



The Cost of Waste Management on Small Inhabited Islands in Malaysia



This report on The Cost of Waste Management on Small Inhabited Islands in Malaysia provides an overview of the current scenario and the potential solutions available for the islands, based on the feasibility and cost of implementation and inaction.

The project was implemented by Reef Check Malaysia in 2021 and 2022 and is funded in part by Ocean Conservancy's Small Grants Program.

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1 Overview

Islands are commonly revered as tropical paradises. Popular tourist islands often portray their most stunning and pristine side while covering up the less attractive issues such as waste management. These isolated islands in fact face a set of unique challenges when it comes to managing solid waste and sewage. Small inhabited islands are particularly vulnerable to waste problems and this is the main focus of this report. Many resorts have some sort of waste management system in compliance with federal law, but what about the local inhabitants? This study describes the current solid waste and sewage management practices on 31 small, inhabited islands of Malaysia, spanning across five states. Due to Covid-19 restrictions, our findings are largely based on online sources and interviewing people on the ground by phone. The top three methods of handling solid waste on islands are: transporting to mainland landfill; open burning; and burying on island. For sewage, most islanders resort to cesspit holding tanks with minimal maintenance. Each island has a different approach to waste management but the various approaches are generally inadequate. This report includes some recommendations for more effective and sustainable approaches to waste management.

The analysis of the costs of effective waste management against the cost of inaction and economic loss due to subsequent environmental pollution & loss of ecosystem services provides a strong case for more resources to be allocated to fund effective waste management in the country.

We acknowledge the limitations of this method and would like to invite researchers to further build upon this study. Contacts of key government agencies have been included for future reference.

2 Introduction

Solid waste management and sewage treatment are essential services to maintain environmental and public health. Both are multifaceted processes involving the generation, storage, collection, transportation, treatment, and disposal of waste and wastewater. For ease of discussion, the phrase “waste management” used in this report hereon will represent solid waste management and sewage treatment.

Islands face distinctive waste management challenges stemming from their unique physical, economic and social structure. Each island has a different set of characteristics which makes standardized management impossible. This is especially true for smaller inhabited islands with low waste volumes and limited potential for economies of scale (Agamuthu and Herat, 2014). Small inhabited islands require tailor-made solutions for their waste problems. How is Malaysia, home to 878 islands, handling waste management on small inhabited islands?

The purpose of this study is to elicit information on current waste management practices on the small inhabited islands of Malaysia with the greater goal to advocate for sustainable management. The inadequate information on this topic suggests a lacuna which this study aims to fill and provide a baseline for.

3 Methodology

The inhabited islands of Malaysia were identified through preliminary research on the internet. Although information online is scarce and often outdated, it provided us with a baseline to work with. From there, we interviewed people on the ground to confirm the population of these islands.

Reef Check Malaysia (RCM) has on-going projects on the Mersing islands, Tioman Island, and Mantanani Island so information is readily available for those islands. Another method we used to obtain information was to approach other island-based non-governmental organisations (NGOs). Finally, for islands without any leads (especially the Sabah islands), we contacted the district council and asked to interview people with knowledge of the island's waste management practices. The interview outcomes were supplemented with relevant journal articles.

Given the Covid-19 restrictions and information scarcity, all the information in this report was derived from online sources, colleagues, and relevant interviewees. There are certain limitations with this methodology pertaining to information accuracy and scope and we encourage further studies to be carried out with the current report providing a baseline.

4 The Small Inhabited Islands of Malaysia

According to the Malaysian Department of Surveys and Mapping, there are 878 islands in the country, approximately half of which belong to the state of Sabah. The goal of this research is to identify waste management and sewage treatment on *small* and *inhabited* islands of Malaysia. Although there is a clear distinction between “*inhabited*” and “*uninhabited*”, there is no textbook definition for “*small*”. “*Small*” is a relative term and we know that the variable in question is population size (not area size) as it is positively correlated to waste generation. So in order to determine what it takes for a particular island to be included in our list of small, inhabited islands, we must first analyse the island demographics of Malaysia.

According to Vogeler et al. (2021), the islands of Malaysia can be categorized into four groups:

- **Large islands** with advanced waste management and sewage treatment in place comparable to mainland municipalities. 80% of Malaysia’s total island population live here: Langkawi archipelago (94,777 locals), Penang island (222,000 locals) and Labuan (99,500 locals)
- **Medium islands** with established waste management such as Pangkor island (25,000 locals), Bum-bum island (25,000 locals), Brait island (30,000 locals) and Sebatik island (25,000 Malaysian locals)
- **Small islands** with little (if any) waste management and sewage treatment; population less than 10,000
- **Very small islands** with little to no waste and sewage systems, population less than 1,000

Using the findings of the World Bank report as a reference, we will focus on islands with a population of less than 10,000 islanders, which require the most assistance to establish a functional and sustainable sewage/ waste management system (recycling too, if possible). Many of these inhabited islands also harbour resorts who have a separate system in place for their waste but the locals are often left to deal with their own waste.

Spanning across five states, there are 31 islands which fit our criteria. This section discusses the current solid waste and sewage management practices of each island. The term ‘*pulau*’ (Malay for island) will be used to denote island names.

4.1 Small Inhabited Islands of Johor

Known collectively as the Mersing islands, the five small, inhabited islands of Johor are: Pulau Aur, Pulau Besar, Pulau Pemanggil, Pulau Sibul and Pulau Tinggi. Information was extracted from the RCM team working on Mersing islands. As waste management and sewage treatment on the five islands are discussed collectively in the latest project quarterly report and are all managed by the Mersing district council, we will explore them collectively under section 4.1. The following sections (4.1.1 - 4.1.5) will highlight the key statistics of individual islands such as population and waste volume.

An estimated 309 kg of solid waste is generated per day among residents and tourism operators of the five islands. This figure undervalues the actual waste volume as it does not take into account the waste generated by day trip visitors. Information on waste composition of the islands is resort-specific as households do not segregate their waste. Our findings from resorts show that 60% of the waste generated is food-based, 29% is general waste and the remaining 13% consists of recyclable materials.

Currently, resorts and households manage their own waste in various ways including open burning, open dumping, composting, recycling, and sending to landfill. The majority of the solid waste gets burnt while only a small percentage is sent to landfills. This clearly shows the inadequacy of current waste management practices and 79% of the local interviewees agree.

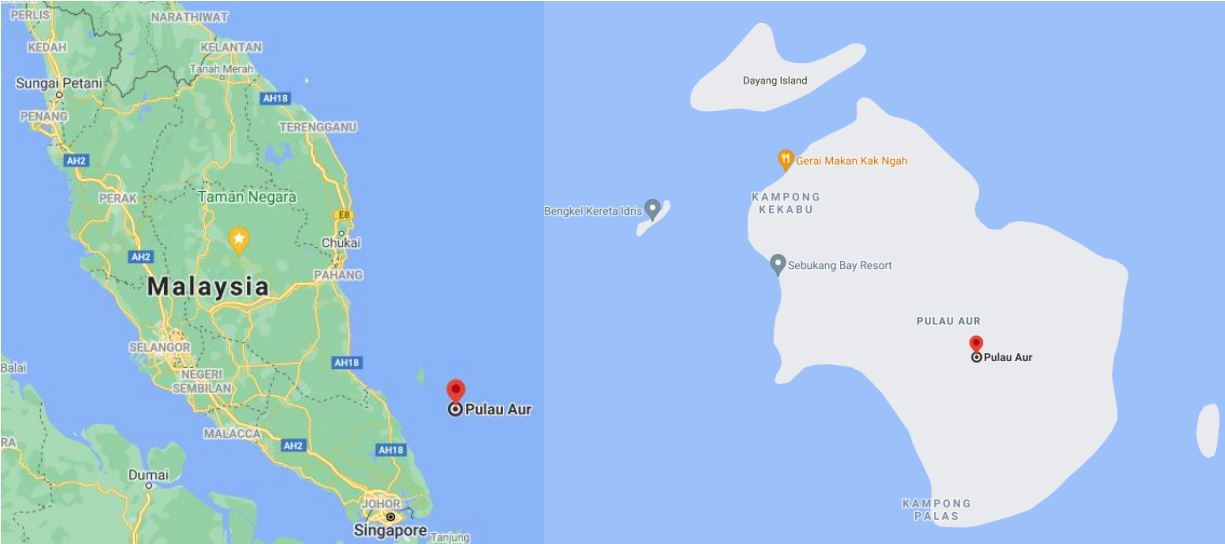
Stakeholders can explore different composting technologies that fit their budget and needs given that a large portion of the waste is organic. Only 5% of the local inhabitants participate in recycling on a consistent basis. Efforts should be channeled into initiating a healthy recycling culture among the Mersing islands, which can take some load off the total amount of waste that needs to be disposed sanitarly.

The baseline review suggests that 11% of the households and tourism operators run septic tanks while the others use cesspits which do not treat sewage. Cesspits are also not particularly good at holding wastewater for long periods of time. Given the low level of maintenance by locals, there is a risk of leakage and sewage pollution. Approximately one third of the islanders are aware of the hazard and responded 'No' when asked if they are satisfied with the current sewage management on the islands.

It is clear that action must be taken to improve the sewage management of the Mersing islands. The most direct approach to tackle this problem would be to upgrade all cesspit systems into septic tanks which provide some form of sewage treatment.

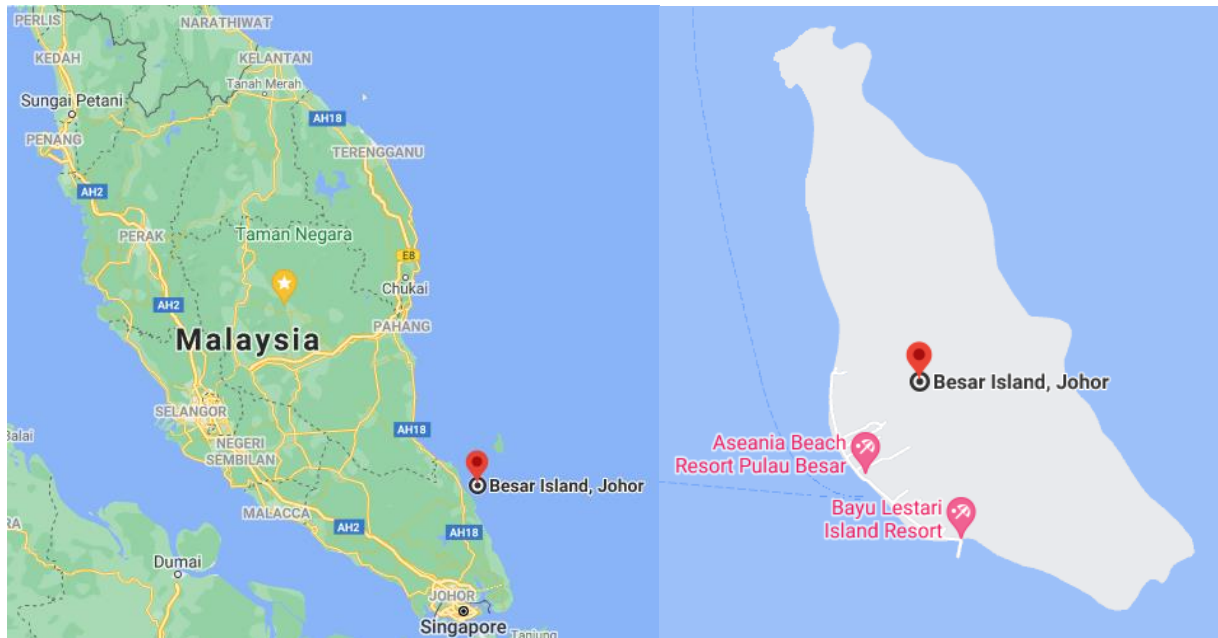
Key Government Agencies	Source of information
<p>Majlis Daerah Mersing http://www.mdmersing.gov.my/ms</p> <p>No. 1 Jalan Tun Dr. Ismail, 86800 Mersing, Johor Darul Takzim</p> <p>No Tel: 07-798 1818 / 07-798 1980 No Faks: 07-799 3975</p> <p>WhatsApp : 018-760 4533 E-mel: mdmsg@johor.gov.my</p>	<p>RCM - Nazirul</p>

4.1.1 Pulau Aur



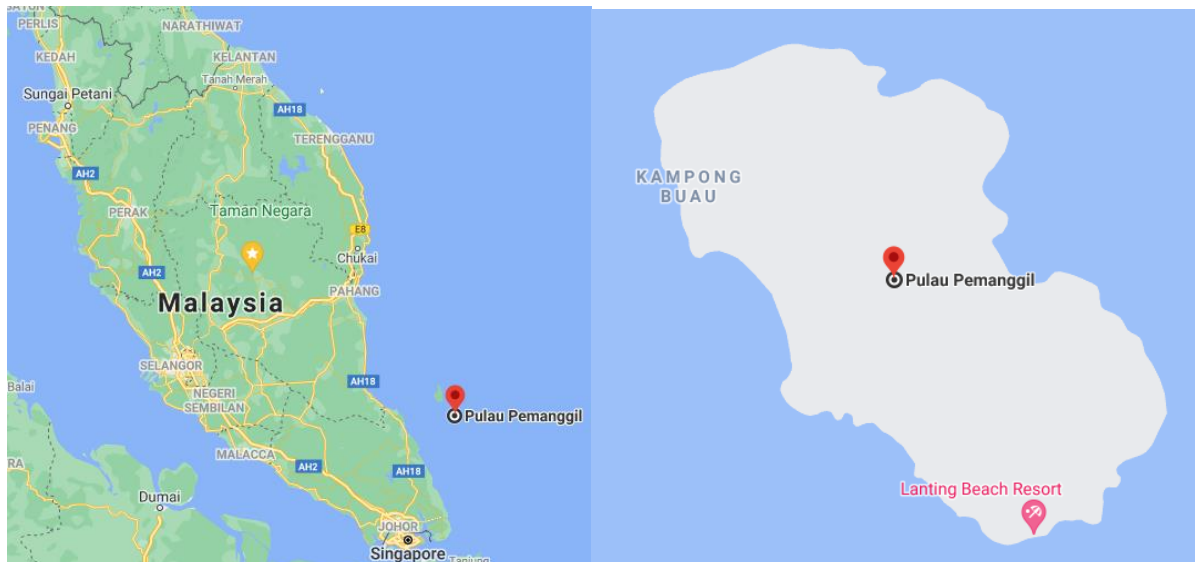
Pulau Aur is the furthest from the mainland of all the Mersing islands, with 124 residents living there. The household waste volume comes down to less than 100kg per day while during the peak tourism season, the six tourism operators on the island produce double that amount.

4.1.2 Pulau Besar



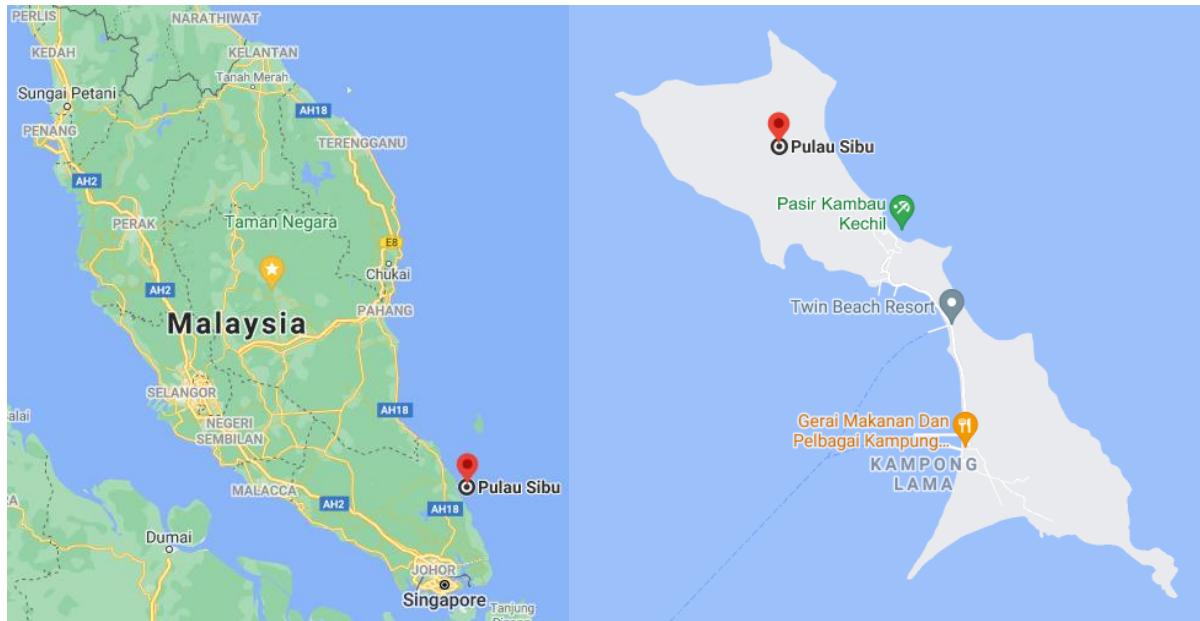
Pulau Besar is home to 18 villagers but houses 10 tourism operators with a maximum capacity of 950 people. The 627 kg of solid waste generated per day by tourists dwarfs the 11 kg produced by locals.

4.1.3 Pulau Pemanggil



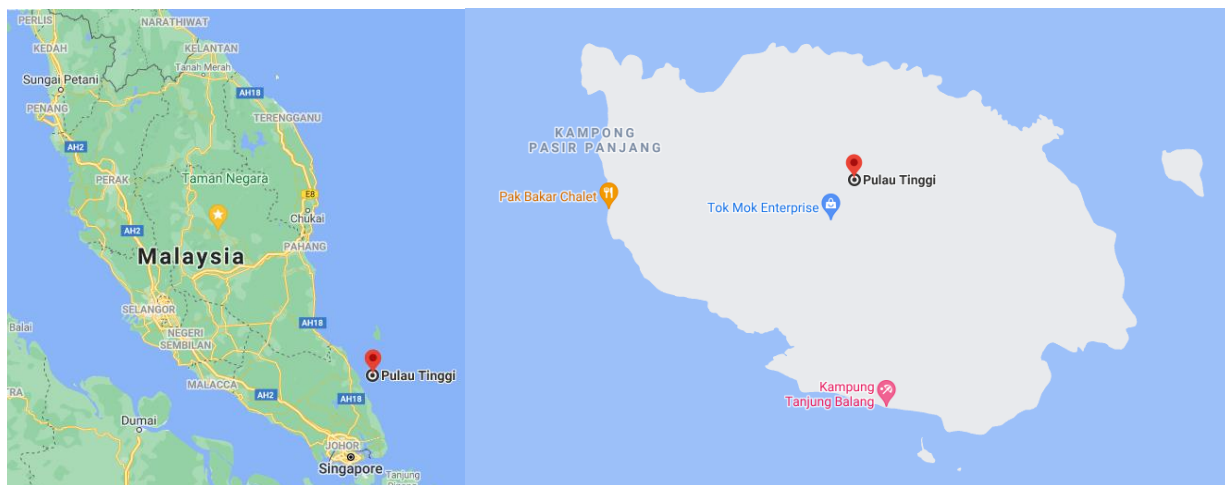
Pulau Pemanggil has 33 local inhabitants who generate about 20 kg of waste per day. Compared to that, the three tourism operators on the island contribute 73 kg of waste daily.

4.1.4 Pulau Sibul



Pulau Sibul has the most inhabitants with 180 people generating 100 kg of solid waste daily. The eight tourism operators contribute another 340 kg of trash per day during peak season.

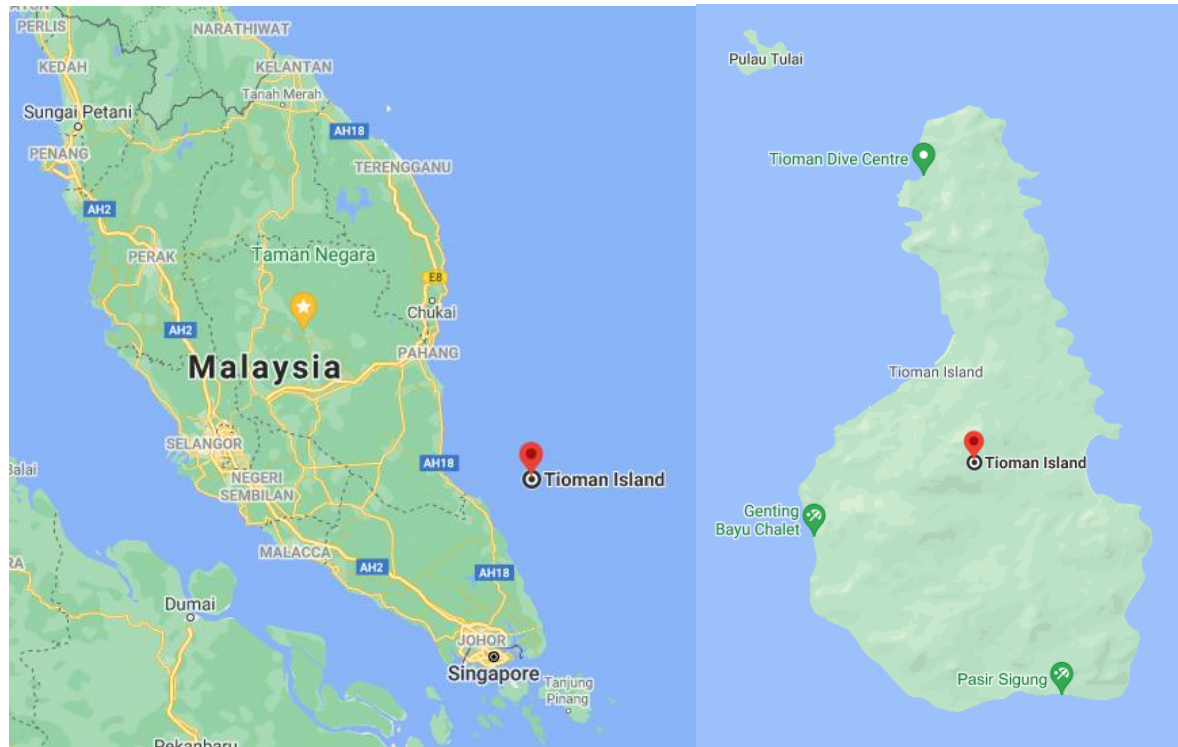
4.1.5 Pulau Tinggi



160 local residents of Pulau Tinggi share their home with five tourism operators. They generate about 96 kg and 373 kg of solid waste everyday respectively.

4.2 Small Inhabited Islands of Pahang

4.2.1 Pulau Tioman



Home to some 3,700 local inhabitants, Pulau Tioman is one of the most popular island destinations in Malaysia. Reef Check Malaysia has been running a long-term community-based programme (Cintai Tioman) with the aim to build reef resilience.

Pulau Tioman has an incinerator located in Tekek Village for the disposal of all municipal solid waste. Besides the frequent breakdowns, the incinerator is also unable to sustain the amount of waste generated on the island (pre-Covid). Of the eight tonnes of solid waste being generated on the island per day, a large portion has been identified as plastics. This presents a challenge in the form of plastic pollution as well as an opportunity for separation at source and the implementation of plastic recycling methods. As of 2022, the island utilizes a baler machine to compress plastic bottles. Each village has a collection centre for recyclables (plastic bottles, aluminium cans, glass bottles and e-waste) which are then fed to the baler/ heat press machine or brought to the mainland. Though small in scale, the application of these technologies serve as an exemplary case study for other islands without any waste management system in place.



Baler machine on Tioman island (left) and the compressed plastic bottles (right) (Reef Check Malaysia)

In terms of sewage, there is no centralized wastewater treatment system on the island. The typical resort and household uses basic septic tanks and soakaway systems. New government projects like the low-cost houses in Tekek have started to incorporate a central sewage collection system.



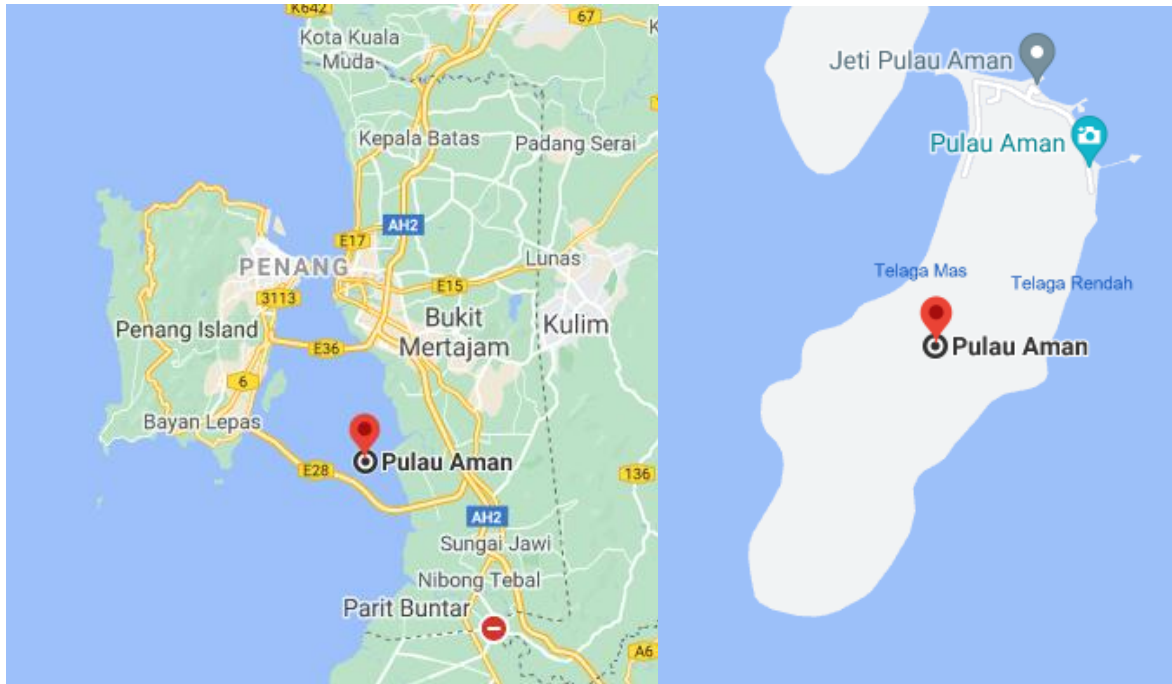
Basic wastewater collection system on Tioman island (Alvin Chelliah, Reef Check Malaysia)

At present, the situation at Pulau Tioman seems to be under control. The low level of pollution indicator on the island (based on Reef Check surveys in 2020) is a testament to that. However, there is room for improvement. There are no ostensible plans to upgrade the sole incinerator on the island so the most logical and pragmatic approach would be to reduce and separate the waste at source. Organic waste can be turned into compost and recyclables can be given a second-life. Coupled with reducing consumption, the waste sent to the incinerator can be significantly reduced. Once this is achieved, attention can then be directed at developing a more centralized and sustainable in-situ sewage treatment system, one that can handle the extra load during peak travel periods.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Daerah Rompin http://www.mdrompin.gov.my/en/visitors/places-interest/tioman-island</p> <p>+609 4146677 / 4146688 mdrompin@mdrompin.gov.my</p> <p>Lembaga Pembangunan Tioman http://www.tioman.gov.my/</p> <p>tda@tioman.gov.my aduanketsa@tioman.gov.my +609-4133 172 / 609-4133 179 609-4191 242</p>	<p>RCM - Alvin</p>

4.3 Small Inhabited Islands of Penang

4.3.1 Pulau Aman



Pulau Aman is a lesser known small Malay fishing village with 250 residents. The island features its own school, community hall, mosque and other facilities (Akmal, 2020). Advancements in technology allowed villagers to travel to the mainland with ease via speedboats. We spoke to the village head of Aman island to get some insights about current waste management practices.



Fishing boats along the fringes of Pulau Aman (Buletin Mutiara)

Waste is divided into organic and non-organic, organic waste is composted and used as fertiliser; while the majority of non-perishable inorganic wastes are sent to Bukit Tambun landfill via boat. The village head admits that the villagers sometimes burn their waste. For the transportation, the Seberang Prai district council MBSP will assign a contract to third parties to collect and transport waste.

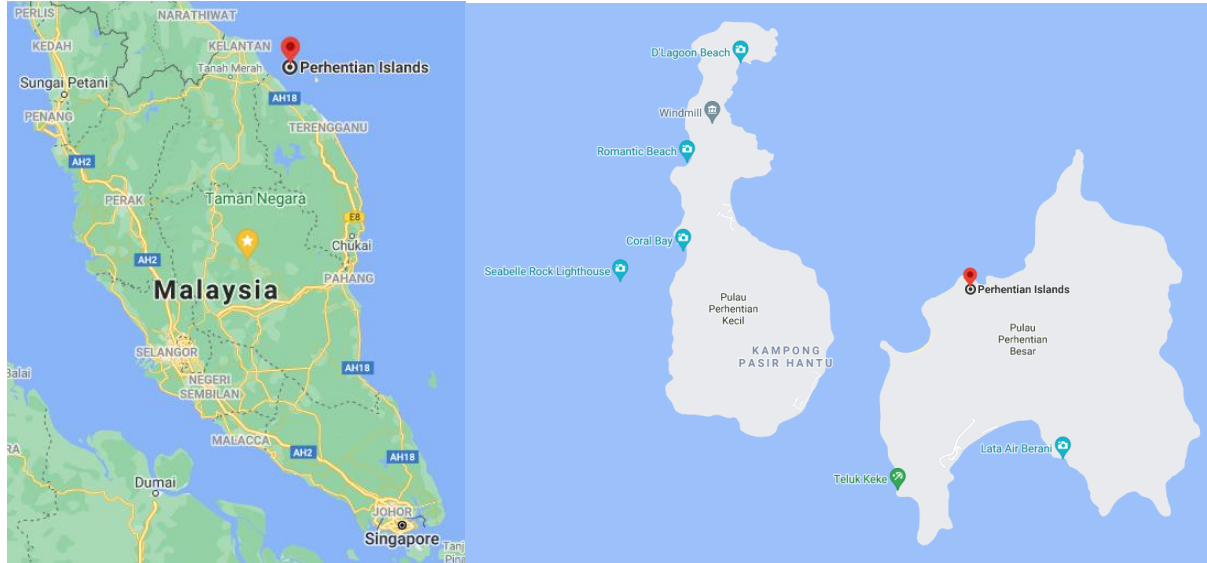
Pulau Aman collects wastewater in two 3-foot tall polytanks. This allows sediments to settle within the tank and when the tanks are filled to the brim, the fluids will be released to the ocean.

Stakeholders should direct their attention to the sewage treatment of Pulau Aman. The act of discharging effluents into the sea should be completely avoided. Besides, holding large amounts of excreta in regular polytanks is a health hazard. A simple septic tank and soakaway system provides an effective short term solution. For a long-term solution, stakeholders can consider an on-site sewage treatment plant. To address the open burning, recycling can be introduced as a means to reduce waste load and potentially extra income (souvenirs for tourists).

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Bandaraya Seberang Perai https://www.mbsp.gov.my/index.php/en/</p> <p>City Tower, Jalan Perda Utama, Bandar Perda, 14000 Bukit Mertajam, Penang.</p> <p>Telephone: 04 - 5497555 Fax: 04 - 5389700 MBSPSMS Info: 012 - 4100300</p> <p>Pejabat Daerah Dan Tanah Seberang Perai Selatan http://sps.penang.gov.my/</p> <p>14200 Sungai Jawi, Pulau Pinang. No.Telefon : 04-5857800 No.Faksimili : 04-5821003 Pautan : http://sps.penang.gov.my</p>	<p>Head of village, Shahidi</p>

4.4 Small Inhabited Islands of Terengganu

4.4.1 Pulau Perhentian



Perhentian islands consists of two main islands: Perhentian Besar and Perhentian Kecil along with five other uninhabited islands. The archipelago sports white sand beaches and turquoise blue sea, attracting over one hundred thousand tourists annually (pre-pandemic). On top of the existing 1,800 locals living on Perhentian Kecil, the influx of tourists generates extra load in terms of waste and sewage which is a challenge for Perhentian.

The Besut district council awards an annual contract for waste management through tender, to collect trash and send it to landfill in Besut. The contractor collects trash directly from resort operators on the various beaches around the islands; in the village a centralized area is designated for waste near to the sea, and the contractor collects from there. Poor contract management has, at times, caused waste to pile up for long periods of time, upsetting tourists and locals alike. This could also explain the high pollution index of 30.88% recorded from RCM surveys in 2020.

Islands	Pollution Indicator
Besar	16.79%
Sibu	5.52%
Tinggi	7.50%
Pemanggil	14.85%
Aur & Dayang	22.92%
Tioman	2.57%
Redang	16.61%
Perhentian	30.88%

Level of pollution indicator on east coast islands of Peninsular Malaysia based on Reef Check survey data in 2020

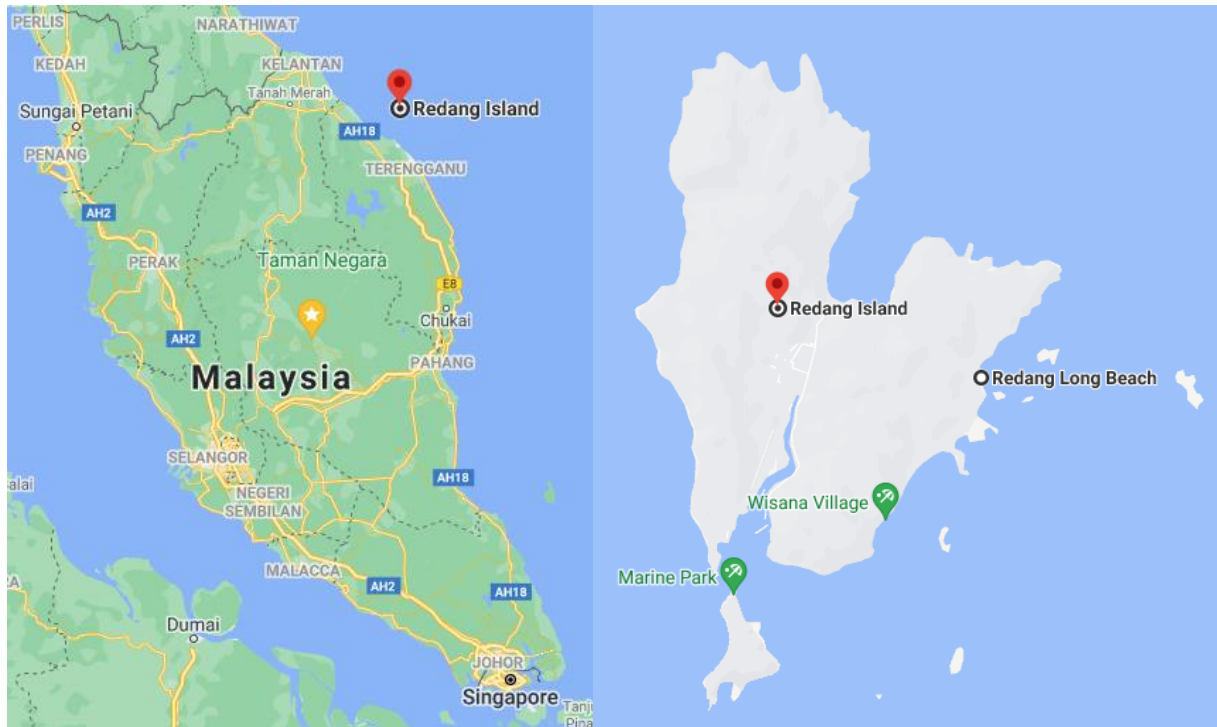
The same study reveals that approximately 80% of the waste generated is organic waste from restaurants. The NGO, Fuze Ecoteer has initiated a recycling programme where stakeholders can adopt a set of three wire mesh bins for basic waste separation. Stakeholders then cooperate among themselves to transport the recyclables to a recycling centre in Kuala Besut. Recycling is still considered fragmented on the island with only around 20% of resorts taking part.

The island features two poorly maintained, open sewage systems. According to Dr Svenja who did a study on Perhentian, the sewage treatment system can only cater to 500 people, which is inadequate for the islanders. The majority of households use septic tanks to process sewage while resorts have their own separate sewage treatment system.

Pulau Perhentian has been tainted with a bad track record of poor waste management. Stakeholders must work together to solve this on-going issue if they were ever going to rejuvenate the island as a pristine travel destination. The obvious first step is to establish a proper waste collection schedule and commit to it. Next, islanders can look to expand their recycling programmes for separation at source. Knowing that a large portion of the waste generated is food-based, composting offers an inexpensive and effective way to manage waste on the island.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Daerah Besut http://mdb.terengganu.gov.my/en</p> <p>General line: 09-6956 388 Hotline:09-6957 400 Fax: 09-6956 199 Email: mdb@terengganu.gov.my Fax : 089 – 782037</p> <p>Contractor for 2021: Mat Yie +60 11-5882 2267</p>	<p>Fuze Ecoteer - Daniel</p> <p>Fuze Ecoteer - Naquiah</p>

4.4.2 Pulau Redang



Another renowned travel destination, Pulau Redang is home to 2,000 islanders. In many ways this island is akin to Pulau Perhentian which was discussed earlier. Similar land size, similar popularity, similar population and similar problems.

Traditionally, the Kuala Nerus district council tenders contractors to collect trash from the village in Redang. The resorts in the Long Beach area on the other hand each have their own separate arrangements. Private boats are used to collect waste from some of the more remote locations. The lack of bins on the island combined with irregular waste collection schedules result in the unsightly scene of overflowing barges and scattered trash. For the longest time, the island has struggled with open burning and ocean dumping. To make matters worse, solid waste collection is disrupted from November to January annually due to the Monsoon season. Locals do not practice recycling while some resorts separate out recyclable wastes.

There are signs of improvements however as a new tender was recently given to a local contractor on the island. The involvement of locals saw the addition of bins and a fixed waste collection schedule. Our source suggests that the island is no longer plagued with foul-smelling garbage heaps anymore. Once again, this highlights the importance of local involvement in addressing waste management issues on islands.



Solid waste collection barge on Redang island (Putri Asma, Reef Check Malaysia)

Like Pulau Perhentian, locals adopt cesspits and septic tanks for sewage treatment. Some resorts dig a hole behind their property to discharge blackwater.

The waste management in Redang is barely satisfactory but change is underway. Hopefully the newly established waste management team can continue delivering positive results. In the meantime, other stakeholders should support the island contractors in setting up waste infrastructures and streamlining waste collection. Sewage treatment should not be neglected too as it poses significant health and environment hazards to the locals.

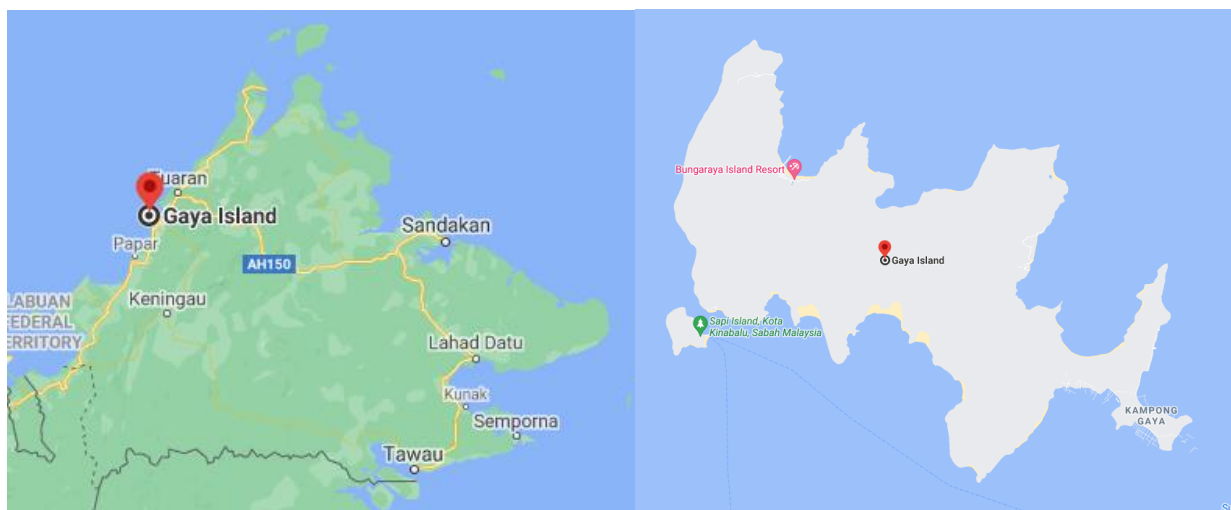
<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Pejabat Daerah Dan Tanah Kuala Nerus http://pdtknerus.terengganu.gov.my/index.php?option=com_webinks&view=categories&Itemid=63 Lot 54998-55003, Jalan Tengku Mohamad, 21200 Kuala Nerus, Terengganu Darul Iman TEL PDTKN : +609-6664000 FAX PDTKN:+609-6624000 ptkn@terengganu.gov.my pdkn@terengganu.gov.my</p>	<p>RCM - Putri Asma</p>

4.5 Small Inhabited Islands of Sabah

At a glance, most Sabah islands lack any real solid waste and sewage management. Information is scarce and sporadic. Some islands are within gazetted marine parks and there seems to be an overlap in waste management responsibility between the local district council and Sabah Parks. Given the vastness and spread of the inhabited islands in Sabah, we will group them according to their geographical location with reference to the state - West coast, North coast and East coast.

4.5.1 West Coast of Sabah

4.5.1.1 Pulau Gaya



Pulau Gaya is the largest and the only inhabited island in the Tunku Abdul Rahman National Park. More than 4,000 islanders call it home. It comprises five villages, namely Lok Urai, Pasir Putih, Pondo, Lok Molom and Pulau Gaya village (Md. Shah and Selamat, 2016). A large portion of the inhabitants live in squatter settlements and the exact population is unknown. There are also some 200 sea gypsies who live in Pulau Gaya.

According to the Dewan Bandaraya Kota Kinabalu (DBKK) Department of Waste Management, locals either burn or dispose of solid waste into the sea. Each of the four resorts on the other hand are responsible for transporting their own waste to the mainland via boat. Sewage systems are non-existent for the locals and the resorts use septic tanks. Recycling is minimal at best. Because of this, the locals are often labelled as the 'culprits' of pollution but a recent coverage from News Straits Times proved otherwise. In fact, the Gaya islanders have been trying very hard to implement some sort of waste management system but are struggling due to the lack of resources. The NGO, Blu Hope is working on a pilot waste management programme in 2021.

As works have already begun to improve the situation on Pulau Gaya, local authorities and government agencies should bolster and support existing efforts. With the support from the local

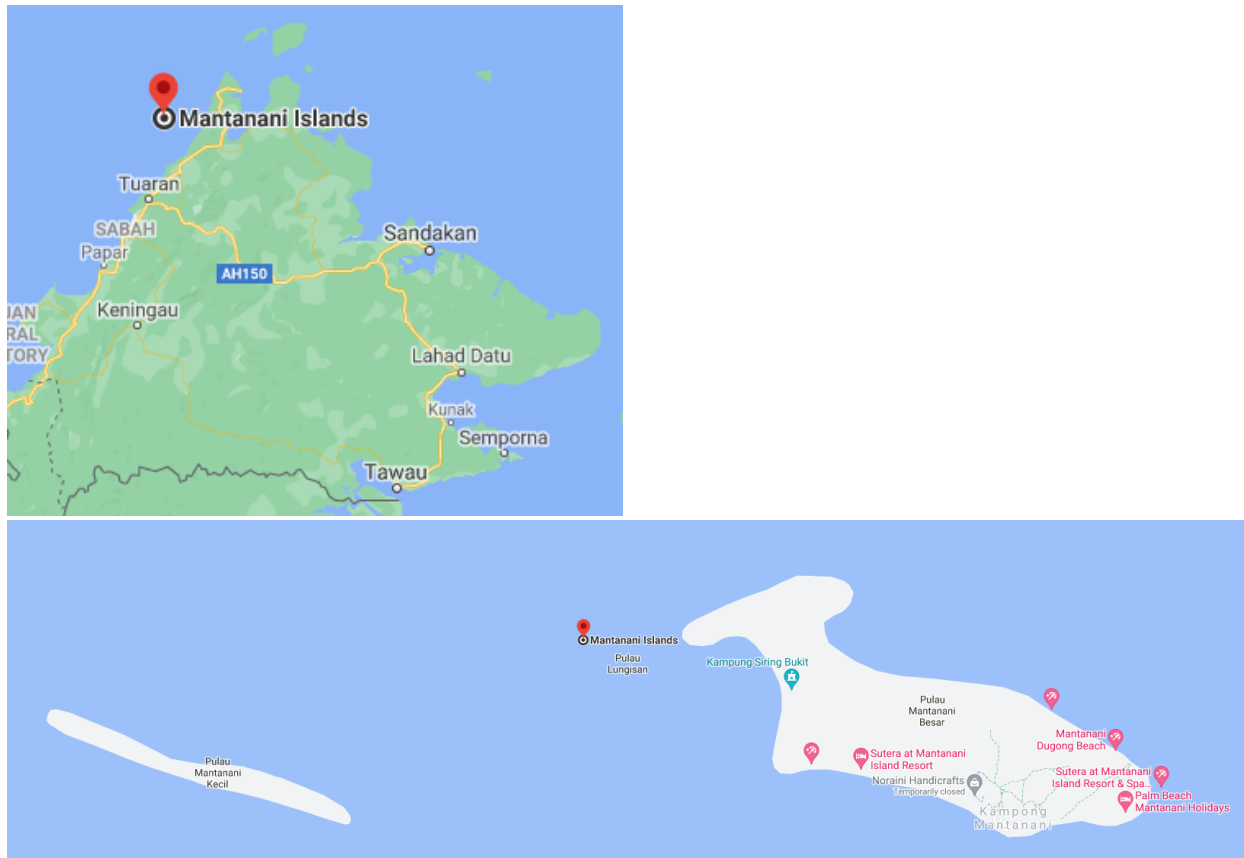
community, Pulau Gaya has the prospect of a sustainable and successful solid waste and sewage management.



Piles of garbage under the stilt houses of Pulau Gaya (Blu Hope)

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Dewan Bandaraya Kota Kinabalu https://dbkk.sabah.gov.my/index.php/en/</p> <p>Headquarters 088-521800 Faks: 088-219175 Hotline 012-222 0220 (WhatsApp) 088-313991</p> <p>Tunku Abdul Rahman Park https://www.sabahparks.org.my/tunku-abdul-rahman-park</p> <p>P.O Box 10626 88806 KOTA KINABALU Tel : 088 – 254201 Fax : 088 – 254202</p> <p>The Board of Trustees of Sabah Parks https://www.sabahparks.org.my/</p> <p>Block H, Level 1-5, Lot 45 & 46, Signature Office, KK Times Square, Kota Kinabalu, Sabah, Malaysia Phone : +6088-523500 Email : admin@sabahparks.org.my</p>	<p>Wikipedia</p> <p>Dewan Bandaraya Kota Kinabalu (DBKK) Official Site</p> <p>Pengarah Jabatan Pengurusan Pepejal - Leong</p>

4.5.1.2 Pulau Mantanani



Mantanani is the collective name for a group of three remote islands off the West coast of Sabah. The local population numbers 1,000 (only one island is inhabited - Pulau Mantanani Besar). Prior to 2013, waste management was non-existent on the islands as the islands were considered too distant for any waste collection system to be economically feasible. Coupled with increasing tourist numbers, waste management has transformed into a key issue on the islands. The traditional disposal at sea, burn or bury method employed by locals is becoming increasingly unsustainable.

A series of recycling and awareness campaigns saw gradual improvements to the waste issue on Mantanani following RCM's intervention in 2013. Today, the success of the early campaigns has been replicated on a wider scale across 174 households (over 90% of the population) in Kampung Siring Bukit and Kampung Padang. Municipal waste collection is arranged daily, gathered and transported to a landfill in Telipok. Recycling is encouraged with the introduction of 78 recycling bins which accept plastic bottles, glass bottles, aluminium cans, scrap metals and e-waste. Recycled plastics are turned into local merchandise with the help of recent recycling technology like the "Shruder" machine. It is a shredder-extruder hybrid which shaves, heats and shapes recycled plastics into little moulded objects such as fridge magnets.



"Shruder" machine (left) and the end-product (right) (Reef Check Malaysia)

Other recycled materials are sold to GNC Sdn Bhd Inanam once every two months and the earnings are used to offset some land transportation costs. The actual monthly expenses for maintenance of daily waste and recycling collection on Pulau Mantanani is at least RM8,000. Just the transportation of municipal waste to the landfill incurs a monthly cost of RM1,800:

- RORO (roll-on/ roll-off) bins rental: RM600
- Lansa wooden boat rental: RM1000
- Labour: RM200

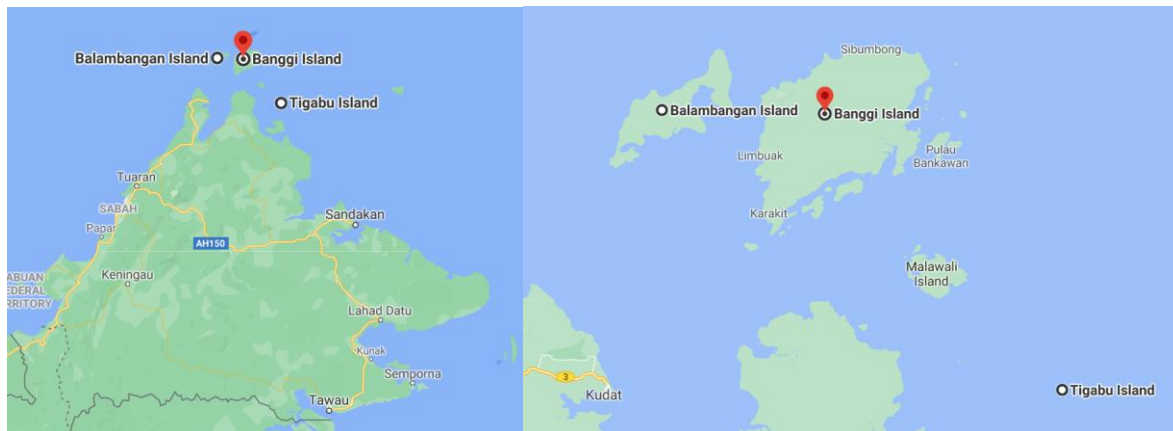
Pulau Mantanani does not have any integrated sewage treatment system and households rely on soak-away pits. Improving sewage management should be one of the focus areas for these islands in the near future. In terms of solid waste management, Mantanani has established a self-sustaining model and should continue to spread awareness to the rest of the locals. More importantly, it exemplifies how community involvement and awareness can make a difference.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Daerah Kota Belud https://mdkotabelud.sabah.gov.my/ PETI SURAT NO.8, 89157, KOTA BELUD, SABAH Email: md.kb@sabah.gov.my Tel: 088-9765299 Fax: 088-976627</p>	<p>RCM - Melynda</p>

4.5.2 North Coast of Sabah

4.5.2.1 Tun Mustapha Park - Pulau Balambangan, Pulau Banggi & Pulau Tigabu

Of the 50 islands and islets within Tun Mustapha Park (TMP), three are inhabited - Pulau Balambangan, Pulau Banggi and Pulau Tigabu. As the situation of these islands are more or less similar, they will be discussed collectively in this section.



Information on these remote locations is scarce but with the help of the WWF Kudat team, we were able to get an understanding of the waste management situation. Pulau Banggi is the largest island among the three in terms of land area and population size, followed by Pulau Balambangan and Tigabu. With almost 10,000 local inhabitants (and barely making the list of small, inhabited islands), Pulau Banggi is the only island in our research with a landfill on the island itself. The Banggi district office is in charge of collecting waste from the local villages but this too is inadequate as some resorts still burn and dispose of solid waste into the ocean. Pulau Balambangan has around 300 inhabitants and Pulau Tigabu has 200. Both islands lack a proper waste disposal system and local islanders have to deal with their own waste, which they almost always choose to burn.

WWF operates in Kampung Batu Sirih (Balambangan), Kampung Perpaduan (Banggi), Kampung Patanunan (Banggi) and Kampung Tigabu (Tigabu). From their observation, there are no sewage treatment systems in place on any of the islands and the solution for the locals are overhung latrines. Like the low-cost housing in Tioman, the newly built E-kasih houses in these villages have built-in toilets.

The situation on the islands of Tun Mustapha Park is poor and there is much to be done. Given the large population size, the islands are in dire need of a proper solid waste and sewage management system. For starters, the landfill on Pulau Banggi can also accept waste from neighbouring Balambangan and Tigabu. Community-based programmes can introduce recycling practices to the locals in order to reduce the volume of municipal waste. As for sewage, a basic septic tank/ soakaway system can be utilized for a short-term solution before exploring other alternatives.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>The Board of Trustees of Sabah Parks https://www.sabahparks.org.my/</p> <p>Block H, Level 1-5, Lot 45 & 46, Signature Office, KK Times Square, Kota Kinabalu, Sabah, Malaysia. Phone : +6088-523500 Email : admin@sabahparks.org.my</p> <p>Pejabat Daerah Kecil Banggi https://pdkbanggi.sabah.gov.my/</p> <p>W.D.T No. 199, 89059 Kudat Sabah Telefon Pejabat : 088-671495 No. Faks : 088-671451</p> <p>Pejabat Daerah Kudat https://pdkudat.sabah.gov.my/</p> <p>PETI SURAT NO.21,89057 KUDAT TEL: 088-620410 FAX: 088-611303 pd.kudat@sabah.gov.my</p>	<p>Sabah Parks - Haslam</p> <p>WWF - Joaniee</p> <p>Unit Pemimpin Pembangunan Masyarakat Sabah 2021 census</p>

4.5.3 East Coast of Sabah

9 of the 10 small, inhabited islands on the Sabah East Coast are located in the Semporna/ Lahad Datu district and are in close proximity. This region of Sabah is frequented by the nomadic sea gypsies.



4.5.3.1 Pulau Bohayan



A lesser-known island of Semporna, Pulau Bohayan is 50 households strong with less than 100 islanders of mainly Bajau Laut tribe. It is a nesting hotspot for turtles. Unfortunately, waste management and sewage treatment is non-existent on the island. Locals usually resort to burning or dumping waste into the ocean. Situated 15 km off the nearest mainland, the island may very well be considered too rural for any waste disposal and collection system to be economically viable. Sadly, most Sabah islands on this list fit this narrative as we will discover later.

Not much can be said about the island as there is not much information about it to begin with. Perhaps a preliminary study can be conducted to elicit some of the struggles locals face and how we can create a functional waste and wastewater management system.

<i>Key Government Agencies</i>	<i>Source of information</i>
Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484	TRACC - Jeeth TRACC/ local at Pulau Kalapuan - Khairul RCM - Adzmin

4.5.3.2 Pulau Denawan

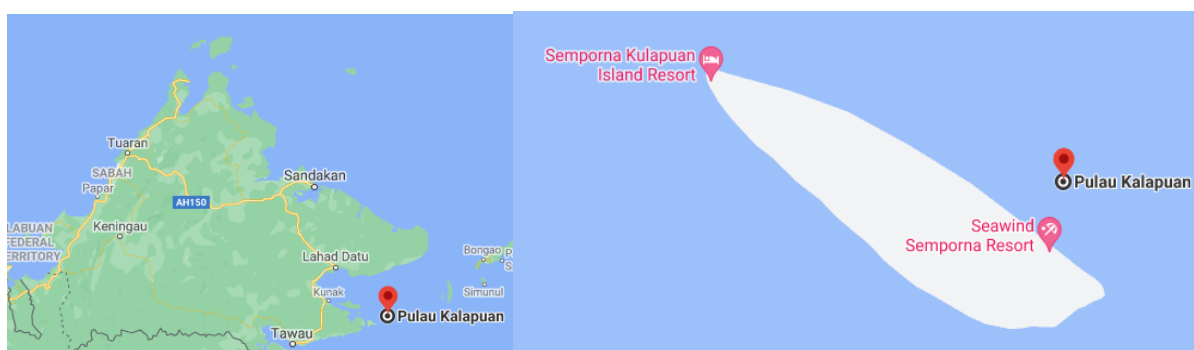


Pulau Denawan, also known as Danawan (but not to be confused with Pulau Dinawan, a privately owned island on the West coast) is one of the few islands frequently being visited by the nomadic sea gypsies along with Pulau Bohayan, Kalapuan, Omdal and Sibuan. Total population size is around 300. Some of the sea-dwelling Bajau Laut community have swapped their sails for roofs, building permanent stilt houses which opens up new avenues for potential waste management strategies. Some 100 sea gypsies call Pulau Denawan home.

For the land-dwellers on the other hand, there is no solid waste and sewage management on the island. The estimated total of 200 locals resort to burning and disposing trash into the ocean just like the residents of Pulau Bohayan. Given its proximity to Pulau Si Amil (another island on our list without any waste management), it would make sense to have both islands share one system for efficiency.

<i>Key Government Agencies</i>	<i>Source of information</i>
Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484	TRACC - Jeeth TRACC/ local at Pulau Kalapuan - Khairul

4.5.3.3 Pulau Kalapuan



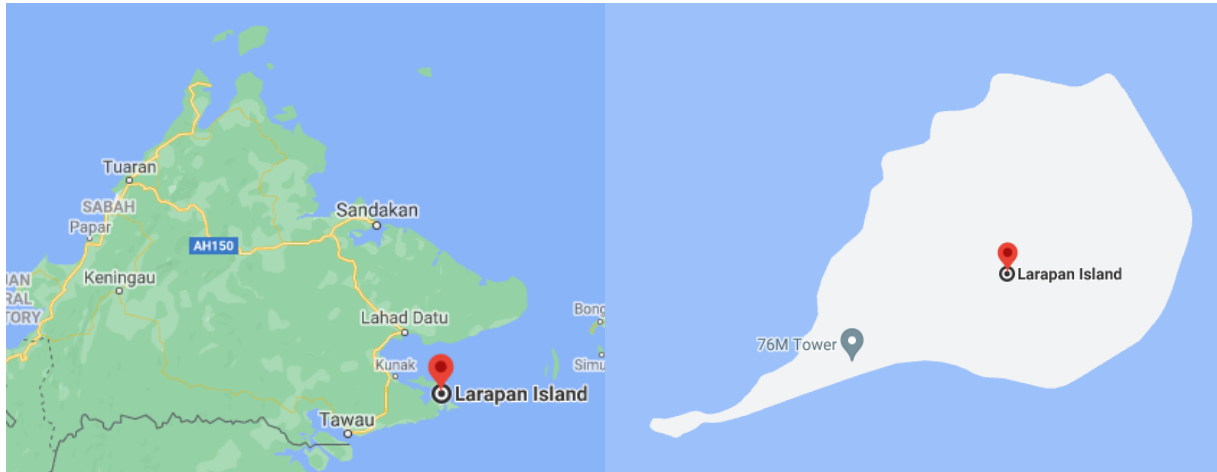
Pulau Kalapuan is a distant island off the coast of Semporna. This fishing village sports 220 families with over 100 sea gypsies. We were fortunate enough to liaise directly with a local from Kalapuan to get first-hand information on the situation of the island.

As of 2021, there is no regular solid waste or sewage management on the island. Solid waste is usually gathered at a designated spot and local contractors occasionally come to collect it. This irregular collection schedule sometimes leaves locals no choice but to burn the garbage when the waste site is jammed. The NGO, TRACC which operates in Semporna is making an effort to educate locals about proper waste management.

Pulau Kalapuan follows the general theme of Sabah islands with no system in place whatsoever. Working with a blank slate, the best we can do is to draw examples from successful case studies such as Mantanani islands which was discussed under section 4.5.1.2.

<i>Key Government Agencies</i>	<i>Source of information</i>
Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484	TRACC - Jeeth TRACC/ local at Pulau Kalapuan - Khairul

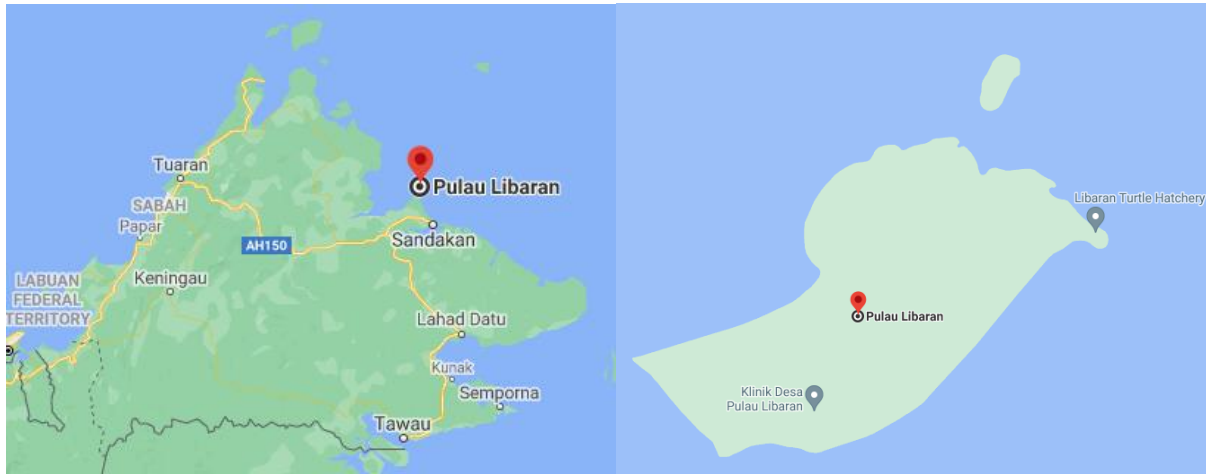
4.5.3.4 Pulau Lrarian



Approximately 1,200 people live on Pulau Lrarian. This relatively populated island does not have any solid waste management or sewage treatment. The Semporna district councils pointed out that their waste management division does not service the islands. According to the engineer working on Pulau Lrarian, island waste management in Semporna is almost always exclusively established by resorts, for the resorts. In other words, islands without resorts like Pulau Lrarian are left to their own devices. It is saddening to see islanders being left out which highlights the need for swift actions. Reef Check Malaysia is starting a pilot waste management programme in 2022.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484</p>	<p>MDS Engineer working on the island - Azhar RCM</p>

4.5.3.5 Pulau Libaran



All inhabited islands off the East coast are situated on the South-East region of Sabah except for Pulau Libaran of the Sandakan district. But when it comes to waste management, it shares the same narrative. Solid waste management and sewage treatment is absent on the island. The 340 Libaran islanders have worked out a simple strategy of gathering all their solid wastes in one spot and burying them. For sewage, a simple hole does the job for them. A small percentage of them use septic tanks.

Libaran island is close to the Turtle Islands Park, and perhaps it would be wise to integrate the waste management system of the island and the park to save cost and time. Turtle Islands Park was gazetted to safeguard Green and Hawksbill turtles and their eggs. Though less frequent, these marine reptiles occasionally nest upon the shores of Pulau Libaran. Therefore, it makes sense to keep the island pristine and we can start by managing local waste and sewage.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Perbandaran Sandakan https://mps.sabah.gov.my/portal/mps_main.cfm</p> <p>Peti Surat 221, 90702 Sandakan Tel : 089-272149, 089-211944, 089-226442, 089-211404 Fax : 089-272112</p> <p>Turtle Islands Park https://www.sabahparks.org.my/turtle-islands-park</p> <p>P.O Box 768 90708 SANDAKAN Tel : 089 – 213320 Fax : 089 – 274718</p>	<p>Local contractor - Jikral</p> <p>MPS officer - Kamal</p>

4.5.3.6 Pulau Mabul



Pulau Mabul harbours a population of 3,845, with almost 600 households. This small fishing island gained its popularity amongst divers due to its proximity to Sipadan island and exotic collection of marine life. We were able to get in touch with one of the few dive resorts - Scuba Junkie for information on the island.

In Mabul, everyone (resorts included) is responsible for their own wastes as there is no centralized waste management system. There have been attempts to establish one previously where Scuba Junkie set up four waste collection points for locals to gather their solid waste. The idea is to get the resorts to transport the accumulated wastes from the collection points to mainland Tawau via boat. This system worked out quite well in the beginning with 3-4 trips per week to transport trash but ultimately failed as businesses started taking advantage of these collection points and added their waste to the pile which prompted the resorts to shut down the operation. Of the four collection points, only one remains, which is operated by Scuba Junkie and can only accommodate roughly 50 families. That leaves the remaining 750+ families “marooned” on their little island of garbage. The majority of the villagers are poor and do not have the capacity to deal with solid waste and therefore the default solution is to burn or bury them. There are also reports of people on boats throwing bags of trash overboard. Small scale recycling and upcycling was done consistently pre-pandemic but has temporarily halted with the Covid-19 restrictions. The island is also collaborating with Universiti Malaysia Sabah (UMS) on a project to develop upcycling programmes that can hopefully convert single-use plastics into boat fuels (Hasan, 2021).

For sewage, locals employ a simple method of storing all blackwater in large poly tanks, burying them and moving on to the next. A highly unsustainable strategy given the limited space and the crowded island. It also poses a threat of sewage pollution and health hazards when these poly tanks eventually break down. Resorts on the other hand have septic tanks to treat sewage, those who do not will release them directly to the ocean.

To address the overwhelming waste volumes on this remote island, minimising consumption and reducing waste creation in the first place can go a long way. Our interviewee believes that an extremely large vessel will be required to transport all the waste due to the sheer volume being

generated. This will of course demand money and proper management to keep the operation functional, therefore the first step is always to minimize waste. The successful community outreach programme implemented on Mantanani islands could prove to be effective on Mabul too. Recyclables can be assigned with monetary value to create ‘value chains’ and encourage locals to separate and recycle. Scuba Junkie is currently running Biosolve systems to treat their wastewater and it can potentially be implemented for all of Mabul.

<i>Key Government Agencies</i>	<i>Source of information</i>
Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484	Scuba Junkie - David RCM – Adzmin

4.5.3.7 Pulau Omadal



Pulau Omadal is home to some 300 residents, of which two-thirds are sea gypsies. Information on Pulau Omadal was contributed by a local from neighbouring Kalapuan island. Similar to Pulau Kalapuan, our interviewee shares that the situation on Pulau Omadal is pretty much the same - zero solid waste and sewage management.

<i>Key Government Agencies</i>	<i>Source of information</i>
Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484	TRACC - Jeeth TRACC/ local at Pulau Kalapuan - Khairul

4.5.3.8 Pulau Timbun Mata



Pulau Timbun Mata is the largest island off the shores of Darvel Bay, spanning 26km long and 10km wide. Despite its size, there are only 10 households on the island according to a local tourism operator. Following the theme of most East coast islands, there is no waste management and sewage treatment in place for Timbun Mata. While the travel agencies are responsible for the trash from tourists, the locals on Pulau Timbun Mata are left to their own devices.

Though small in population size, the island should not be overlooked. The small cohort requires the support from the mainland to manage their solid waste and sewage, and since there are only a few people, it should technically be inexpensive.

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>Majlis Daerah Semporna https://www.sabah.gov.my/md.sprn/ Peti Surat 134, 91308 Semporna md.sprn@sabah.gov.my 089-785350 / 089-785484</p>	<p>Semporna Paradise Travel & Tours Sdn Bhd - Local tourism operator</p>

4.5.3.9 Tun Sakaran Marine Park



Tun Sakaran Marine Park (TSMP) was gazetted in July 2004 and it comprises of 8 islands, namely Pulau Bodgaya, Pulau Bohey Dulang, Pulau Tetagan, Pulau Selakan, Pulau Sebangkat, Pulau Maiga, Pulau Sibuan and Pulau Mantabuan. For ease of discussion, these islands will be examined collectively.

According to census carried out in year 2006 and 2015, the population in TSMP are 2510 and 3150 respectively. The numbers of population are expected to have dwindled to around 1,500-2,000 due to closures of seaweed farms causing workers to leave TSMP and look for work elsewhere.

The exact figure of the local inhabitants on each island is unclear. This may be due to the nomadic lifestyle of sea gypsies. They are expected to make out one third of the total population in TSMP.

They are traditionally seaborne, living their life on wooden sailing vessels as a self-sustaining community. Further discussion with the NGO TRACC (based in Semporna) reveals that some of the sea gypsies in TSMP have actually settled down in stilt houses. They are however, still considered stateless without governance nor proper waste management. With no alternatives, solid wastes are therefore disposed to the sea and sometimes burned. There is a contractor appointed by Sabah Parks to transport trash but only for their base stations, Pulau Bohey Dulang, Pulau Mantabuan, and Pulau Sibuan only.

Besides the Bajau Laut people, other ethnic groups such as Suluk and Bajau also reside in TSMP particularly in Pulau Bohey Dulang and Pulau Selakan.

Given the scarce information available on the islands of TSMP and their waste management, it is recommended that more detailed research is conducted on the islands before developing solutions. The anchoring of the sea gypsies to one fixed spot opens up the possibility of establishing a waste and sewage management system for them.



Static houses of the sea gypsies on Bohey Dulang (Google Earth)

<i>Key Government Agencies</i>	<i>Source of information</i>
<p>The Board of Trustees of Sabah Parks https://www.sabahparks.org.my/</p> <p>Block H, Level 1-5, Lot 45 & 46, Signature Office, KK Times Square, Kota Kinabalu, Sabah, Malaysia. Phone : +6088-523500 Email : admin@sabahparks.org.my</p> <p>Tun Sakaran Marine Park https://www.sabahparks.org.my/tun-sakaran-marine-park</p> <p>P.O Box 163 91307 SEMPORNA Tel : 089 – 782014 Fax : 089 – 782037</p>	<p>TRACC - Jeeth</p> <p>TRACC/ local at Pulau Kalapuan - Khairul</p> <p>RCM</p>

5 Recommendations

5.1 Solid Waste Management

Generally speaking, the solid waste management on small inhabited islands of Malaysia is inadequate. The transportation of solid waste to mainland landfill seems to be the default solution for most islands. Open burning is still prevalent among small islands. Some of the Sabah islands also dump solid waste into the ocean. But the islanders have no choice as the waste volume is sometimes too small and the islands too far away to justify transporting the waste to the mainland.

Based on the findings of this report, the collection and transportation of solid waste has a lot of inefficiencies due to irregular collection schedules, insufficient collection points and in some cases, sheer volume of waste. Stakeholders should initiate a dialogue amongst the various parties involved (local council, external contractors, resorts, companies) to streamline the waste collection process and have it communicated clearly to locals. To address the high load of waste, islanders can explore different ways to minimize waste generation: reducing consumption, separation at source and recycling. Organic food wastes need not be sent to landfills as they can be composted locally. Adequate space and infrastructure should be assigned for waste separation and collection on islands.

It is clear that the main mode of solid waste disposal on islands is sending them to nearby landfills. Should there be additional financial leeway, small inhabited islands can look into integrating different technologies to further streamline the process. Drawing examples from Tioman island, the baler machine provides a quick and easy solution to optimize logistics. It compresses solid wastes into bales and saves space during transport. For islands with considerable waste volumes, artisanal recycling is a viable option. Like the 'Precious Plastics' machine on Mantanani, this technology can convert recyclables (eg. plastic bottles) into raw materials which can be fed into existing value chains for secondary products (eg. souvenirs). Incineration is typically avoided whenever possible due to environmental concerns but remains as a viable alternative. For islands within close proximity, an integrated waste management approach could increase efficiency by combining solid waste from nearby islands. This can concentrate the waste volumes and hopefully incentivize waste collection for small and remote islands.

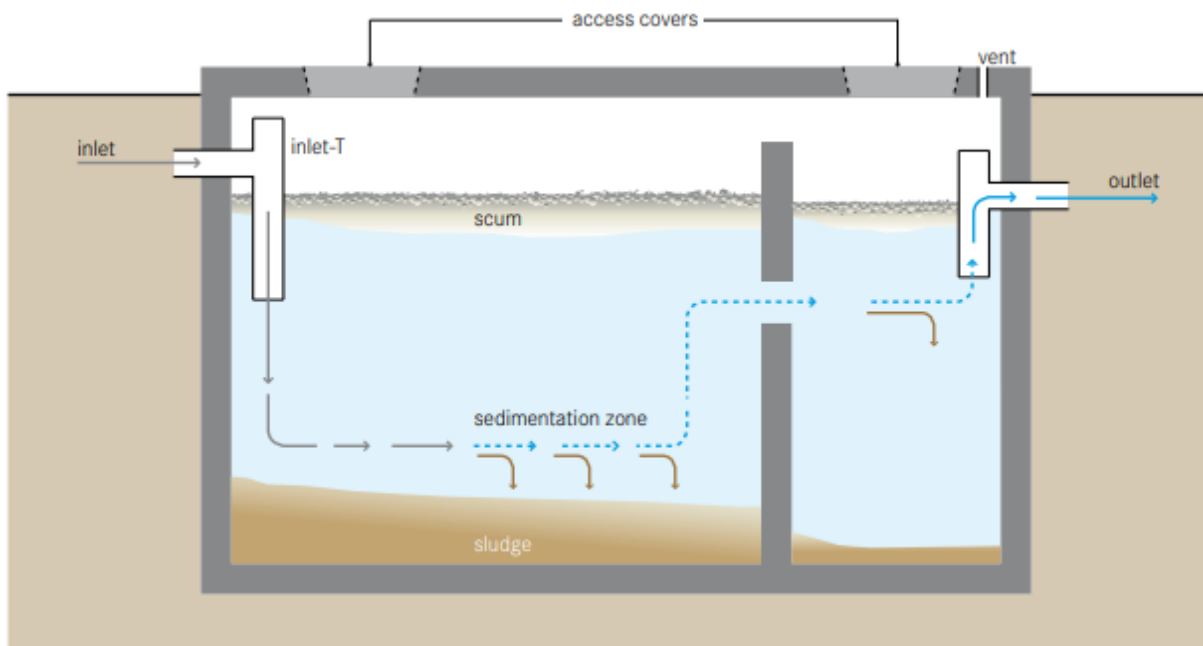
Technology classifications		Operational Complexity	Economic Viability	Environmental Effects	Social Effects	Contribution to waste mgmt		
Separation	Bins and Containers	Low	Moderate	Beneficial	Beneficial	Significant		
	Material Recovery Facility (MRF)	Medium	Moderate	Beneficial	Beneficial	Significant		
Handling/ Logistics	Baler	Medium	Profitable	Neutral	Neutral	Significant		
	Artisanal	Medium	Profitable	Beneficial	Beneficial	Marginal		
Recovery	Eco-bricks	Low	Moderate	Neutral	Beneficial	Marginal		
	'Downcycling'- Sintering & Intr.	High	Moderate	Beneficial	Beneficial	Marginal		
	'Recycling'- Commercial Scale	High	Moderate	Beneficial	Beneficial	Marginal		
	Material or mechanical recycling	Micro Pyrolysis	High	Loss-making	Neutral	Neutral	Absent	
		Industrial Pyrolysis	High	Moderate	Neutral	Beneficial	Absent	
	Feedstock or chemical recycling	Mobile Incineration	Low	Profitable	Unacceptable	Unacceptable	Absent	
		Technical Incineration	Medium	Moderate	Unacceptable	Unacceptable	Absent	
	Disposal	Incineration	Medium	Moderate	Neutral	Neutral	Significant	
		Land -fill	Controlled Landfill	Low	Moderate	Neutral	Neutral	Significant
			Sanitary Landfill	High	Loss-making	Beneficial	Beneficial	Significant

Details of currently available solid waste management technologies (Vogeler et al., 2021)

5.2 Sewage Treatment

Sewage treatment is minimal at best for all 31 islands. Many of the Sabah islands do not even have any holding tanks for wastewater. Just like the solid waste on small islands, the volume of wastewater generated is too little to justify the construction of costly sewage treatment plants.

Cesspits are underground holding tanks which require emptying from time to time and it is a commonly used solution by local inhabitants on small islands. These collection units are not the best for containing wastewater and pose significant environmental and health hazards. Most resorts on the other hand employ septic tanks. This system collects wastewater in a chamber which allows settling and anaerobic reduction. Given the financial constraints, this simple onsite sewage facility is the most practical short term solution for small islands. They are cost-effective, easy to deploy, offer primary sewage treatment and can be coupled with other treatment units like biofilters. One of the downsides to septic tanks is the need for regular maintenance. According to Indah Water, the national wastewater and sanitation company, septic tanks require desludging at least once every two years. Untreated septic tanks may result in accumulation of solids and eventually leakages detrimental to health and environment. Owners who do not desludge their septic tanks regularly can be fined under the Water Services Industry Act 2006. Establishing a desludging schedule should not be overlooked when introducing septic tanks to small, inhabited islands. It is unclear if the islanders who employ septic tanks have a fixed desludging schedule but it is clear that septic tanks are not sustainable long term solutions. The book “Compendium of Sanitation Systems and Technologies” describes an array of large scale sewage treatment systems, detailed with great length which can be applied in the long run.



Septic tank layout (Tilley, 2014)

6 Cost of Effective Waste Management against Cost of Inaction and Economic Loss

6.1 Cost of effective waste management

Based on Reef Check Malaysia's experience in establishing a waste management and recycling programme on Mantanani Island in Sabah with 190 households, we have created a model on cost estimation to implement a waste management system on each island. We have compared the costs with a larger island on Peninsular Malaysia, Tioman Island with 550 households, which has a formal waste management system and taken the average costs between the two islands. Reef Check Malaysia (RCM) has experience of establishing and managing recycling and waste management on two small, inhabited islands in Malaysia.

On Mantanani island, we established a waste management and recycling programme that serves 190 households and small village businesses on the island. Waste is segregated at source using bins provided to households. Waste is collected on a daily basis, sorted and stored temporarily before being transported back to the mainland for either disposal or recycling. All costs for the establishment and operation of the system are funded by RCM.

On Tioman island, a formal waste management system has been in place for several years and which serves 550 households. RCM established recycling on the island to supplement this and reduce the volume of waste being incinerated, which is now operated by several small businesses. The domestic waste collection and disposal system is now run by a government-contracted company, Alam Flora, which collects household and other waste daily (mainly from resorts and small retail/restaurant businesses) and transports it to an incinerator on the island. Estimates of the cost of running the system have been collected.

We have taken an average of costs of waste management on the two islands and used this as a model for estimating the cost of waste management on other islands.

Table 1: Set up cost on Mantanani Island

Particulars/Items	Quantity	Estimated Costs
Wire mesh bins	190 pcs X RM 30	RM 5700
Food waste storage	190 pcs X RM 10	RM 1900
Plastic bin	190 pcs X RM 5	RM 950
Wheelbarrow	4 pcs X RM 150	RM 600
Reusable gloves	10 pairs X RM 5	RM 50
Weighing scale	1 pcs	RM 250
Big storage box	4 X RM 20	RM 80
Segregation area construction costs		RM 3000
Total Set Up Costs		RM 12,530

Table 2: Monthly operational cost on Mantanani Island (190 houses)

Particulars/Items	Quantity	Estimated Costs
Part time wages	12 part timers X RM 15 X 30 days	RM 5400
Supervisor	1 X RM 40 X 30 days	RM 1200
Materials – (plastic bags, gloves, etc.)		RM 500
Site for rent	1	RM 500
Big wooden boat rent	2 boat	RM 2000
RORO bin	2	RM 600
GNC transportation	1	RM 150
Total Monthly Costs		RM 10,350

Table 3: Monthly operational costs on Tioman Island (550 houses)

Particulars/Items	Quantity	Estimated Costs
Formal waste collectors	10 X RM 1500 X 7 villages	RM 105,000
Recycling collectors	RM 300 x 7 villages	RM 2100
Port charge for recyclables	RM 50 x 7 villages	RM 350
Boat transport for recyclables	RM 35 x 3 bags x 7 villages	RM 735
Total Monthly Costs		RM 108,185

Table 4: Average set up cost per household

Island	Number of houses	Set up cost	Estimated set up cost per household
Mantanani	190	RM 12,530	RM 66

Table 5: Average monthly operational cost per household

Island	Number of houses	Monthly operational cost	Estimated monthly cost per household
Mantanani	190	RM 10,350	RM 54.47
Tioman	550	RM 108,185	RM 196.70
		Average cost based on two islands	RM 126

Noting the vast difference between the monthly operational costs for two islands, we are valuing the average monthly cost per household to be RM126. This is based on the best available information we have on hand. Further studies and evaluation may need to be conducted for a more accurate cost of operating holistic waste management on each island based on distance from mainland, accessibility of cargo barges, and current infrastructure on the islands.

We have applied this information on set-up and operating costs per household to other inhabited islands in Malaysia, to calculate annual waste management operational costs based on the number of households on each island.

Table 6: Estimated set up and operational costs for all islands

Islands	Estimated set up costs, if required (RM)	Estimated monthly operational costs (RM)	Annual operational costs (RM)
Aur	2508	4788	57456
Besar	726	1386	16632
Pemanggil	924	1764	21168
Sibu	3168	6048	72576
Tinggi	3168	6048	72576
Tioman*	N/A	108185	1298220
Aman	5280	10080	120960
Gaya	54133	103344	1240134
Mantanani*	N/A	10350	124200
Balambangan	3867	7382	88581
Banggi**	N/A	246058	2952700
Tigabu	2578	4921	59054
Bohayan	3300	6300	75600
Denawan	3867	7382	88581
Kalapuan	14520	27720	332640
Larapan	6600	12600	151200
Libaran	5412	10332	123984
Mabul	36828	70308	843696
Omadal	3867	7382	88581
Si Amil			0
Timbun Mata	660	1260	15120
Tun Sakaran Marine Park			
Bodgaya			
Boheydulang			
Tetagan			
Selakan	25778	49212	590540
Sebangkat			
Maiga			
Sibuan			
Mantabuan			
Perhentian	15180	28980	347760
Redang	16500	31500	378000
TOTAL	RM 208,862	RM 763,330	RM 9,159,959

* These islands' figures are accurate and not estimated, but do not include set-up costs as it is in existence.

** This island already has own waste management on the island with a landfill, hence do not include set up costs, but the operational costs are estimated.

On this basis, we estimate that the cost of implementing and operating waste management systems on all small, inhabited islands in Malaysia to be **RM 184 million for 20 years**.

Set up costs (RM208,862) + Operational costs for 20 years (RM9,159,959 x 20)
= RM 183,408,042

6.2 Value of marine ecosystems in Malaysia

Limited data are available on the value of marine ecosystems in Malaysia. The value of marine biodiversity is naturally hard to quantify, as there are a multitude of direct and indirect benefits to consider. For the purpose of this study, we are proposing to use the latest data from Department of Fisheries Malaysia on the Total Economic Value of Marine Biodiversity in Marine Parks of Malaysia¹. To date, there are 42 Marine Parks in Malaysia covering an area of 2,486.13 sq. km and they have an estimated annual value of RM 8.7 billion (USD 2 billion).

Fisheries - RM580.4 Million

Coral reefs and their surrounding ecosystems, including mangroves and seagrass beds, provide important fish habitat. In Malaysia, consumption of fisheries product per capita 56kg year which is among the highest in the world. This shows the importance of fish resources to our people. Fisheries industry also contribute 1.3% of our national Gross Domestic Product.

Bequest Value - RM14 .5 Million

Coral reefs serve as natural barriers to storm surges that can cause great destruction to coastlines and communities. Our coastal zones laced with mangroves and coral reefs were reported to be able to act as barriers for storms, tsunami and coastal erosion. This was proven when areas with mangroves were left intact after the 2004 tsunami in Straits of Melaka. This in an important budgetary saving for the country and our people. Bequest value is an intangible value and classified as Non-Use Value. The value is measured from the perspective of the tourist on how far their desire in conserving the future ecosystem of goods and services that is not going to be used at present. The measurement is being proximate on the monetary value which, considering their willingness to pay in the future towards all the goods and services provided in marine parks.

Carbon Sequestration - RM30.24 Million

Carbon sequestration is a very important component in supporting the life of community globally by regulating the climate. Carbon dioxide can be sequestered through mangrove, seagrasses and to some extent coral reefs. These ecosystems are commonly found in our coastal areas. These ecosystems coexist to support each other and balance CO₂ emissions, whilst assists to decelerate the greenhouse effect.

Coastal Protection - RM56.25 Million

Coral reefs serve as natural barriers to storm surges that can cause great destruction to coastlines and communities. Our coastal zones laced with mangroves and coral reefs were reported to be

able to act as barriers for storms, tsunami and coastal erosion. This was proven when areas with mangroves were left intact after the 2004 tsunami in Straits of Melaka. This in an important budgetary saving for the country and our people.

Tourism - RM4 .6 Million

Coral reefs are among the most visited natural areas in the world. SCUBA diving is an important component of marine tourism, a multi-billion dollar industry and one of the world's fastest growing recreational sports. Marine Parks in Malaysia receive an average of 630,000 visitors a year with an annual increment of 5%. This shows growing interest of tourists to natural environment especially one that is protected and effectively managed to ensure maximum satisfaction.

Aesthetic Value - RM8.0 Billion

Researchers around the world have searched for universally valid criteria for aesthetic principles and exploring methods to quantitatively describe the value of beauty and ugliness. A study suggest that human perception of aesthetics is well-aligned with healthy, thriving ecosystems. The World Heritage system, recognises aesthetic values of a property as outstanding universal value. Alongside the presence of values, properties inscribed on natural criteria must also satisfy conditions of integrity. This therefore means value of protecting these areas to ensure integrity and sustainability.

Biological Support - RM1 Million

Generally, it is agreed that the main functions of marine park area are to protect species, habitat and biodiversity. According to Constanza et. al. (1997), these functions in turn provides the goods and services which benefit human populations. Marine parks in Malaysia is home to many endangered species. Endangered species that are found and automatically protected are sea turtles, giant clams, dugongs, and sharks just to name a few. This area serves as refuge from predators, food source, grow out area and breeding grounds.

6.3 Economic Cost of Inaction due to Environmental Pollution

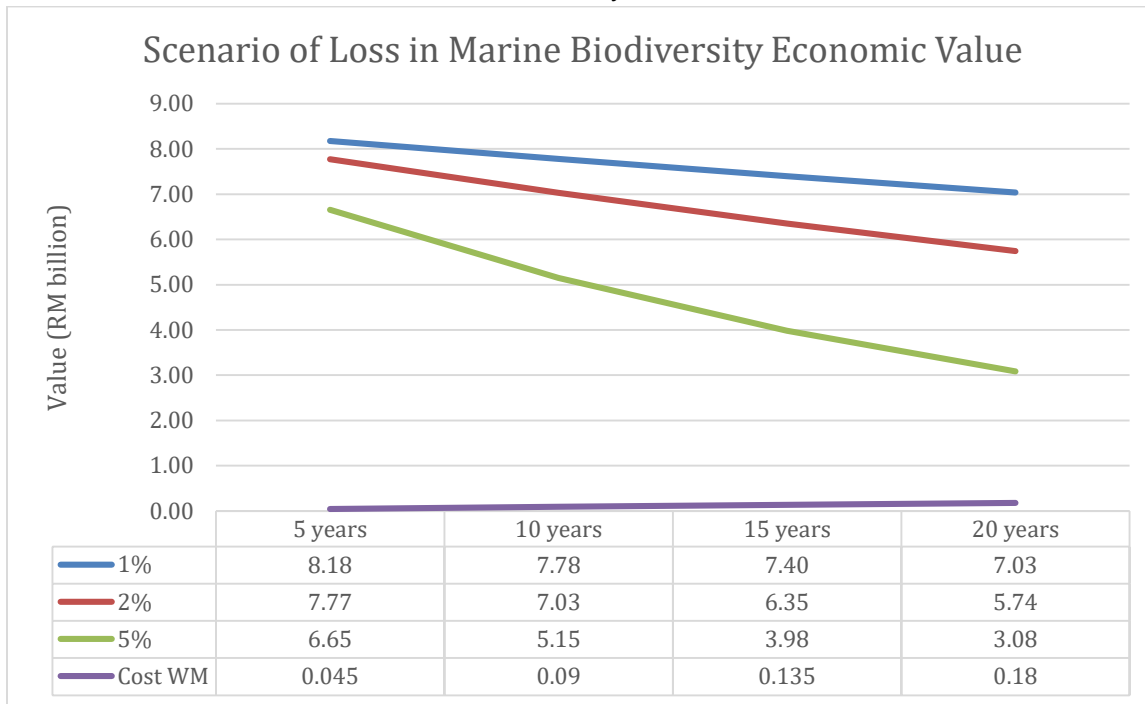
Based on the costs of implementing waste management on the inhabited islands and the total economic value of marine biodiversity in Malaysia, we can model various cost scenarios for loss in economic value due to environmental pollution. We will be able to infer if the costs of implementing waste management systems are justified in the long term.

The rate of Marine Biodiversity Economic Value annual loss of 1%, 2%, and 5% is based on secondary research and studies conducted in other regions (Beaumonta et al. 2019).

“Based on available research it is not yet possible to accurately quantify the decline in annual ecosystem service delivery related to marine plastic. However, the evidence set out suggests substantial negative impacts on almost all ecosystem services at a global scale. In light of this evidence, it is considered reasonable to postulate a 1–5% reduction in marine ecosystem service delivery as a result of the stock of marine plastic in the oceans in 2011. Such a conjecture is conservative when compared to the reduction in terrestrial ecosystem services due to anthropogenic disturbances available in the literature, e.g. a 11–28% decline of global terrestrial ecosystem services (by value) arising from land use changes between 1997 and 2011 (Constanza et al., 2014), and a reduction of up to 31% (by value) due to urbanisation in China (Su et al., 2014; Su et al., 2012).”

“This 1–5% decline in marine ecosystem service delivery equates to an annual loss of \$500–\$2500 billion in the value of benefits derived from marine ecosystem services. With the 2011 stock of plastic in the marine environment having been estimated between 75 and 150 million tonnes (Jang et al., 2015; McKinsey, 2015), this would equate in 2011, under 2011 levels of marine plastic pollution and based on 2011 ecosystem services values to each tonne of plastic in the ocean having an annual cost in terms of reduced marine natural capital of between \$3300 and \$33,000. This postulation of an economic cost relates only to the impacts of marine plastic on marine natural capital and as such represents a ‘lower bound’ of the full economic costs of marine plastic. This figure does however illustrate the potential order of magnitude of the impacts. In recognition of the limitations of this economic cost, we identify four key areas of research to further develop the economic cost: (1) we recognise that the economic cost presented here is an underestimate as there are broader social and economic costs that need to be quantified and included, for example, direct and indirect impacts on the tourism, transport and fisheries sectors as well as on human health.”

Chart 1: Scenario of Loss in Marine Biodiversity Economic Value in Marine Parks in Malaysia



If we take into account the value of marine biodiversity (Chart 1), the total economic value of marine ecosystems is RM 8.7 billion annually.

At a rate of 1% annual loss in value over 20 years, the cost would be equivalent to RM 1.57 billion.

At a rate of 2% annual loss in value over 20 years, the cost would be equivalent to RM 2.86 billion.

At a rate of 5% annual loss in value over 20 years, the cost would be equivalent to RM 5.52 billion.

6.4 Analysis and Conclusions

This analysis has shown that inaction on improving waste management on small inhabited islands in Malaysia will cause very significant economic losses.

Using data from RCM's own work, the cost of establishing and operating waste management on small islands in Malaysia is estimated at **RM 184 million** over a period of 20 years. Using published data on the value of ecosystem services in Malaysia's Marine Parks, the loss of economic value of marine biodiversity ranges from **RM 1.6 billion to over RM 5.5 billion** over the same 20-year period, depending on the annual loss assumed.

At this early stage of the science of valuing ecosystem services, it is often impractical to determine the value of more than one or a few services. Part of the difficulty of determining the value of all the services within an ecosystem is that the methods for obtaining the necessary information are often so different for each service. However, we have decided to use the available government data on the value of Marine Parks as a reliable benchmark figure. It should be duly noted that the value is estimated only for Marine Protected Areas, not taking into account the value of all marine biodiversity in Malaysia waters, which is likely to be worth much more.

7 Appendix

7.1 Consolidated list of 31 small inhabited islands

ISLAND	POPULATION	HOUSEHOLDS	SOLID WASTE MANAGEMENT	SEWAGE TREATMENT
<i>Small inhabited islands of Johor (Known collectively as Mersing islands)</i>				
Aur	124	38	Open burning; open dumping; composting; recycling; sent to landfill on mainland	Cesspits and septic tanks
Besar	18	11		
Pemanggil	33	14		
Sibu	180	48		
Tinggi	160	48		
<i>Small inhabited islands of Pahang</i>				
Tioman	3700	550	Controlled incineration but limited capacity; minimal recycling	Non-centralized; septic tanks and soakaway systems
<i>Small inhabited islands of Penang</i>				
Aman	250	80	Open burning; composting; sent to landfill on mainland	Cesspit with occasional maintenance
<i>Small inhabited islands of West Coast Sabah</i>				
Gaya	4200+	<i>Data unavailable</i>	Open burning; bury; dump into sea	Non-existent; resorts use septic tanks
Mantanani	1000	190	Sent to landfill on mainland, wide-scale recycling	Non-existent
<i>Small inhabited islands of North Coast Sabah (All under Tun Mustapha Park)</i>				
Balambangan	300	<i>Data unavailable</i>	Open burning	Non-existent
Bangi	10000	<i>Data unavailable</i>	Own landfill on the island but some still burn/ dump	Non-existent

			into sea	
Tigabu	200	<i>Data unavailable</i>	Open burning	Non-existent
<i>Small inhabited islands of East Coast Sabah</i>				
Bohayan	100	50	Open burning; dump into sea	Non-existent
Denawan	300	<i>Data unavailable</i>	Open burning; dump into sea	Non-existent
Kalapuan	<i>Data unavailable</i>	220	Open burning; dump into sea; sometimes collected by contractors	Non-existent
Larapan	1200	100	Open burning; dump into sea	Non-existent
Libaran	340	82	Bury on island	Some use septic tanks
Mabul	3845	558	Open burning; dump into sea; some are sent to landfill on mainland	Wastewater stored in poly tanks and buried on the island
Omadal	300	<i>Data unavailable</i>	Open burning; dump into sea	Non-existent
Si Amil	<i>Data unavailable</i>	<i>Data unavailable</i>	Open burning; dump into sea	Non-existent
Timbun Mata	<i>Data unavailable</i>	10	Open burning; dump into sea	Non-existent
Tun Sakaran Marine Park Bodgaya Boheydulang Tetagan Selakan Sebangkat Maiga Sibuan Mantabuan	At least 2000	<i>Data unavailable</i>	Open burning; dump into sea; some are gathered and collected by contractors	Wastewater stored in holding tanks and emptied out by contractors
<i>Small inhabited islands of Terengganu</i>				
Perhentian	1800	230	Collected at irregular times and sent to landfill on mainland	Poorly maintained open sewage treatment; households use septic tanks
Redang	2000	250	Some open burning, sent to landfill on mainland	Cesspits and septic tanks

7.2 List of Interviewees

- Alvin (RCM)
- Azhar (Semporna Islands engineer)
- Daniel (Fuze Ecoteer)
- David (Scuba Junkie)
- Haslam (Sabah Parks)
- Jamie (RCM)
- Jeeth (TRACC)
- Jikral (Pulau Libaran contractor)
- Joaniee (WWF Kudat)
- Khairul (TRACC)
- Leong (Pulau Gaya Director of Department of Waste Management)
- Melynda (RCM)
- Naquiah (Fuze Ecoteer)
- Nazirul (RCM)
- Semporna Paradise Travel & Tours (Pulau Timbun Mata tourism operator)
- Shahidi (Pulau Aman Head of Village)
- Putri Asma (RCM)

8 References

- Agamuthu, P. and Herat, S., 2014. Sustainable waste management in Small Island Developing States (SIDS). *Waste Management & Research: The Journal for a Sustainable Circular Economy*, 32(8), pp.681-682.
- Akmal, R., 2020. *Discover the uniqueness of Pulau Aman | Buletin Mutiara*. [online] Buletin Mutiara. Available at: <https://www.buletinmutiara.com/discover-the-uniqueness-of-pulau-aman/> [Accessed 7 August 2021].
- Beaumonta, NJ., Aanesenb, M., Austena, M.C., Börgerc, T., Clarka, JR., Colea, M., Hoopera, T., Lindequea, PK., Pascoea, C., Wylesd, KJ., 2019. Global ecological, social and economic impacts of marine plastic. *Marine Pollution Bulletin*, Volume 142, May 2019, pp. 189-195.
- Constanza, R., et al., 2014. Changes in the global value of ecosystem services. *Glob. Environ. Chang.* 26, 152–158.
- Hasan, C., 2021. *UMS working to help Mabul community manage plastic waste*. [online] Ums.edu.my. Available at: <https://ums.edu.my/v5/en/banner-link/10539-ums-working-to-help-mabul-community-manage-plastic-waste> [Accessed 7 August 2021].
- Jang, Y.C., et al., 2015. Estimating the global inflow and stock of plastic marine debris using material flow analysis. *Journal of the Korean Society for Marine Environment and Energy* 18, 263–273.
- Lim, AG., Md Repin, I. (eds.), *Total Economic Value of Marine Biodiversity*. [online] Jabatan Taman Laut Malaysia. Available at: https://wdpa.s3.amazonaws.com/Country_informations/MYS/TOTAL%20ECONOMIC%20VALUE%20OF%20MARINE%20BIODIVERSITY.pdf [Assessed on 3 January 2022].
- Majid, M. and Tan, Kowang., 2007. Sustainable Solid Waste Management For Island Resorts: Potential For Perhentian Island, Terengganu.
- McKinsey, O., 2015. Conservancy. In: *Stemming the Tide: Land-based Strategies for a Plastic-free Ocean*.
- Md. Shah, J. and Selamat, N., 2016. Urban Fishermen in Gaya Island, Kota Kinabalu, Sabah: The Challenges. *World Applied Sciences Journal*, 34(12), pp.1643-1651.
- Su, S., Xiao, R., Jiang, Z., Zhang, Y., 2012. Characterizing landscape pattern and ecosystem service value changes for urbanization impacts at an eco-regional scale. *Appl. Geogr.* 34, 295–305.
- Su, S., Li, D., Hu, Y., Xiao, R., Zhang, Y., 2014. Spatially non-stationary response of ecosystem service value changes to urbanization in Shanghai, China. *Ecol. Indic.* 45, 332–339.
- Tilley, E., 2014. *Compendium of sanitation systems and technologies*. Dübendorf: EAWAG.
- Vogeler, T., Mangelmann, T., binti Abdul Satar, Q., Anom, J., Lohle, S., Brinkmann, J. and Chaabane, W., 2021. *Toolbox for determining appropriate technology and solutions for plastic on small and remote islands in Malaysia*.