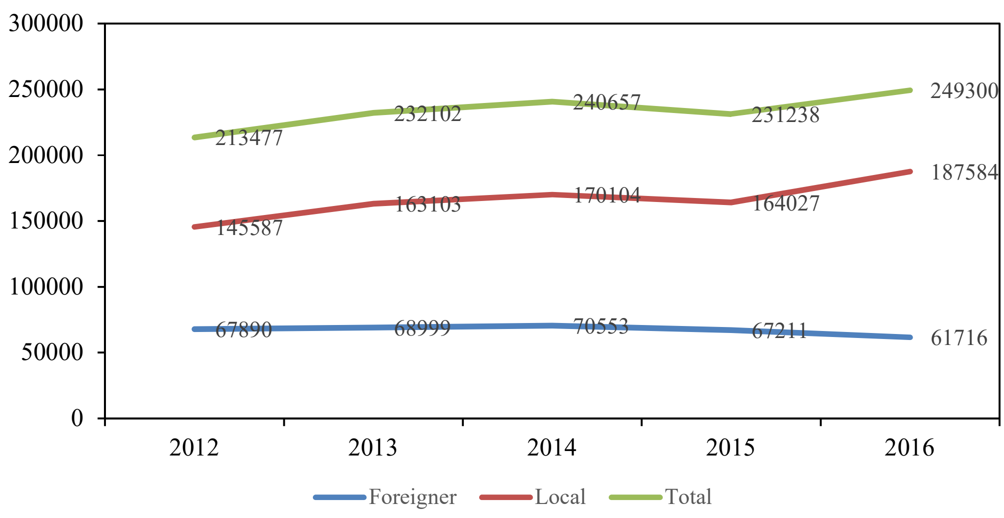

Figure 1. Tioman Marine Park Tourists Arrival from year 2012-2016 (Source: Tioman Development Authority)

Coral reefs around Tioman Island provide economic value to important industries such as fisheries and tourism as well as in terms of coastal protection (Reef Check Malaysia, 2010, 2013). The estimated economic value of the reefs is RM3.4 billion every year (Baird, & Eaton, 2012; Reef Check Malaysia, 2017). Over the last 8 years, the reefs in Tioman Island have been consistently rated to be in fair or good condition (Figure 2).

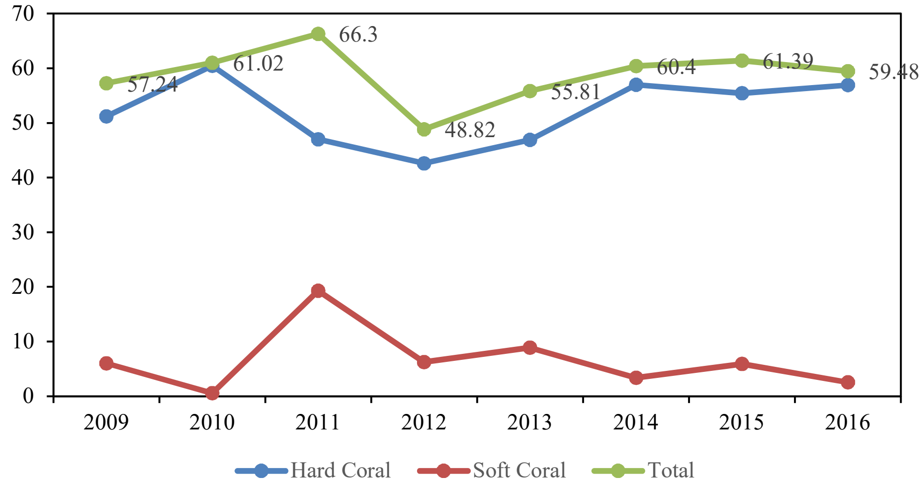

Figure 2. Percentage of Hard Coral and Soft Coral in Tioman Island Marine Park

Table 1. Coral Reef Health Criteria (Source: Chou et al., 1994)

Percentage of live coral cover	Rating
0 – 25	Poor
26-50	Fair
51 - 75	Good
76 - 100	Excellent

However, tourism activities bring about significant negative impacts on the island as the areas which are in "fair" condition are those where major tourism activities occur while areas with "good" condition are isolated (Reef Check Malaysia, 2013; Shahbudin, Fikri Akmal, Faris, Normawaty, & Mukai, 2017). The reef sites in Tioman Island Marine Park are divided into three areas: east coast area, west coast area and isolated area. These areas are divided based on the differences in environmental settings, coastal developments, and human activities that might establish a gradient of human impacts, allowing comparisons in diversity and distribution of corals to be made. The west coast area refers to the area where a high number of tourism activities takes place, whereas the east coast area has a low level of tourism activities but is still subjected to human impact due to the activities of the communities living there. On the other hand, the isolated coast area refers to the area located far from Tioman Island; it has no coastal development and receives less impact from tourism activities.

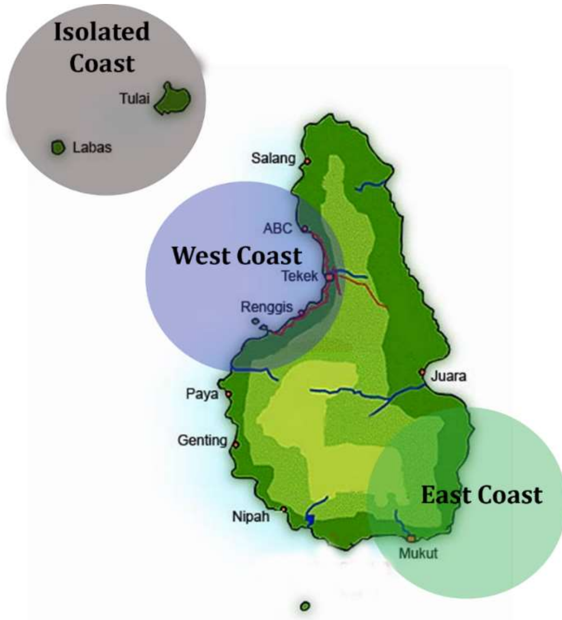

Figure 3. A map showing the location of Tioman Island Marine Park and its three types of reef categories (Source: Reef Check Malaysia, 2013; Shahbudin et al., 2017)

Research conducted by Reef Check Malaysia (2013) and Shahbudin et al. (2017) found that the average live coral coverage at Tioman Island was at 51.4%. The east coast area recorded a higher live coral coverage compared to the isolated and west coast areas with 57.7%, 51.2%, and 47.8%, respectively.

Table 2. Percentage of coverage of live corals, dead corals and coral condition at Tioman Island in 2016 (Source: Reef Check Malaysia, 2013; Shahbudin et al., 2017)

Reef Site	Live Corals (%)	Dead Corals (%)	Coral Condition
East Coast Area	57.7	20.9	Good
West Coast Area	47.8	28.9	Fair
Isolated Area	51.2	23.2	Good
Total Average	51.4	24.8	Good

The result suggests that an area with high tourism activities might represent a great threat to the coastal areas and the marine ecosystem. This is supported by studies done by Ahmad Kamil, Hailu, Rogers, and Pandit (2017), Burke et al. (2012), and Hyde, Yee, and Chelliah (2013) which highlighted that scuba divers, snorkelers and reef walkers have become one of the major culprits of coral reef degradation. The study also found that boating activities for tourism might have increased the build-up of bottom sediment, resulting in the increase of light intensity for the algae in coral reef to undergo photosynthesis (Shahbudin et al., 2017).

The biggest threat to marine ecosystem is the development of tourism industries on the land area (Rice, Baird, & Eaton, 2012). The construction of tourist resorts and facilities leads to sedimentation of nearby reefs, poor sewage treatment and solid waste disposal system, which are all the causes of the high level of nutrient indicator algae that can halt the marine life photosynthesis cycle (Rice, Baird, & Eaton, 2012). The marine ecosystem that failed to tolerate this activity will not survive the condition.

The island also faces several other challenges and problems commonly faced by small islands such as high transportation and communication costs, vulnerability to extreme climate events and other natural disasters, limited ability to develop economies of large scale as well as scarce land resource and restriction at certain degrees of physical development (CTA, 2014). This suggests that MPA management units need to focus on a study that pursues a trade-off solution to balance economic development and environmental conservation and adapt it in their management strategies (Hanafiah et al., 2013; Latif & Omar, 2012; Ng, Chia, Ho, & Ramachandran, 2017).

Life Cycle Assessment

International Organization for Standardization (ISO) introduced a standard framework for using Life Cycle Assessment analysis. ISO is a global federation of national standards bodies where international governmental and non-governmental organizations work in tandem to prepare a set of standards which champions various types of subjects and methodologies. Standards which emphasize on environmental protection are recorded in the ISO 14000 series.

ISO 14000 is a standard created to govern the environmental management field. It is introduced to provide a systematic approach for governing environmental management to achieve sustainability. The ISO 14000 was introduced in 1996, from which various other standards in relation to environmental management came to exist. Among them, the ISO 14040 series comprise a standard that provides the framework and guidelines to conduct a Life Cycle Assessment study. According to the ISO 14040 standard, Life Cycle Assessment consists of four distinctive phases, (Figure 4) namely:

i. Goal and Scope definition (explains the study’s purpose, defines a functional unit for analysis and sets up system boundaries),
ii. Lifecycle Inventory (explains data collection and systematization),
iii. Impact Assessment (evaluates the magnitude of an environmental impact), and
iv. Interpretation of results (describe the impact and provides recommendations for environmental improvements).

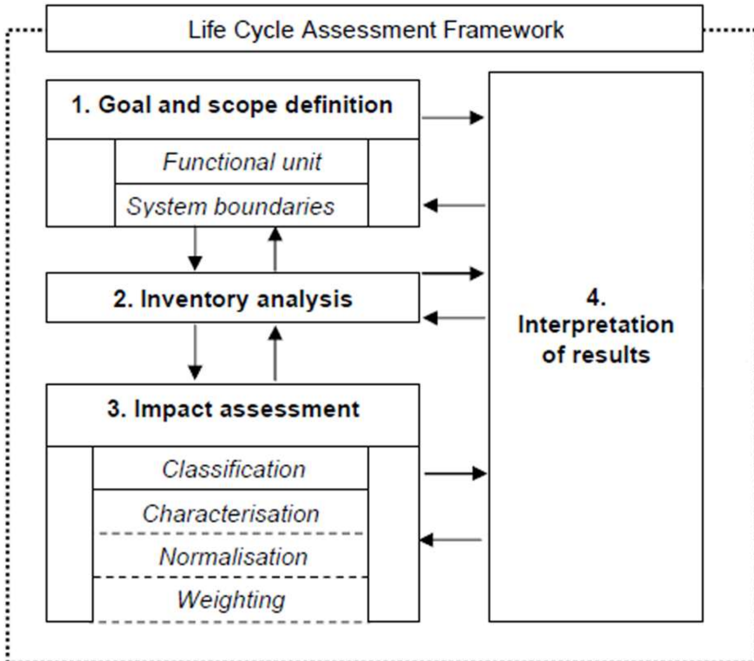

Figure 4. Framework for Life Cycle Assessment Application (Source: Adapted from ISO 14040, 2006)

Goal and Scope Definition

This study seeks to quantify the carbon footprint from all aspects directly associated with tourism in Tioman Island Marine Park, including transportation, meal consumption, accommodation, and waste management, but excludes the impacts of travel from their house to the port of embarkation. The functional unit used for this is "1 tourist per holiday package". An average holiday package in Tioman Island Marine Park consists of a 2-night accommodation with a visit to snorkeling sites using boat and a sightseeing trip to a waterfall using a jeep (Ahmad Kamil et al., 2017; Reef Check Malaysia, 2013; Shahbudin et al., 2017).

The system boundary for the analysis follows the "gate-to-gate" concept suggested by Camillo De Camillis, Raggi, and Petti (2010) and El Hanandeh (2013). The system boundary begins with the arrival of the tourists to the Marine Park jetty to their return at the jetty. This includes the accommodation available at the island, tourism activities carried out and waste management processes involved at the Tioman Island Marine Park. The transport to/from their home origin are not included in the scope of Life Cycle Assessment Analysis as it seems an indispensable element of the tourism experience. This study also only considered the use phase of transportation and machinery (not the manufacturing phase of vehicles and other resources used for making the product). The construction phase of the accommodation was also excluded. The reason this category of data was included in this study is because it might expand the analyses too far off the scope of the study and generate problems of allocation. Moreover, this also might divert the main objective of this study, which is to assess the impact of tourism activities in the park. Figure 5 shows the system boundaries of the tourism activities under assessment in Tioman Island Marine Park.

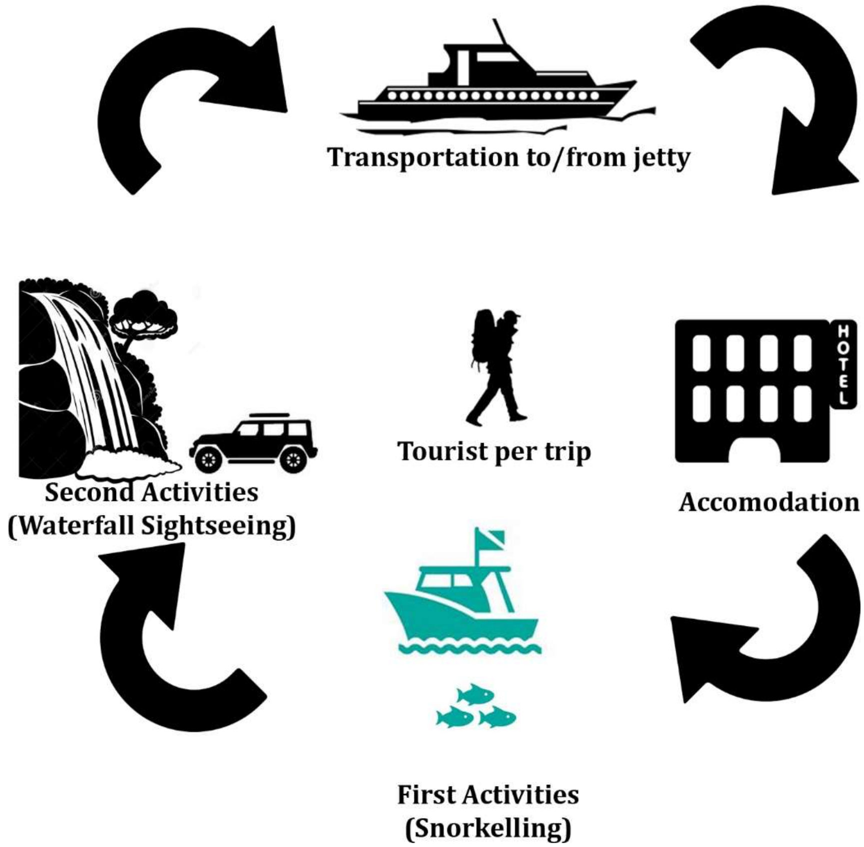

Figure 5. System boundaries of tourism activities under assessment in Tioman Island Marine Park

Life Cycle Inventory

Data for Life Cycle Inventory were collected from various sources; these include statistical databases, material and energy flow spreadsheets, expert estimates and surveys. The data were derived from direct interviews with hotel management staff and tourists survey. The transportation system was modelled as a weighted average of travel distances (using Google Maps) and the distribution of transportation used by tourists (ferry, boat and jeep investigated through site visits and surveys). The process of determining the number of night accommodation was modelled by considering electricity, water consumption, wastage (solid wastage and wastewater) and meal consumption. The activities engaged by tourists were retrieved from literature as "real life" data were not available for tourism in Tioman Island Marine Park. The use of secondary data sources, calculations and smart estimation were needed to enhance the data. The LCA software, SIMAPRO was used to run the LCA impact studies. It is essential that the data must be credible at all times; hence, only scientific journals were referred to and all assumptions were made transparent. Table 3a – 3d below show the parameters used and the emission factors considered in this study.

Table 3a. Data for Ferry Transportation to/from the Island

Parameter	Quantity	References
Number of passengers	120 passenger/per trips	Interview with ferry provider
Distance	52 km/per trips	Google Maps
Resources and pollution produced within the ferry transportation	CO^2 emissions: 71.6 gram/per kilometer	Pizzol (2019)
	CO emissions: 0.375 gram/per kilometer	
	HC emissions: 0.115 gram/per kilometer	
	NO_X emissions: 0.568 gram/per kilometer	

Table 3b. Data for Accommodation in the Island

Parameter	Quantity	References
Average Number occupancy per room	2 person /per rooms	Interview with hotel provider
Resources and pollution produced within the hotel accommodation	Water Demand: 292 Liter/per day	Eco Indicator 99
	Electricity: 16.416 Megajoule/per day	
	Solid waste: 0.94 kilogram/per day	
	Water waste: 20 Liter/per day	
	Meal consumption emissions: 7.4 kilogram CO^2 per person/per day	

Table 3c. Data for 1st Activity (Snorkeling) Transportation (Boat)

Parameter	Quantity	References
Number of passengers	10 passenger/per trips	Interview with boat provider
Distance	20 km/per trips	Google Maps/interview/observation
Resources and pollution produced within the boat transportation	CO^2 emissions: 58 gram/ per kilometers	Hemez et al. (2020)
	CO emissions: 20.4 gram/per kilometers	
	HC emissions: 1.52 gram/per kilometers	
	NO_X emissions: 0.09 gram/per kilometers	

Table 3d. Data for 2nd Activity (Waterfall Sightseeing) Transportation (Jeep)

Parameter	Quantity	References
Number of passengers	6 passenger/per trips	Interview with jeep provider
Distance	10 km/per trips	Google maps/interview/observation
Resources and pollution produced within the jeep transportation	CO^2 emissions: 51 gram/ per kilometers	Hemez et al. (2020)
	CO emissions: 0.375 gram/per kilometers	
	HC emissions: 0.115 gram/per kilometers	
	NO_X emissions: 0.568 gram/per kilometers	

Impact Assessment

This study used ECO-INDICATOR 99 as a method to assess the life cycle of "1 tourist per holiday package". This method comprises three main impact categories, namely: (i) human health, (ii) ecosystem quality, and (iii) resources. The difference between Eco-Indicator 99 methodology and other approaches in Life Cycle Assessment theory is that it can quantify the damage categories into a metric approach with measurements such as DALY, PDF, PAF and Surplus Energy (Hofstetter, 1998; Murray & Lopez, 1994).

After determining the damage categories, the metric is normalized and weighted to make interpretation of the scores much easier. The weighted impact is measured using Pt unit. The Pt unit is a dimensionless value which represents one thousandth of the yearly environmental load of an average human. The environmental scores are derived from normalizing the three-damage indicators, then dividing the scores with reference situation scores.

Human health damage assessment was done with the DALY measurement method. DALY (Disability Adjusted Life Years) is the various disabilities caused by diseases that are weighted into years. DALY has been developed by the World Health Organization and the World Bank. Ecosystem quality is measured in PDF*m^2year. PDF*m^2year is measured as the percentage of all species present in the environment which are living under toxic stress. Resources impact categories are measured in megajoules of surplus energy. The explanation of each damage categories measurement and its description are given in Table 4.

Table 4. List of Impact categories according to Eco-Indicator 99

Damage Assessment	Impact Categories	Descriptions	Unit Measurement
Human health	Carcinogens	Carcinogens affects due to emissions of carcinogenic substances into air, water and soil	
	Respiratory organics	Respiratory effects resulting from summer smog due to emissions of organic substance into air, causing respiratory effects	
	Respiratory Inorganics	Respiratory effects resulting from winter smog caused by emissions of dust, sulphur and nitrogen oxides into air	
	Climate change	Climate change resulting from an increase of diseases and death caused by climate change	DALY/kg emission
	Radiation	Damage resulting from radioactive radiation	
	Ozone layer	Damage due to increased UV radiation as a result of the emission of ozone depleting substances into air	
Ecosystem Quality	Ecotoxicity	Damage resulting from the emission of Eco-toxic substances into air, water and soil	
	Acidification/ eutrophication	Damage resulting from the emission of acidifying substances into air	PDF*m^2year/kg emission
	Land use	Damage resulting from either conversion of land or occupation of land	PDF*m^2year
Resource Depletion	Minerals	Damage resulting from decreasing ore grades	
	Fossil Fuels	Damage resulting from lower quality resources	MJ surplus

A detailed Life Cycle assessment for the environment impact of tourism activities in Tioman Island Marine Park was created for four cases: (a) transportation from and to the island using ferry, (b) accommodation in the island, (c) waterfall trekking using jeep and boat, and (d) snorkeling in the island area (Figure 6). Eco-Indicator 99 impact assessment method for Case (a), transportation from and to the island using ferry, was found to cause greater environmental damage than the other three cases. 60.96% of the damage was detected to come from this form of transportation whereas 9.17% was found originating from waterfall trekking using jeep. This is in line with the results of other similar studies which highlighted that the beginning and the end transportation are the most damaging in any tourist services (Herrero et al., 2022; Castellani & Sala, 2012; De Camillis, Raggi, & Petti, 2010; El Hanandeh, 2013; Kuo & Chen, 2009; McDonald & Patterson, 2004).

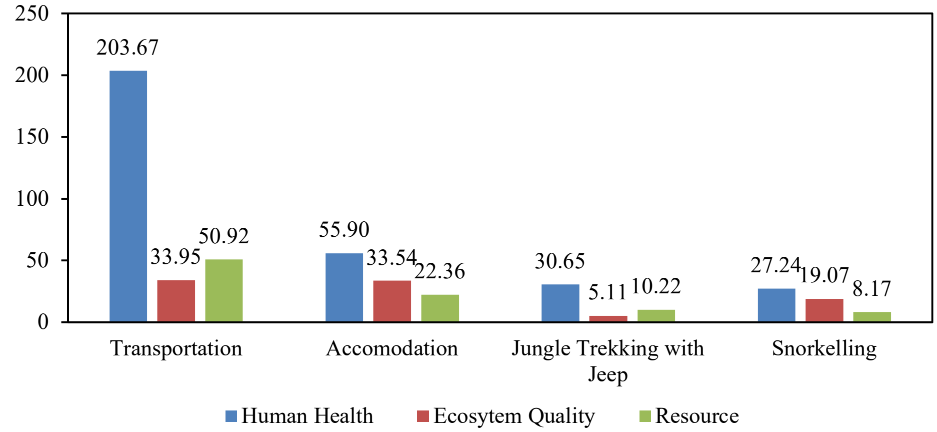

Figure 6. Normalization and Weighting results for 1 tourist per-package at Tioman Island Marine Park (Pt)

The damage assessment showed that human health receives the highest impact in all the 4 cases (Figure 7). Respiratory inorganics were found as the highest variable impact while carcinogens were the lowest in human health categories. Respiratory inorganics effects result from smog coming from emissions of dust, Sulphur and nitrogen oxides which are released into air. This leads to an increase of UV radiation and harmful risks to human health. The high number of respiratory inorganics release will have a serious negative impact on humans overall. The use of fuel and diesel generators might be the reason for the high level of respiratory inorganics.

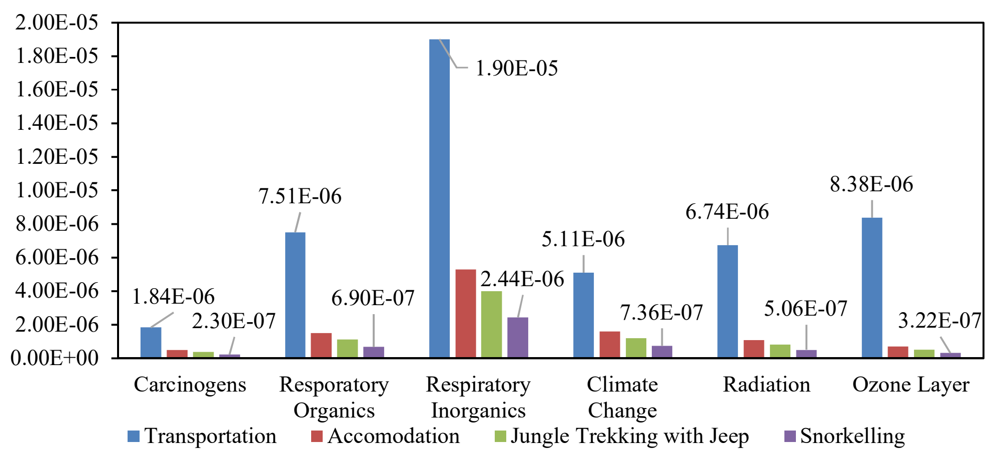

Figure 7. Damage Assessment in Human Health Categories (DALY)

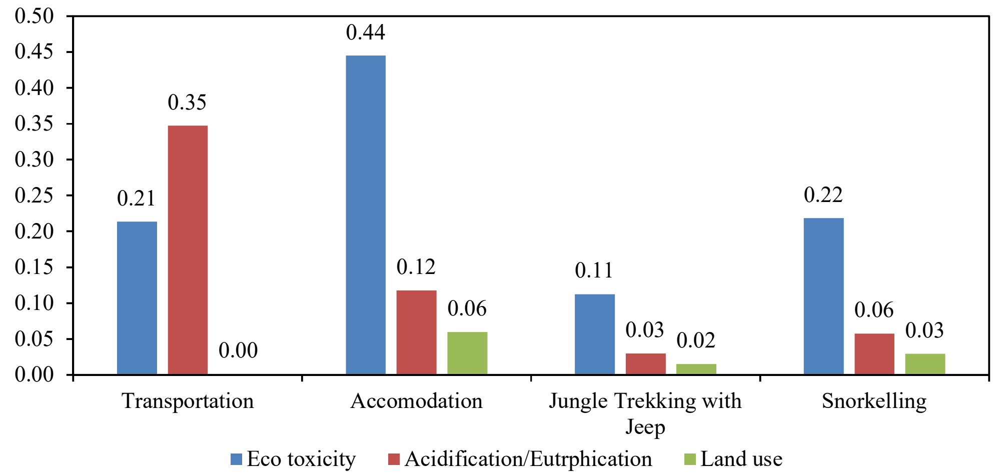

Figure 8. Damage Assessment in Ecosystem Quality (PDF*m2year)

Damage assessment in ecosystem quality categories revealed ecotoxicity as having the highest impact on the environment (Figure 8). With a high level of ecotoxicity, the environment, particularly the marine ecosystem, is at risk of chemical exposure which might lead to their demise. Additionally, the high level of ecotoxicity might cause global warming, ozone depletion, depletion of resources and decline of marine life sustainability.

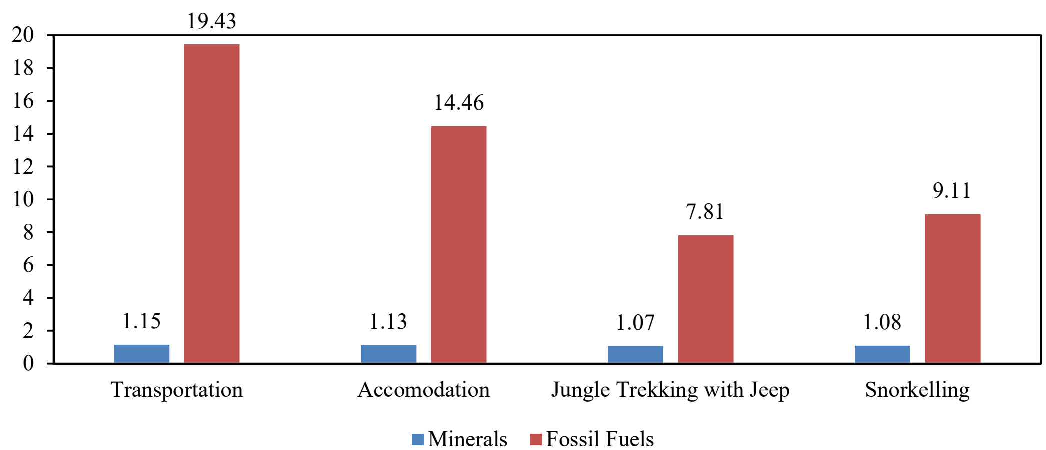

Figure 9. Damage Assessment in Resources (Mj Surplus)

The use of fuels and diesel generators in all the activities under assessment has showed a high level of impact on fossil fuels since electricity and transportation used in the area are generated from fossil fuels (Figure 9). The damage of this resources will be felt by future generations as the resource are declining and the process to acquiring it will cost more.

RESULTS AND DISCUSSION

The purpose of this study is to assess the impact of tourism activities in Tioman Island Marine Park. This study aims to assess the environmental impact of tourism activities by using the theory of Life Cycle Assessment. This assessment is capable of providing new insights into the environmental impact and offers benefits to policy makers in planning and monitoring tourism activities in the protected areas. The results suggest that each of the assessment cases (transportation to/from the island, accommodation, snorkeling activities, waterfall trekking activities) indicated negative impacts on human health, ecosystem quality and resources. Transportation cases showed the highest impact to the park environment (339.46 Pt). In addition, the impact of accommodation case was recorded at 111.81 Pt which is about 2 0.08% of total impact. This might be because in Tioman Island, every hotel provides its own food and activities; this resulted in tourists spending more time in the hotel, leading to the increased intensity of emissions.

In general, tourism activities damage assessment for tourist per trip is at 556.81 Pt, which can be enumerated as 7.23E-05 DALY, 1.65 PDF*m^2year and 51.24 Mj surplus. This is in line with other studies in transportation, hotel and activities (Castellani & Sala, 2012; De Camillis et al., 2010; El Hanandeh, 2013; Konig et al., 2007; McDonald & Patterson, 2004). Konig et al. (2007) observed that the damage assessment for small island tourism is within the range of 400-700 Pt per tourist. Hence, tourists in Tioman Island seem to cause an average level of damage to the area's surroundings. However, this result also suggests that policy makers should put more emphasis on the sustainability of the tourism activities and its impact on the protected area before the situation worsens.

Suggestions to improve this situation include placing more emphasis on: (i) waste management, (ii) energy utilization, and (iii) awareness programs. Waste generation rate for Tioman Island is estimated to be in the range of 0.5 – 1.1 kg/per tourist/day (Demirbas, 2011; Masud, Kari, Binti Yahaya, & Al-Amin, 2014; Saripah & Mohd Shukri, 2012). Even though Tioman Island has its own incineration technology, sadly, it has never been used due to its design failure, namely in complying to Malaysia's high moisture content (Demirbas, 2011; Saripah & Mohd Shukri, 2012). Policy makers can educate tourists and service providers on the importance of recycling and lowering waste consumption by informing them how higher waste can lead to higher amount of methane and carbon dioxide which in turn will impact the environment negatively. An effective recycling program can reduce emissions and offset some of the impacts caused by other activities.

The other recommendation is to utilize solar energy. Solar energy can be an alternative source of power for the accommodations in the island. Switching to solar energy can reduce ecosystem quality impact and resources impact. The final recommendation is to educate tourists and service providers about the impact of their actions and to increase the awareness about their responsibilities towards the environment in order to lower the direct harmful impacts caused by humans on the protected area. For such education programs to be effective and innovative, they should be designed with the co-operation between all the important stakeholders.

Limitations of the Life Cycle Assessment Approach

One advantage of LCA method is that the method offers a rational and comprehensive approach to evaluate environmental impacts in every stage of a product's system. However, in this study, some limitations were also found in the approach. Problems can arise from the decision making in identifying input-output to determining the products' life cycle process or system boundary. For example, there are no exact unit to determine the functional unit and it might vary from study to study; furthermore, the calculation is quantitatively not fixed. Hence, determining the cut off criteria can be problematical due to the difficulties in identifying and neglecting sources and waste that are not significant. These problems make the analysis to rely on secondary data from earlier research, and the results from this analysis tend to reduce the data's credibility (Kulkarni, 2006; Pena et al., 2021).

CONCLUSION

This study suggests that tourism activities have significant impacts on the environment and marine ecosystem of Tioman Island Marine Park. Nevertheless, this study's limitations suggest opportunities for future research. The findings of this study were specific to Tioman Island Marine Park and the approach utilized focused only on four elements (transportation, accommodation, snorkeling activities and waterfall trekking activities). Future studies are recommended to identify the damage assessment on other tourist sub-systems such as caterers, souvenirs and second tier suppliers.

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Not applicable

AUTHOR CONTRIBUTIONS

Azniza Ahmad Zaini: Conceptualization, Data Collection, Methodology, Funding Acquisition, Writing-original draft, Writing-review and editing. Mohd Iqbal Mohd Noor: Conceptualization, Data Collection, Methodology, Funding Acquisition, Supervision, Writing-original draft, Writing-review and editing. Badli Esham Ahmad: Supervision, Funding acquisition, Writing-original draft, Writing-review and editing. Amira Mas Ayu Amir Mustafa: Conceptualization, Data Collection, Methodology, Writing-original draft, Writing-review and editing.
All authors have read and agreed to the published version of the manuscript.

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DATA AVAILABILITY

Not applicable

COMPETING INTEREST

The authors declare no conflict of interest. The funders had no role in the study's design; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

COMPLIANCE WITH ETHICAL STANDARDS

Not applicable

SUPPLEMENTARY MATERIAL

Not applicable

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