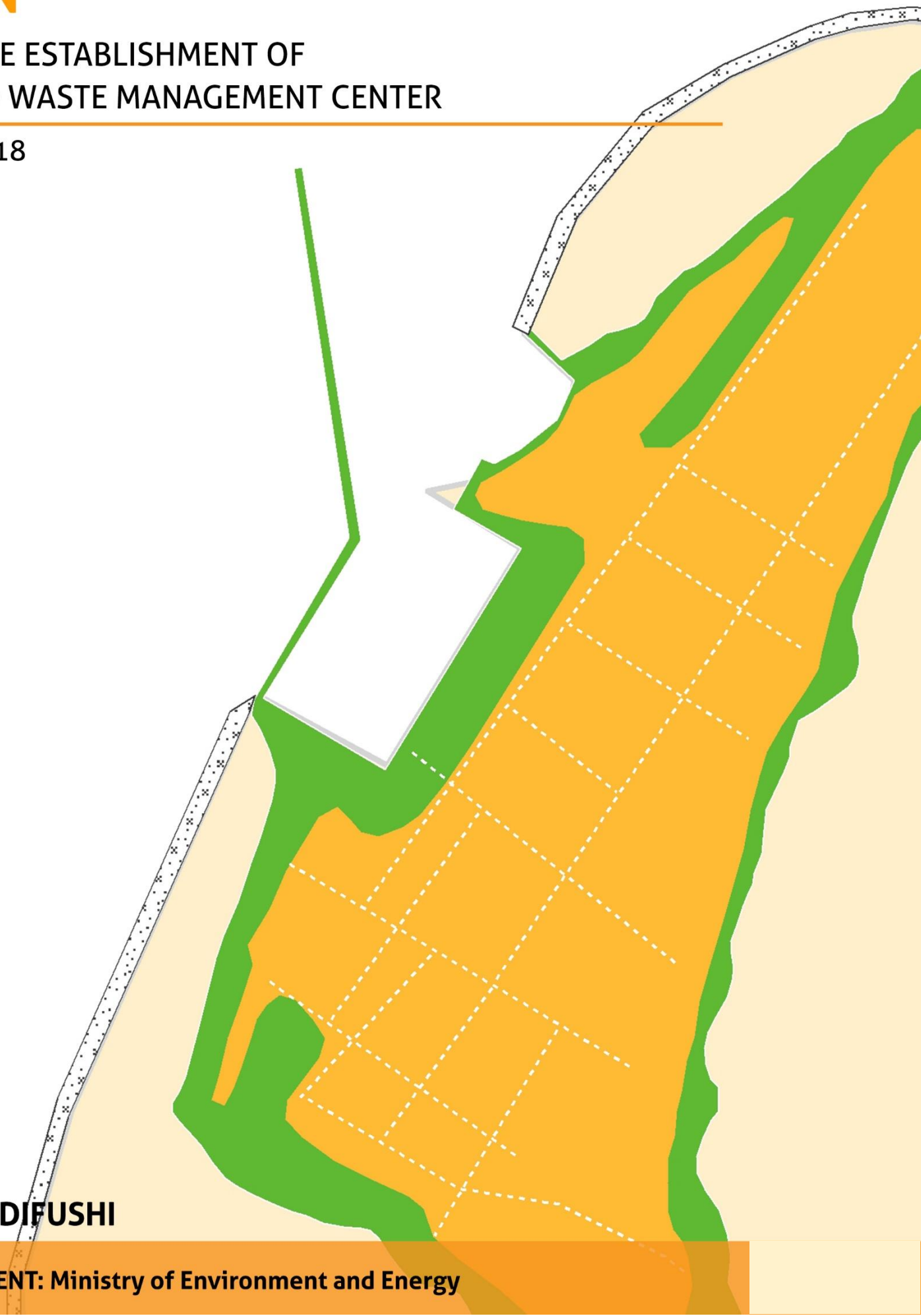
ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

FOR THE ESTABLISHMENT OF ISLAND WASTE MANAGEMENT CENTER

JULY 2018



TH. MADIFUSHI

PROPONENT: Ministry of Environment and Energy

July 2018

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN
FOR
THE ESTABLISHMENT OF ISLAND WASTE MANAGEMENT CENTRE
IN
TH. MADIFUSHI

PREPARED FOR
MINISTRY OF ENVIRONMENT AND ENERGY

PREPARED BY
AHMED SALEEM

JULY 2018

PROJECT SYNOPSIS

Name of the Project: Establishment of Island Waste Management Centre in Th. Madifushi
Project Proponent: Ministry of Environment and Energy
Project Value: -
Expected Duration: 12-24 weeks
Consultant: Ahmed Saleem
Date: July 2018

WEIGHTS AND MEASURES CONVERSIONS

1 metric tonne = 2,204 pounds (lbs.)
1 kilogramme (kg) = 2.2 pounds (lbs.)
1 metre (m) = 3.28 feet (ft.)
1 millimetre (mm) = 0.03937 inches (”)
1 kilometre (km) = 0.62 mile
1 hectare (ha) = 2.471 acres

LIST OF ABBREVIATIONS

CBD	Convention on Biological Diversity
CO_2-e	Carbon dioxide equivalent
DA	Decentralisation Act
DDRPM	Development of Disaster Risk Management Profile Maldives
DIRAM	Detailed Island Risk Assessment in Maldives
DNP	Department of National Planning
DO	Dissolved Oxygen
EIA	Environment Impact Assessment
ESMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
EPPA	Environmental Protection and Preservation Act
ES	Environmental Score
EPZ	Environmental Protection Zone
GHG	Green House Gas
GPP	Gross Primary Production
GoM	Government of Maldives
HIES	Household income and expenditure survey
HIA	Hanimaadhoo International Airport
Hs	Peak Height
IWM	Island Waste Management
IWMC	Island Waste Management Centre
IWMF	Island Waste Management Facility
MCA	Multi Criteria Analysis
MEE	Ministry of Environment and Energy
MHI	Ministry of Housing and Infrastructure
MMS	Maldives Meteorological Service
MOFA	Ministry of Fisheries and Agriculture
MPA	Marine Protected Area
MSL	Mean Sea Level
MoT	Ministry of Tourism
NBSAP	National Biodiversity Strategy and Action Plan
NBSAP	National Biodiversity Strategy and Action Plan
MNSSD	Maldives National Strategy for Sustainable Development
NAPA	National Adaptation Programme of Action
RWM	Regional Waste Management
RWMC	Regional Waste Management Centre
RWMS	Regional Waste Management System
WMP	Waste Management Plan
RWMP	Regional Waste Management Plan

IWMP Island Waste Management Plan

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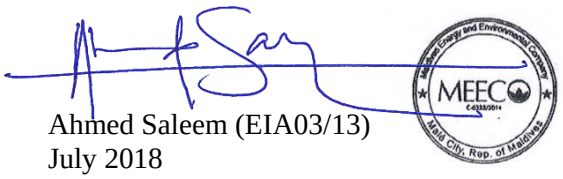
DECLARATION OF THE CONSULTANT AND PROPONENT

I certify that the statements made in this Environmental and Social Management Plan are true, complete and correct to the best of my knowledge and available information at the time of writing this report.



Ahmed Saleem (EIA03/13)
July 2018

Proponent

The proponent of this project Ministry of Environment and Energy, Maldives has provided the declaration and commitment letter which is attached in **Annex 1.**

AKNOWLEDGEMENT

The author of the report is Mr. Ahmed Saleem who is a registered EIA consultant with the Maldives EPA. In preparing the report the author was assisted by a multi-disciplinary team of experts and wish to acknowledge their invaluable input in preparing the report. The team members, their respective field of expertise and areas of contribution to the assessment is given in **Table 1**.

Table 1: The ESMP Team

Name	Qualification	Designation/Field of Expertise	Contributing Area
Mr. Ahmed Saleem	MSc. Ecology & Environment	Author, Lead EIA Consultant	• Overall administration of the ESMP preparation • Chapter reviews • Report compilation
Mr. Ali Hammadh	BSc. Environmental Management	Consultant	• Stakeholder consultations • Contributed to the various chapters of the report.
Mr. Maumoon Saleem	BSc. (Hons) Civil Engineering	Civil Engineer / EIA Consultant	• Data analysis • Data collection • Concept review • Stakeholder consultations • Field work • Contributed to the various chapters of the report.
Mr. Dinal Shalika		Surveying	• Preparation of maps and charts, filed work
Mr. Muslih Mujtaba		Surveying	• Surveys, field work

NON-TECHNICAL SUMMARY

1. Recognising that preventing and managing waste is at the heart of sustainable development in the islands of the Maldives, the Ministry of Environment and Energy as the Proponent has proposed a project to establish an Island Waste Management Centre (IWMC) in six (6) islands of Zone IV and V (islands within the atolls of Meemu (M), Faafu (F), Dhaalu (Dh), Thaa (Th) and Laamu (L)) in order to manage waste generated at island level. The project is funded by the World Bank under the "Saafu Raajje – Maldives Clean Environment Project for Zone IV and V". The proponent has requested consultancy services of the Consultant for the preparation of an Environmental and Social Management Plan (ESMP) for the proposed project. This ESMP includes 1 of the 6 islands, namely Th. Madifushi.

2. Th. Madifushi has a demarcated area for dumping waste where waste can be segregated and stockpiled. This 3000 sqft dumpsite has been operational for the past 2 years and has now reached its capacity due to lack of volume reduction machinery and transportation of waste. Green waste is burnt on site, and kitchen waste is dumped into the lagoon area. Th. Madifushi Council has formulated an Island Waste Management Plan which is yet to be approved by the EPA.

3. The proposed IWMC under the current project is located in the southern end of the island at the newly reclaimed area. No vegetation clearing is required for this plot, and the plot is easily accessible.

4. The main activities involving the construction of the IWMC include shallow excavation, substructure and superstructure works as well as masonry works. The proposed design of the IWMC requires a shallow foundation due to the structure being a single story structure. After the structural works are done, masonry, plastering, roofing works are completed prior to the addition of the services components such as electricity, fire-fighting and plumbing. The construction phase of the project is expected to be completed within 12-24 weeks.

5. The operational phase of the project would mainly include waste collection from households, institutions, and public spaces, sorting, volume reduction and stockpiling of re-usable, recyclables, composting of organics, and storage of hazardous waste.

6. Key activities anticipated to have a negative impact during construction phase are:

Table 2: Impacts envisaged during construction phase and proposed mitigations

Activity	Main Impacts	Major mitigations
Workers Influx and Settlement	Impacts on flora and fauna	Sensitive workers on intentional/unintentional damage to flora, sensitive sites, against catching birds and animals, damage to flora, workforce kept at minimum, littering prohibited.
	Impacts on resource use	Keeping workforce to minimum needed, creating awareness on avoiding wastage of resources, proper supervision and auditing of the resource use.
	Sociocultural impacts	Encourage choosing local workers, if foreign workers are brought ensure proper work permits, worker orientation

		to the island's social, religious and traditional values and customs.
Transportation of Materials	Marine and terrestrial pollution	Prevent littering, containing waste generated during construction phase, clear guidelines implemented by workers on managing various types of waste generated during construction phase.
	GHG Emissions	Obtain materials from closest source, buy materials in bulk, and reduce wastage, use of well serviced, efficient, and vehicles conforming to regulations during all stages of the project.
	Roads deterioration	Include in agreement with the contractor to repair any damages to roads after project, use the shortest route for transportation, only the required amount and size vehicles shall be used.
	Accidents & injuries	Licensed drivers, speed limits shall be strictly observed, avoid transportation at night, secure loads being transferred.
Site Demarcation and Fencing	Accidents & injuries	Workers safety guidelines shall be in place and properly explained before work begins, provide to the workers protective clothing, works done during daytime
Construction	Material storage	Equipment fenced off, no naked flames allowed in the storage area, National Fire Code followed for handling fuel, firefighting equipment's made available.
	Terrestrial pollution	Temporary waste storage area set onsite, cleaning of litter, hazardous waste shall be stored in closed containers and stored separately, transfer all project related waste to nearest approved waste management facility.
	Noise	Provide PPE equipment, use well serviced plant and machinery, and reduce vehicle idling time.
	Accidents & Injuries	Occupational safety plan, orientation, PPE provided.
Waste Generation	Marine and terrestrial pollution	No construction related waste shall be allowed to enter into marine environment through proper waste management during construction phase, littering of waste shall be prohibited by the workers, containment of waste at the project site and waste transported to nearest waste management facility after works are completed.
Resource Use	Water	Water conservation practices shall be followed by all workers as a work site rule, regular checking of leaks, practice water conservation.
	Electricity consumption	Electricity wastage at site shall be avoided through good practices and creation of awareness, work shall be planned to be conducted during daytimes as far as possible.

Out of the construction phase activities the impacts identified are expected to be minor to moderate negative impacts.

Key activities anticipated to have an environmental impact during operation phase were:

Table 3: Impacts envisaged during operational phase and proposed mitigations

Activity	Main Impacts	Major mitigations
Waste collection and transportation	Habitat degradation (land, reefs, beaches)	• Island level regulations on preventing waste littering, dumping of waste on undesignated areas through imposing fines and penalties. • Requirements for waste separation and containment for collection.
	<u>Climate impacts</u> Residual waste transport from the island to the nearest waste management facility would generate GHGs	• Minimize waste generated at source by regular waste awareness programs and introducing polluter pay principle to discourage waste generation • Regularly servicing of vehicles. • Restrict use of vehicles only certain times in WMP. • Ensure that battery operated vehicles are used for waste collection and transportation where applicable.
	Accidents and injuries Potential health risks to workers - collecting certain types of waste such as metals and glass people can get cuts and infections	• Adequate PPE shall be made available to those collecting wastes • Overloading of vehicles prevented. • Occupational safety plan, orientation, well trained personnel to use vehicles.
	<u>Air quality</u> Odour issues during transport	• Use well serviced vehicles, vehicle covered, spray water to suppress dust during dry periods if necessary.
Waste management activities (dumping, sorting, volume reduction and composting)	Impact on land The island has very limited land area, which limits allocation of large areas of land for waste management. Allocation of space for waste management would mean having to forgo alternative uses of the allocated land plot.	• Reduction of waste at its sources and the reduction of the total volume of waste requiring disposal. Waste reduction should include use of clean technologies, reuse and recycling. Regular public awareness campaign to promote reduction of waste at household and community levels is also fundamental. • Development and introduction of a regulatory framework, including proper guidelines for managing waste, are needed. Once these instruments are in place enforcement measures will need to be in place.
	<u>Health impacts</u> Waste collection site can become a breeding ground for pests and disease causing agents such as mosquitoes and rats. Odour issues. Waste can pollute groundwater through the leaching of toxic chemicals into the ground.	• Waste shall be dumped on paved areas. • Piling and overfilling of waste dumping area shall be prevented through volume reduction, transport to final site etc.. • Hazardous waste shall only be stored in closed and sealed containers and kept on hard surfaces to prevent seepage into the groundwater lens. • Compaction and baling of waste needing transport to final waste management site.

	Groundwater pollution	• HDPE linings provided through design, leachate collection system. • waste not stockpiled on the ground.
	Amenity impacts	• Developing and enforcing island level waste management rules to prohibit littering within the premises and en-route to the site on the island. • Impose penalties for littering, regular cleaning and supervision of the IWMC, keep stockpiles of organics low, keep pest and vermin population controlled through various IWM practices described.
	Air quality impacts	• Preventing long-term accumulation of unmanaged waste at the site through proper IWM practices.
	Fire hazards	• Burning of waste as a waste management practice is not encouraged at the site. • Firefighting equipment's shall be made available at the waste management site. • Proper electrical wiring by a certified person. • Naked flames shall not be allowed at IWMC, placing awareness signs at the premises.
	Accidents and injuries	• Formulate occupational safety plan. • Worker training on safety practices and providing PPE. • Use licensed drivers and operators. • Placing a first aid kit at IWMC.
Waste generation	Groundwater pollution Waste generation being the main cause of all related impacts most efforts need to be focused on reducing the waste generated at source.	• Regular targeted awareness programs to all members of the community on ways to minimize waste generated. • Measures at island level on the use of non-biodegradable wastes. • Placing awareness sign boards at appropriate locations of the island. • Introducing polluter pays principle through fee schemes after a proper willingness to pay study.
Resource consumption	Water	• Ensure compost windrow is shaded during dry periods. • Use a spray hose to decrease water consumption. • Arrangements to collect rainwater within the facility which can be used for cleaning and composting purposes.
	Electricity consumption	• Ensure the equipment are properly serviced and maintained • Equipment shall only be operated when under a given schedule and switched off as soon as operations are complete. • Use of solar panels and solar lights to minimize use of fossil fuel based electricity.

Introducing a proper waste management scheme to the island is expected to have significant positive impacts to the island. These include positive effects on the overall health and well-being of the island community and improved air qualities, prevention of polluting beaches and marine environment, controlling of pests and disease causing animals. In islands poor waste management leads to overpopulation of crows and rats which can directly negatively impact cash crops in addition to them acting as agents for spreading certain diseases. Proper waste management would control their population explosion of pests and disease causing organisms

and thereby positively impacting the population. In addition proper waste management would improve the overall aesthetic appeal of the island improving overall mental wellbeing of the residents and visitors to the island. The local economy is also envisaged to have such impacts due to the generation of jobs, business opportunities through transportation of waste, and income from selling of compost, and other recyclable materials such as metals, glass and plastics.

7. It is expected that approximately 70% of the waste generated within the island can be managed at the IWMC and 30% would need removal from the island as residuals. However in the absence of a regular arrangement to remove residuals from the island, these can quickly accumulate and the whole waste management system could collapse. Therefore, in order to avoid the IWMC reaching capacity for storage and composting, it is recommended to have in place a regular transport mechanism to transport unmanaged waste to the nearest waste management facility. In contingency for cases where transportation is delayed, it is recommended to provide wheelie bins within the premises to temporarily store the unmanaged organic waste, while alternative transportation options are arranged.

8. It should be noted that without the proper assistance, financially (in terms of regular budgetary allowances for operational and transport requirements) and technically (in terms of provision of trainings and equipment), the IWMC runs the risk of potentially turning into a dumpsite, exacerbating the possible negative impacts to the receptors. Provision of resources to the Island Council, in the form of budgetary allocations, proper training and waste management equipment is seen as a central cog in ensuring the proper management of waste in the island. The Proponent shall ensure the aforementioned assistance is provided.

9. Implementation of the island's Waste Management Plan, in addition to the enforcement of Waste Management Regulations and Guidelines is seen as crucial in achieving proper waste management within the island. The Island Council also shall ensure the proper operation of the IWMC and waste management within the island through enforcing penalties on non-conformances to gazetted waste management regulations and guidelines.

10. A reporting mechanism has been proposed with this ESMP, which includes the IWMC occupier, the Island Council, and the Proponent. Proper reporting of the IWMC operations within the mechanism can ensure the continued monitoring and evaluation of the operations, provision of required assistance, and provide crucial information for future planning and policy decisions for the Proponent.

11. The Proponent of the project, Ministry of Environment and Energy guarantees their commitment to undertake the necessary mitigation measures and monitoring during all stages of the project that has been proposed in the report.

12. In conclusion, the findings of the ESMP shows that the proposed activities for this project has minor to moderate negative impacts during the construction works, and minor negative impacts as well as major positive impacts during the operational phase. With the proposed measures, the envisaged negative impacts can be mitigated, and the positive impacts enhanced. Given that the Proponent has committed to the mitigation actions it is anticipated that the project can be implemented with almost all significant impacts brought to an acceptable level, and ensure the positive impacts envisaged from this much-needed project.

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1 INTRODUCTION

1.1 PROJECT BACKGROUND

Ministry of Environment and Energy, Maldives (MEE) has proposed a project to establish an Island Waste Management Centre (IWMC) in six (6) islands of Zone IV and V (islands within the atolls of Meemu (M), Faafu (F), Dhaalu (Dh), Thaa (Th) and Laamu (L)) in order to manage solid waste generated at island level. The project is funded by the World Bank under the "*Saafu Raajje – Maldives Clean Environment Project for Zone IV and V*".

The completion of the proposed project will result in the establishment of an Island Waste Management Centre (IWMC) in these six islands (6), and the operation of the IWMC will be facilitated under the Waste Management Plan (WMP) formulated by the respective Island Councils and approved by EPA.

The project will be implemented under the *Saafu Rajje Policy* formulated by MEE to:

- Reduce the amount of waste produced and discarded;
- reuse, items discarded as waste;
- recycle waste to create value added products;
- use waste to generate energy; and
- dispose waste in an environmentally sound manner.

The main objectives of the policy are to:

- Ensure that all Maldivians understand the importance of waste management and create awareness with regard to the waste management policy;
- evolve and develop the society through awareness so that it strives to protect and manage the natural environment sustainably;
- ensure all aspects of civil life are hygienic;
- ensure that air pollution is controlled and prevented; and
- ensure that Maldives retains its natural coastal and marine environment free from pollution.

In order to achieve the objectives of *Saafu Raajje Policy*, a Regional Waste Management Center (RWMC) will be created in each zone/region as the final treatment and disposal facility for the waste collected at island level.

The scope of the proposed IWMC is to facilitate island level management of the waste generated within the island, which includes sorting of waste types, storage of hazardous wastes, volume reduction of inorganic waste, stockpiling and composting of the waste. The waste that is not manageable in the island level is to be transported to the proposed Regional Waste Management Center (RWMC). At the time of the report, MEE is currently in the process of selecting a consultant to undertake the feasibility study of the RWMC for the region.

The proposed IWMC will be financed by World Bank and constructed by contractors procured by MEE locally. Prior to construction of IWMC, preliminary studies such as site selection/approval, environmental and social management plans are to be completed. Therefore, proposed locations for IWMC was screened by EPA and Ministry of Housing and Infrastructure (MHI). The initial screening of the locations resulted in the following six (6) islands listed below was classified as requiring an Environmental and Social Management Plan (ESMP).

- M. Mulah

- Th. Buruni
- Th. Omadhoo
- Th. Madifushi
- Th. Kinbidhoo
- Th. Thimarafushi

This report includes one (1) of the aforementioned six (6) islands, namely Th. Madifushi.

1.1.1 The Project Island

Among the other Project islands, this report is focussed on Th. Madifushi, which is one of the inhabited islands of Thaa atoll located at 02°21′20″N and 73°21′10″E. Situated on the eastern side of the atoll the island covers an area of about 19.5 ha naturally. The island is undergoing reclamation which is in its final stages. The reclamation adds an addition 20 ha which makes the island's total area into approximately 40 ha. Along with this, construction of the new harbour works are also underway. The newly constructed harbour is 800 x 300 ft in size. The island has a population of 1340 people and was one of the islands severely devastated during the 2004 tsunami. The nearest inhabited island is Dhiyamigili on the southwestern side of Madifushi and is roughly 2.65 km away. The nearest uninhabited island is Ufuriyaa just 0.28 km away. COMO Maalifushi in Maalifushi is the closest resort to the island 9.16 km away. Moreover, the closest airport is in Thimarafushi located on the southern region of the atoll.

The island has 24-hour electricity service and a central sewerage system. The island has a health centre and education provided up to grade 10.

Project Management and Overall Organisation

The proposed project is facilitated by MEE and financed by the World Bank under the "*Saafu Raajje – Maldives Clean Environment Project for Zone IV and V*". It is expected that upon completion of the project, the island will have a proper waste management facility in place. The operation of the IWMC will be in accordance with the Waste Management Plan devised by the Island Council and Approved by EPA.

The scope of the IWMC would include sorting, volume reduction and stockpiling of recyclables, composting of organics, and temporary storage of hazardous waste. The waste that is not manageable in the island level shall be transported to an approved waste management facility.

The Consultant prepared this document in accordance with the EIA Regulations 2012 (in addition to the Environmental and Social Assessment and Management Framework (ESAMF) of MCEP and the TOR provided by MEE) to obtain the required environmental clearance for the proposed construction of IWMC. This ESMP provides an assessment of the proposed IWMC in terms of existing environmental conditions and potential environmental impacts on the island. The findings of this report are based on information collected from a site visit, professional expertise and experiences from past projects of similar nature. For site investigations, a field visit was conducted during the month of June 2018.

1.2 INTERPRETATION OF SPECIFIC TERMINOLOGY USED IN THE REPORT

Certain terms used in this report shall be interpreted in the context of the current project taking into account legal and administrative requirements for preparing the ESMP in the Maldives. The term Environment has been used in a broad context to include, natural environment, human environment, heritage, recreation and amenity assets and livelihood, lifestyle and well-being of those affected by the Project.

Proponent in the document implies to the project owner MEE and Project Island shall be interpreted as Th Madifushi. The term Project means 'Establishment of IWMC in Project Island' and the contractor shall be interpreted as the company undertaking development works of the Project. IWMC occupier shall be interpreted as the party undertaking the operational works of the IWMC.

Nearest waste management facility shall be interpreted as Thilafushi. If in the future, waste from zone IV and V is accepted by another approved Regional Waste Management Centre (during project construction and operational phase) which is closer than Thilafushi, then the facility which is closest to the source island shall be selected to reduce transportation impacts.

1.3 OBJECTIVE OF THE ESMP

The objective of the ESMP study is:

a) To provide the ways by which the proponent will manage and control the works associated with the construction and operation of the IWMC;
b) to provide an assessment of the potential environmental effects of the proposal and determine which of these, if any are likely to result in a significant effect on the environment and to propose ways and means of avoiding, mitigating, and or compensating the perceived negative effects of the project;
c) enhance Project benefits; and
d) to provide necessary information to EPA applicable to the proposed development in line with the EIA Regulations.

1.4 ESMP IMPLEMENTING PROCESS

In general the objective of an ESMP report is to address the environmental and social concerns of the developmental project. The ESMP report will also help to promote informed environmental and sound decision making during the development of the project.

The aim of the ESMP is to identify, describe and assess in an appropriate manner, proposed development, in accordance with the provisions of guidelines and regulations of the Government of Maldives, the direct, indirect and residual effects of the project on the physical and biological environment of project environment. The ESMP would also provide the ways by which the proponent will manage and control the works associated with the construction and operation of the IWMC.

This ESMP has been developed within the framework outlined in the EIA regulations 2012 (in addition to the Environmental and Social Assessment and Management Framework (ESAMF) of MCEP and the TOR provided by MEE). This ESMP establishes the environmental management controls to be followed by the contractor, its employees, subcontractors and sub consultants in carrying out the construction and operation of the IWMC.

Once the decision note is issued from EPA the proponent is obligated to implement the ESMP and matters highlighted in the decision note.

1.5 PROJECT SETTING

Th. Madifushi is located at 02°21′20″N and 73°21′10″E. Situated on the eastern side of the atoll the island covers an area of about 19.5 ha naturally. The nearest inhabited island is Dhiyamigili on the southwestern side of Madifushi and is roughly 2.65 km away. The nearest uninhabited island is Ufuriyaa just 0.28 km away. COMO Maalifushi in Maalifushi is the closest resort to the island 9.16 km away. Moreover, the closest airport is in Thimarafushi located on the southern region of the atoll.

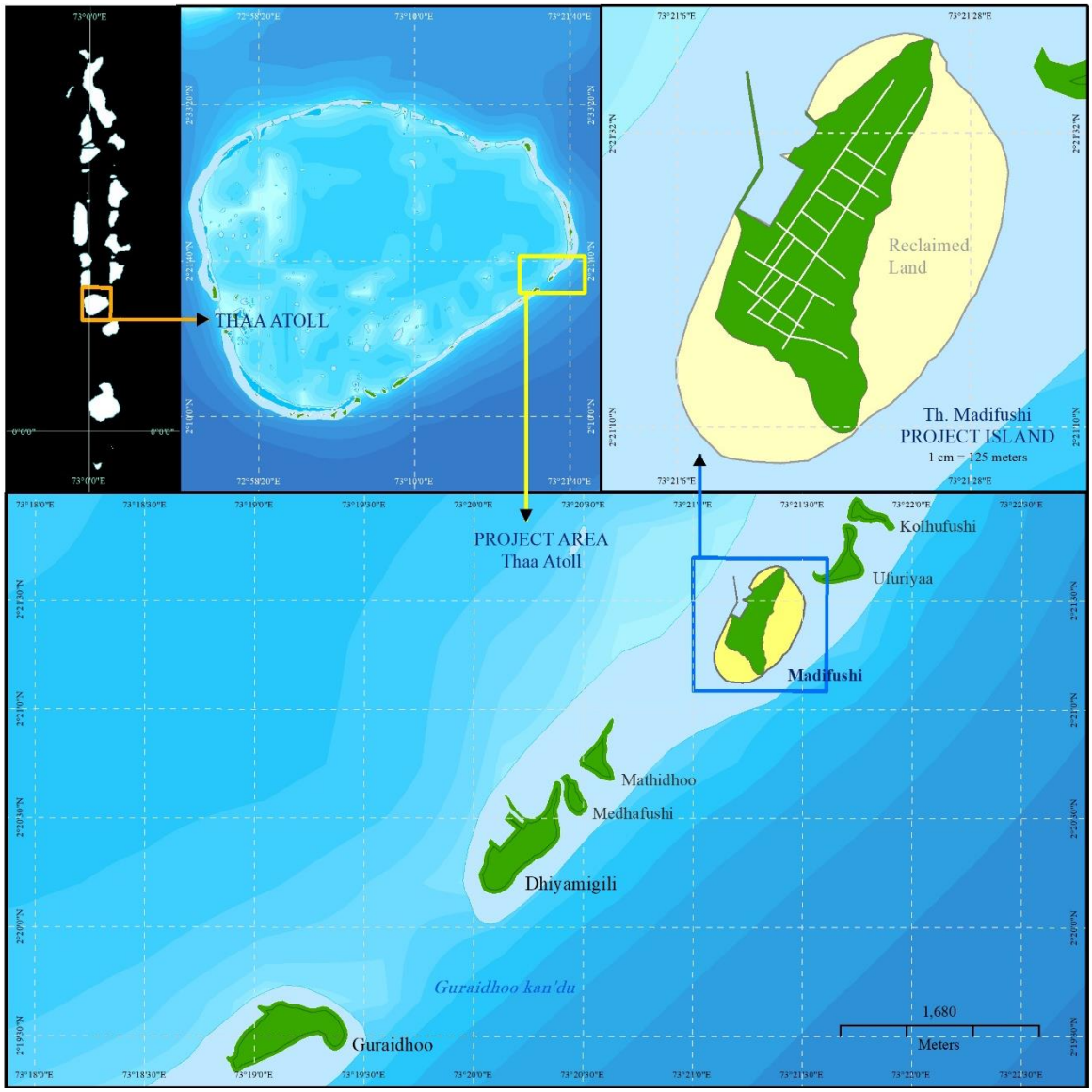

Figure 1: Project setting

1.5.1 Site Location

The proposed Island Waste Management Centre (IWMC) is located at the southern side of the island. The land has been recently reclaimed. There is no vegetation at the site. The site is easily accessible.

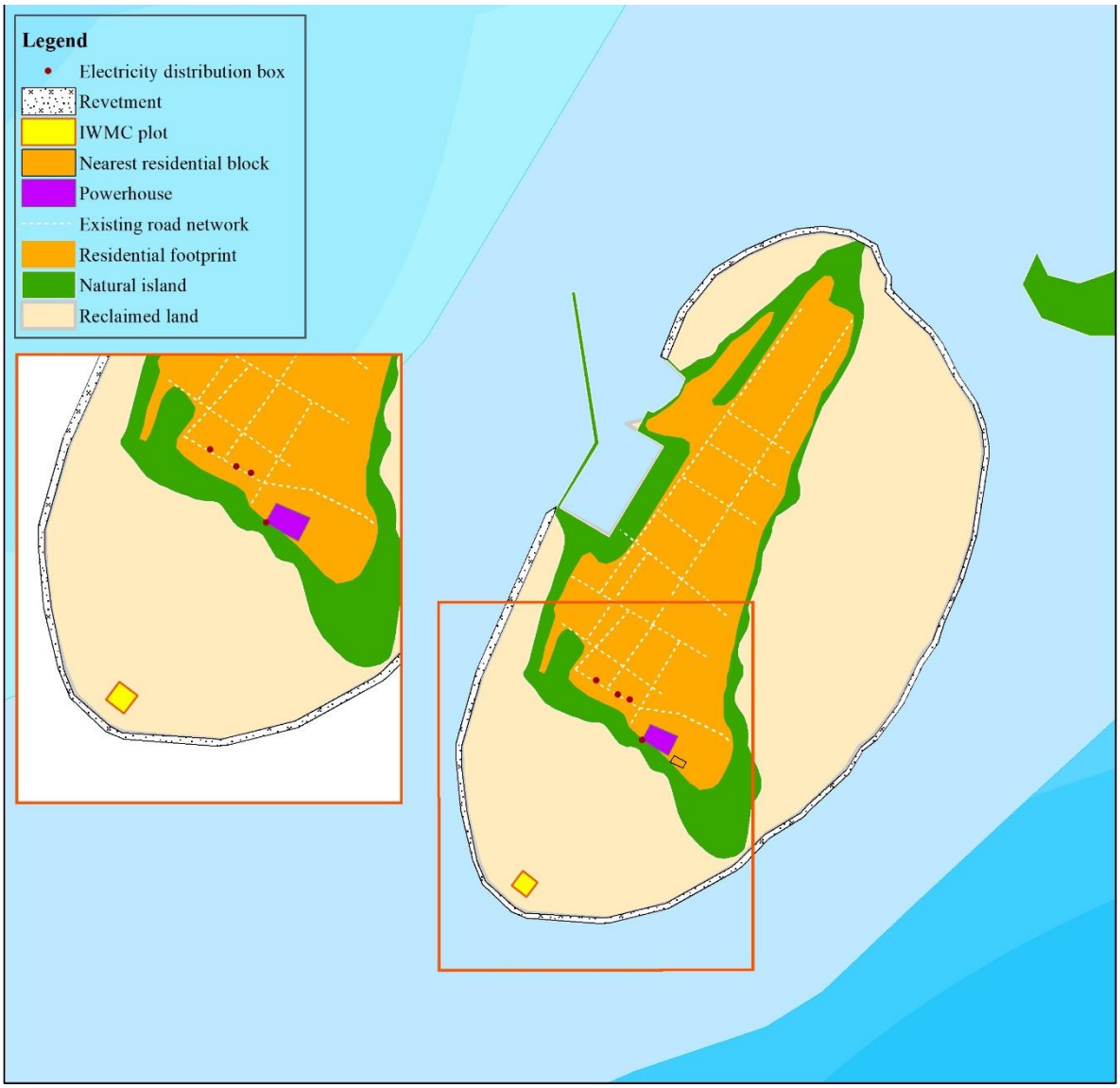

Figure 2: Proposed location for the waste management site on Th. Madifushi

1.6 CURRENT STATE OF WASTE GENERATION AND WASTE MANAGEMENT

1.6.1 Waste Generation in Th. Madifushi

The rate of solid waste production depends on the socio-economic situation, the level of industrialization, type and numbers of industries, climate, and land use and therefore can vary from island to island. However such variations are not expected to be significantly different from island to island and therefore in making estimates waste audits conducted for similar islands can be safely applied. Hence, past waste audits had been used to estimate waste composition and quantities for Madifushi.

According to the waste audit conducted in 2016 for Zone 1 (which includes HA, HDh, and Sh.) an average per capita waste generation was found to be 1.30 kg/person/day. The study also finds that, by far the most significant proportion of the waste is green and compostable (75%), plastics comprising of 6%, paper and cardboard making 5% of the waste, 1% metals, 6% hazardous waste, 1% glass and 6% attributed to all other types of waste.

In another waste audit study conducted by the Ministry of Environment and Energy in 2011 under the Maldives Environmental Management Project (MEMP) for five inhabited islands in the north central region of the Maldives (Hinnavaru, Naifaru, Eydhafushi, Maalhos, Lhohi), it was determined that 0.83 Kg of waste was generated/person/day. Similar to the above study it was revealed that organics was the largest component making 65% of the household waste stream, plastics comprising of 5%, paper and cardboard making 5% of the waste, 1% metals, 8% hazardous waste, 2% glass and 8% attributed to all other types of waste.

The estimated percentage of organic waste as well as the sum of the plastics, glass and metals for the for both zones were found to be very similar hence the averages of the two studies were taken and considered to be the estimated percentages of various types of waste generated in Madifushi Island as shown in **Figure 3**. Similarly per capita waste generation for the island had been determined by taking the average per capita in the two studies above which is **1.07 Kg/person/day**. This finding is expected, since the lifestyle and food habits are similar for most of the inhabited islands across Maldives with the exception of Male' and few other cities.

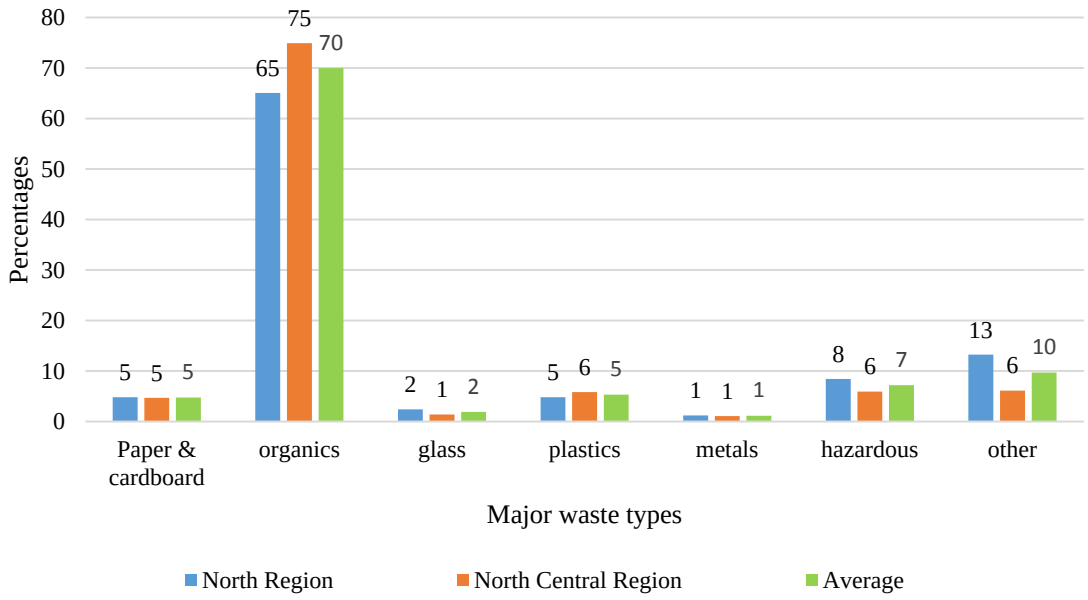

Figure 3: Waste composition comparison in two separate regions of the Maldives

Hence it is expected that the majority of the waste generated in the island to be organic wastes at 70%, which include kitchen and green wastes or compostable waste. Paper and cardboard wastes is estimated at 5% of the total waste generated. Recyclable materials such as plastic, metals, and glass make up 8% of the composition. Approximately 7% of the total waste generated is chemicals and hazardous waste and all other types are expected to be at 10%. Using these estimates and considering the current population of Th. Madifushi, the daily waste generation was determined as shown in **Table 4**.

Table 4: Estimated waste generation quantities of Th. Madifushi households

Waste Type	Average (%)	Waste Generation (Kg/Person/Day)	Total (Kg/Day)
Organic (kitchen & green waste)	70	0.75	1004

Paper / cardboard	5	0.05	72
Glass	2	0.02	29
Plastic	5	0.05	72
Metals	1	0.01	14
Chemicals / Hazardous	7	0.07	100
Others	10	0.11	143
Total	**100**	**1.07**	**1434**

Hence it is estimated that a total of **1434 Kg** of solid waste will be generated daily at Madifushi.

1.6.2 Current state of waste management in Th. Madifushi

The majority of waste sources in Th. Madifushi are households. Boat building is one of the notable commercial activities observed on the island. As far as institutions are concerned, typical institutions that are commonly found in an average island were found. These include School, Health Centre, Secretariat of Island Council and magistrate court. Agriculture is not practiced at a large scale. The island has two café's currently in operation

After the Saafu Raajje symposium, Madifushi Council allocated a 3000 sqft area as the island's designated dumpsite (see **Figure 4**). This area is demarcated with compartments for separated metals, glass and plastics. During the visit it was observed that this area was completely filled up during the two year's of its operation. The operation of the dumpsite as well as cleaning of the public spaces is being conducted by the Women's Development Committee. The council stated that the dumpsite has filled up due to there being no way to reduce the volume of the waste, nor there being any way to transport the waste out of the island. As the dumpsite has been filled, waste is now being dumped in the open area next to the demarcated dump (see **Figure 5**). Green waste is regularly burned here. Kitchen waste is dumped into the lagoon. The island council stated that waste is separated at household level. There are three battery powered mini pickups that operate on the island to provide waste transportation service for approximately 100 – 150 MVR per month. These vehicles are operated by private parties, according to the Island Council.

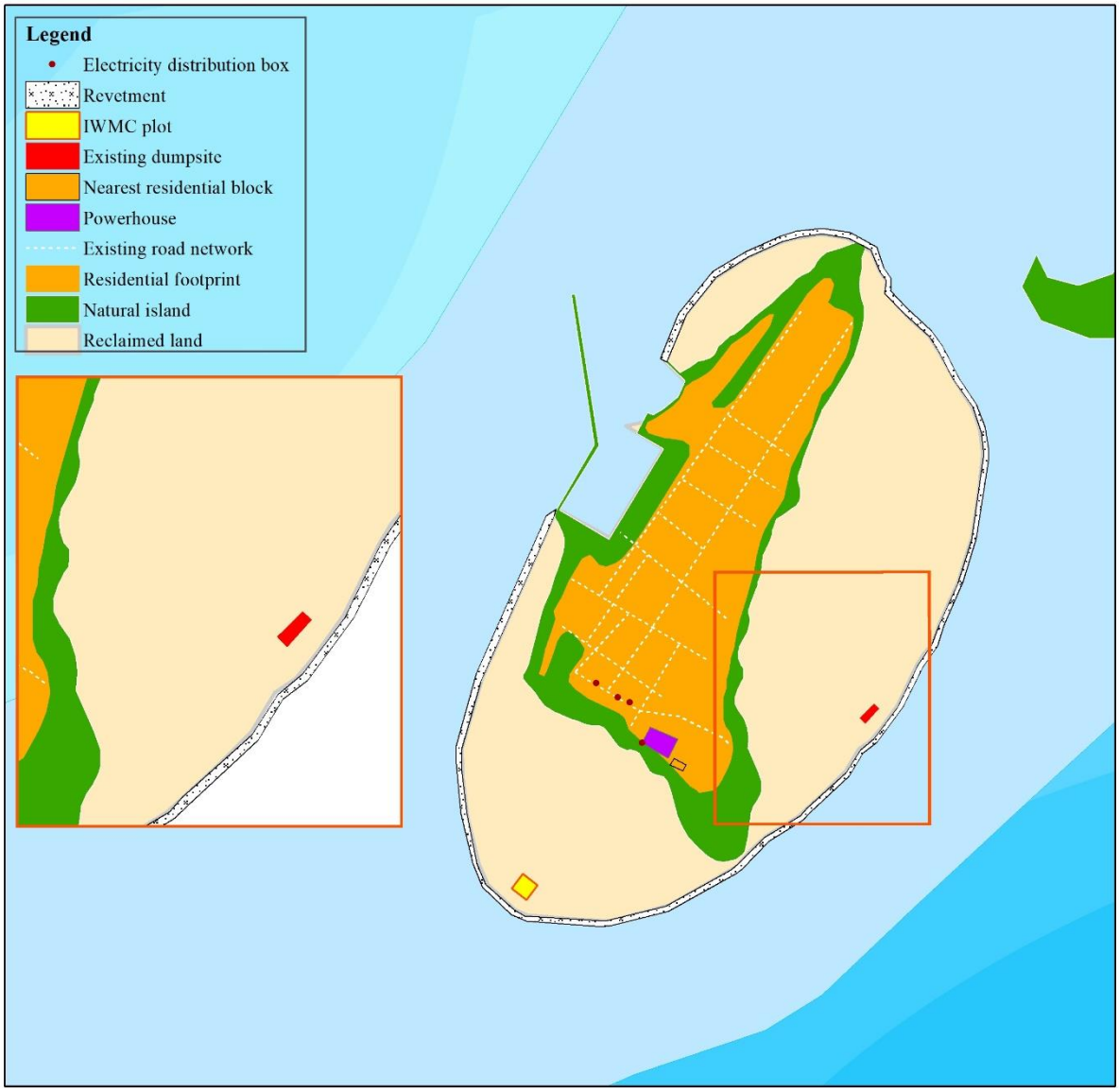

Figure 4: Areas where waste is currently disposed at Th. Madifushi

The current state of waste management on the island is summarised in **Table 5**

Table 5: Current waste management status of the island

Parameter	Yes	No	Number	Description
Harbor (accessibility)			-	• Determined to be accessible. Ramp provided
Waste transportation			-	• Waste collection services are provided by private parties
Vehicles for waste transportation			-	• Three mini pickups belonging to private parties. No such vehicles belong to the Council
Waste management equipment			-	• No waste management equipment
Presence of dumpsites			1	• 1 dumpsite is present
Dump site demarcated				• Site is demarcated
Separation of waste at dumpsite			-	• Waste is separated into metal, plastic, glass, green waste
Burning waste			-	• Green waste is burnt regularly
Burying waste			-	• Waste is buried to reduce volume
Dumping waste into the beach/sea			-	• Kitchen waste is dumped into the lagoon
Presence of large waste piles			-	• Dumpsite has filled up during the two years with no means of reducing volume of transporting the waste out of the island
Pollution of inland/other areas			-	• Terrestrial pollution of inland areas is controlled
Clinical waste management			-	• Clinical waste is managed at the Health Centre
Public area waste collection			-	• Council contracts Women's Committee to clean and collect waste from public areas.
Presence of waste bins			-	• No
Presence of workers			-	• Women's committee is contracted to operate the dumpsite
Electric connection at the dumpsite			-	• No

Figure 5: Current state of waste disposal in the island. (A) and (B) Mixed waste outside current dumpsite (C) Metal waste accumulated at the current dumpsite (D)Construction waste accumulated.

Table 6: Type of waste separated, burnt, buried and dumped at the island (Highlighted cells show which waste type is managed in the stated way)

Types of waste separated	Types of waste burnt	Types of waste buried	Type of waste dumped into beach/sea
Plastics	Plastics	Plastics	Plastics
Metals	Metals	Metals	Metals
Construction	Construction	Construction	Construction
Yard/Organic	Yard/Organic	Yard/Organic	Yard/Organic
Kitchen	Kitchen	Kitchen	Kitchen
Hazardous	Hazardous	Hazardous	Hazardous
Diapers	Diapers	Diapers	Diapers
Paper/cardboard	Paper/cardboard	Paper/cardboard	Paper/cardboard
Partial separation of mixed Waste	Mixed Waste	Mixed Waste	Mixed Waste
All	All	All	All

1.7 ISLAND WASTE MANAGEMENT PLAN

Th. Madifushi has a draft Island Waste Management Plan which has not been approved by the EPA at the time of the visit. During the consultation with the Island Council, it was stated that the Council plans to conduct the operational activities of the IWMC themselves by hiring staff for waste collection and IWMC management. A fee of 150 MVR per household is planned to be taken monthly to conduct the operation sustainably.

2 DESCRIPTION OF THE PROJECT

2.1 THE PROPONENT

The Proponent of the project is Ministry of Environment and Energy (MEE) of the government of the Maldives. The proposed activity is part of a greater project titled "Saafu Raajje – Maldives Clean Environment Project for Zone IV and V" financed by the World Bank.

2.2 PROJECT DURATION AND SCHEDULE

The construction works of the proposed project is expected to be carried out in 12-24 weeks. A tentative schedule of the shortest work duration is found in **Table 7**.

Table 7: Tentative work plan for IWMC

		Weeks											
#	Activity	1	2	3	4	5	6	7	8	9	10	11	12
1	Mobilization												
2	Site clearing												
3	Excavation works												
4	Substructure and superstructure works												
5	Masonry works												
6	Plastering works												
7	Roofing works												
8	Structural steel works												
9	Electrical works												
10	Plumbing works												
11	Doors and windows												
12	Demobilization												

2.3 PROJECT DESCRIPTION

The proposed site plan is presented in **Figure 6.** Approved concept plan is provided in **Annex 2**.

The development of the IWMC consists initially of site selection, site approval, mobilization, site clearing followed by site construction. The works include shallow excavation, substructure and superstructure works as well as masonry works. The proposed design of the IWMC requires a shallow foundation due to the structure being a single storey structure. After the structural works are done, masonry, plastering, roofing works are completed prior to the addition of the services components such as electricity and plumbing.

The operational phase of the project will include the daily collection of waste from the households and institutions, in addition to waste management works in the IWMC, which include;

- Sorting of waste;
- Storing of hazardous waste;
- Volume reduction of plastics, glass and metals;
- Stockpiling of sorted waste; and
- Composting of organic waste.

The proposed IWMC is made up of an equipment room, and separate areas to store metal waste, paper and cardboard, plastic waste, glass waste, reusables as well as hazardous waste. Staff quarters as well as an office and a toilet is included in the IWMC. A compost pad as well as a compost storage area is also provided.

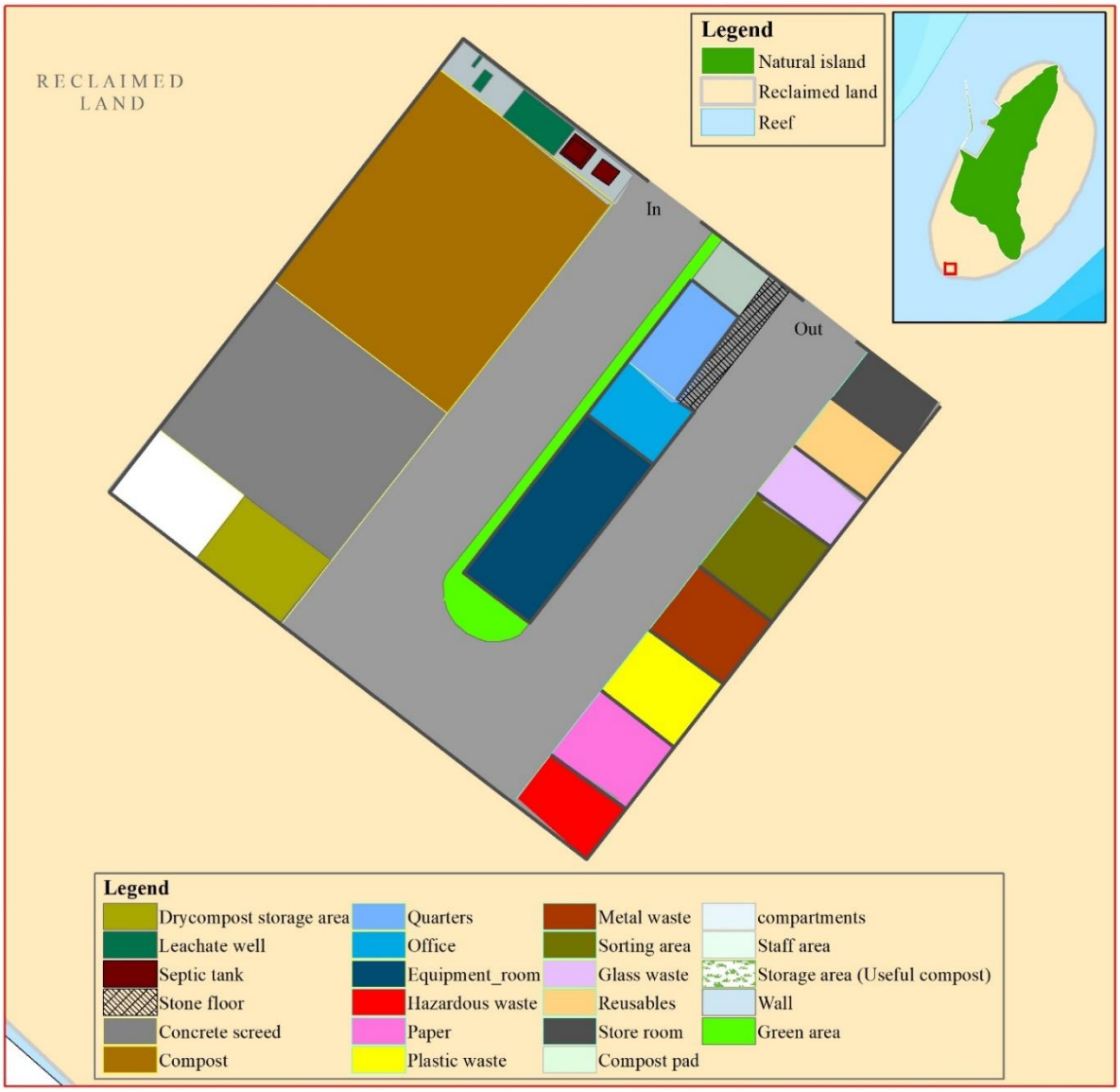

Figure 6: The site plan

2.3.1 Machinery

The following plants and equipment will be mobilized specifically for the project during construction phase.

- Vibratory plate compactor;
- Concrete mixer;
- Concrete supply pump and piping; and
- Daily 4” pump.

2.3.2 Mobilisation

As the amount of input materials are relatively minor, the construction materials shall be stored inside the demarcated site throughout the construction period. The workers if sourced from outside the island can be accommodated in the existing houses with a small rent. This is expected to eliminate the need for putting up a labour quarter and can be cost effective.

2.3.3 Demarcation

Prior to beginning construction works, a survey shall be done by the contractor to demarcate the limits of the site. The site shall be fenced off and work shall be conducted within these limits.

The site in the project island requires no removal of vegetation as this site is located in the newly reclaimed area of the island.

2.3.4 General construction works

All construction works will follow the Annex 5 of the ESAMF Guidelines for IWMC Establishment.

2.3.5 Foundation

The foundation for the proposed IWMC consists of 300mm wide foundation beams. 300x300mm footings are proposed for the collection bay, in addition to the 450x450mm footings for the lamp post.

Excavation: Excavation will be undertaken to the required width, depths and dimensions of footings shown on the Drawings. Excavations will be done manually to receive the ground beams as per the drawings indicate. The foundation level will be defined as the level at the underside of the concrete. The base of the excavation will be compacted and trimmed to ensure that at no point the level is more than 25mm above or below the foundation level.

Any over-excavation of earth below foundation level will be backfilled and re-compacted. Surplus excavated material will be used in the construction of embankments or spoiled as directed by the project officer. The excavation will be kept free of water.

The deepest excavation expected from foundation works include the 700 mm excavation to receive the light post foundation.

Concreting Materials: Cement used will be Ordinary Portland Cement. All cement will be transported in watertight containers and will be protected from moisture until used. Caked or lumpy cement will not be used.

2.3.6 Construction of Compost Slab

The compost slab has an area of 23.05 m by 9 m. The 100 mm thick reinforced concrete slabs are cast over ground beams B1, B2 and B3. The ground beams B1 and B2 have a depth of 0.3m while B3 has a depth of 0.4m from the top of the slab. B3 has a void on top of the beam centrally to receive a 100mm PVC pile cut in half sloping at 1% from the upper end to the lower end, connecting to the leachate tank at the end. Excavations will be done manually to receive the ground beams as per the drawings indicate. The maximum depth of excavation for the beams is 0.3m. The construction of the slab and ground beams include initially laying of HDPE membrane on the slab and beam footprint. Formwork will be added to the sides of the beams, and following that, the arrangement of the required reinforcing steel. Concrete will be poured for the ground beams, followed by the slabs. Concrete mixing will be done on site.

Control Movement Joints: Control movement joints will be built into slab where shown on the Drawings and at all points of potential cracking. The joint spacing will not be greater than 6 metres and shall be continuous across the full width of the base. Reinforcement mesh and bars will be clear of the control movement joints by the specified cover.

2.3.7 Construction of Leachate Tank

The leachate collection tank is located at the end of the compost slab. The leachate tank has an area of 2 m by 4 m and a depth of 1 m extending below ground. Excavation of the leachate tank area will be done to the required depth. Formwork is placed to the sides prior to placement of 10 mm reinforcing bars at 100 mm centre to centre distance, horizontally and vertically. The mixed concrete will be poured into the formwork and curing commences until the concrete reaches desired strength. The excavation can be done manually and the excavated material is stored on the side of plot.

2.3.8 Construction of Sorting Area

The sorting area is 4.15 m long by 4.0 m wide and 100 mm thick slab consisting of high tensile reinforcement placed at 200 mm centre to centre along the breadth and width. The slab rests on 300 mm thick concrete columns. The top of the sorting area is 750 mm above the floor finish level. Formwork is placed to the sides prior to placement of 10 mm reinforcing bars at 200 mm centre to centre distance, horizontally and vertically. The mixed concrete will be poured into the formwork and curing commences until the concrete reaches desired strength.

2.3.9 Construction of Perimeter Fence

The perimeter of the site is to be fenced except the gate area. The fencing includes a 150 mm thick masonry wall of 0.6 m height from ground level, followed by the PVC coated mesh fence of elevation 2.8 m from ground level. The mesh is held together by 50 mm diameter GI pipes vertically at equal centres which are welded to three evenly spaced 50 mm GI pipes horizontally. The strip foundation below the masonry wall has a depth of 0.6 m with a 50 mm thick lean concrete placed below. The trenches required to receive the strip foundation and footings will be excavated manually.

2.3.10 Construction of Well

A well is proposed to be constructed at the eastern corner of the IWMC. This well is 1000 mm in diameter and the walls will be precast concrete while the base and top cover will be precast reinforced concrete. The pre-casting of the well will be done on site. Excavations will be done to a depth depending on the depth of the water table. After the excavation, the well base and body is fitted into the pit, and the top cover is laid on top of it.

2.3.11 Construction of Superstructure

The superstructure of the IWMC consists of the sorting area, storage area, staff quarters, office and the equipment room. The structure consists of a 4 m high wall for the office/equipment room building. The 150 mm masonry wall and roof beams are supported by reinforced concrete columns 150 x 150 mm size. The roofing is made of LYSAGHT roofing sheets. The roof truss is made of 50 mm GI pipe horizontal members and 25 mm GI pipe vertical members

2.3.12 Construction of Septic Tank

Construction of a septic tank is proposed to manage the sewage generated during the operational phase. The tank will be constructed to ensure water tightness. Waterproof paint will be used on the masonry wall.

The septic tank consists of a primary tank of 1.3 m by 1.3 m made of 150 mm brick wall, covered with 75 mm thick concrete with 6 mm reinforcing steel placed at 150 mm center to center. The primary tank is 2 m deep. The primary tank is connected by a 100 mm diameter PVC pipe to a secondary tank of the same dimensions filled with 1 m of coral stone and white sand filling. The bottom 1 m of this secondary tank is perforated with 25 mm equally distributed holes to allow for discharge of treated effluent.

2.3.13 Inspection of concrete works

Inspection of foundation, formwork and reinforcement will be made by the Proponent before concrete pouring is commenced.

2.3.14 Labour Requirements and Availability

A 10 person workforce would be involved in the construction. It is encouraged to choose workers from within the island, to reduce the impacts of influx of non-local workers. If no such arrangements are made, labour accommodation will be arranged for the 10 person workforce from existing houses.

2.3.15 Waste Management

Construction waste, which would mainly be excavated earth, nylon cement bags and general construction debris shall be collected and temporarily stockpiled in the project site. The small amounts of waste oil that may be generated from vehicles shall be contained in closed containers and shall not be allowed to leak into the ground.

A description of how various types of wastes generated from the project will be managed is given below.

A. Biodegradable waste

Wastes such as leaves, branches, paper, and materials collected from the general cleaning of the site areas will be stored as described in **Figure 7.**

B. Non-biodegradable waste

Materials such as plastics and glass will have to be collected separately and transported to nearest waste management facility at the end of the project construction period. These will most likely be nylon cement bags, wrappings, steel/glass leftovers and other municipal waste generated at the construction site.

C. Kitchen waste

Food wastes and other biodegradable wastes generated in food preparation shall be buried in the ground. The pit dug to bury such wastes shall not reach the water table.

F. Hazardous waste

During construction phase, hazardous waste generated from machineries such as oils, solvents, batteries etc shall be sealed in labelled containers and shall be stored on paved hard surface before being transported to the nearest waste management facility. They shall be stored at the designated areas illustrated in **Figure 7**. It is essential to ensure that hazardous waste is fully contained and transported out of the island to nearest waste manage facility as quickly as possible. It is recommended to install signs in the designated temporary storage area.

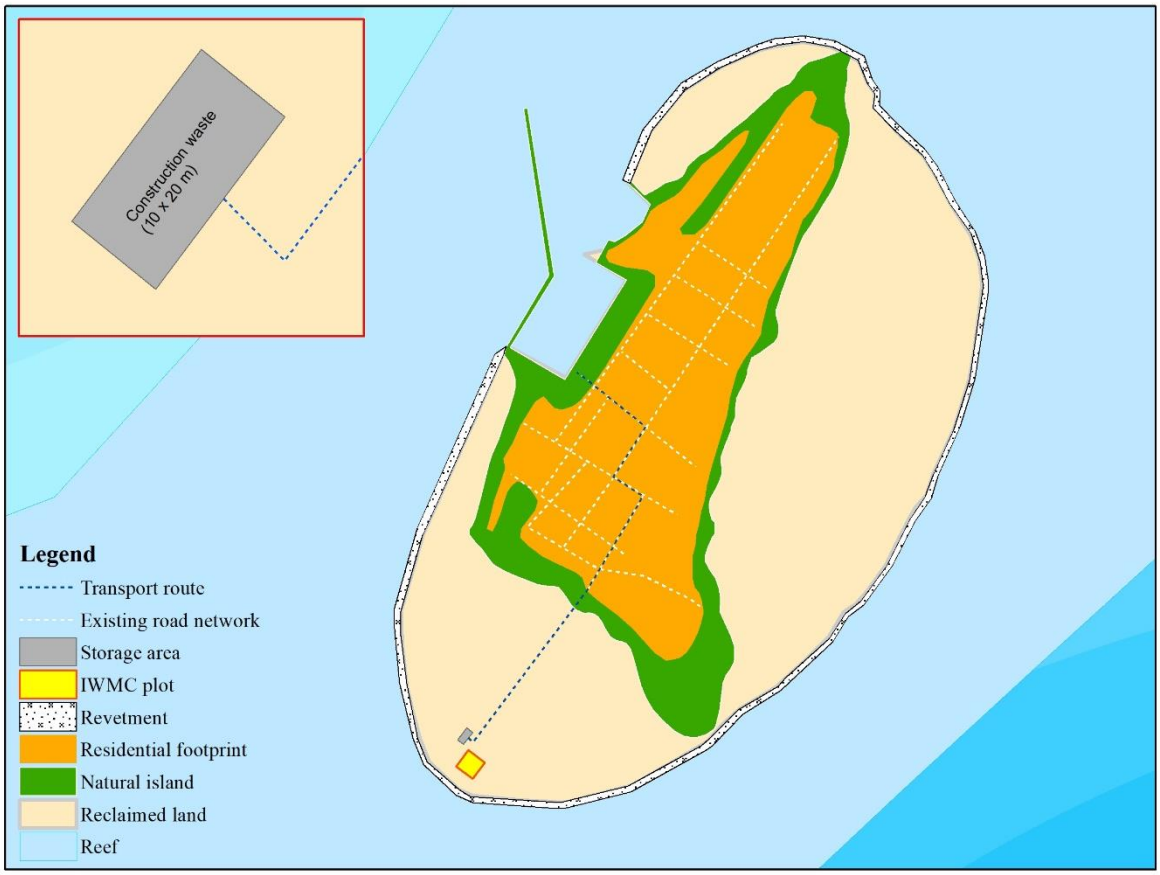

Figure 7: Transportation route and storage area

2.3.16 Pollution and Control Measures

The following measures will be taken to control pollution during construction stage.

a) Machinery to be properly tuned and maintained to reduce emissions/spills/leaks;
b) fuel storage, paint, lubricants will be stored securely and bunded; and
c) spill kits would be made available on site to control any liquid spills;
d) construction site will be wetted regularly to minimize impacts of dust; and
e) all vehicles used for the project must have up to date road worthiness license.

2.3.17 Health and Safety Measures

The project involves many activities that can put workers as well as the general public to risk of injuries and accidents. However, with careful precautionary measures and good practices during the works can eliminate or reduce many of these risks. Health and safety measures for the construction phase include and are not limited to:

a) Undertaking all relevant safety measure during construction works shall be part of the legal contract to undertake the works. The contractor shall be made to bear the responsibility to protect the workers as well as the general public from activities related to the project.;
b) Strict supervisor shall take place during construction and decommissioning phase of the project;
c) Only experienced and licensed operators will be allowed to operate heavy machines;
d) First aid kit should be made available at the work site;
e) PPE should be provided to all workers and the work force would be required to use safety gears as appropriate;
f) Fire extinguishing equipment would be available at the site;
g) Operation of any heavy machinery will need the assistance of a banksman as all times;
h) All heavy lifts must be supervised and slings inspected; and

i) Appropriate safety signs shall be placed at the work site.

2.3.18 Demobilization

The demobilization plan will commence in the last week of the contract. This would involve removing all items and personnel belonging to the contractor and handing over of the site to MEE. Prior to demobilisation and site handover site inspection by the officials of the MEE will take place to ensure that project has been completed to the full satisfaction of MEE and scope of work fully competed. The demobilisation shall also involve removal of all residual waste generated from the project and repairing of any public property damaged during the project. These will be the responsibility of the contractor.

2.4 OPERATIONAL PHASE

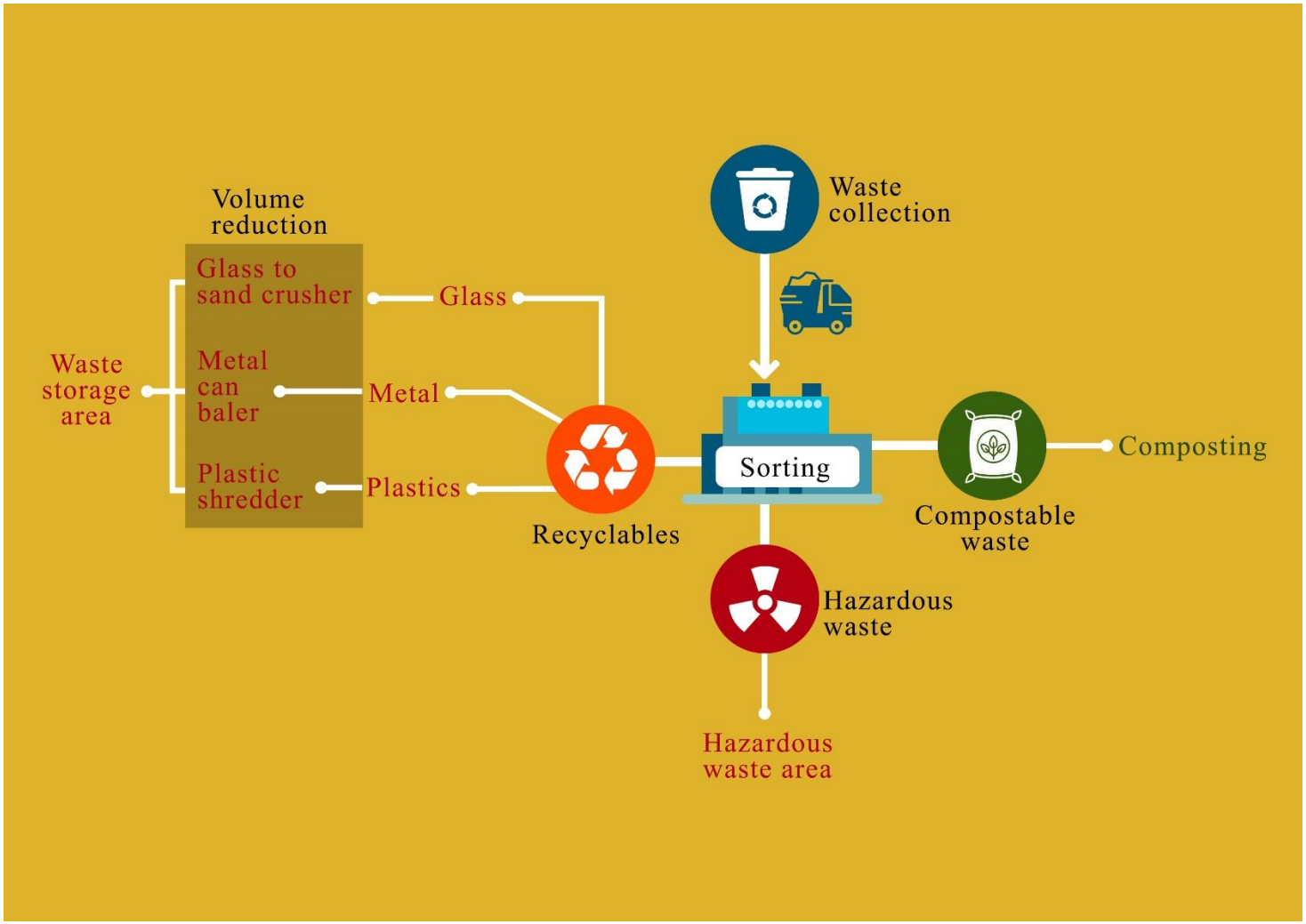

Figure 8: Operational phase flowchart of the IWMC of Th. Madifushi

The following Section will briefly highlight the operational aspects of the IWMC. This includes the machinery and equipment proposed to be used in the IWMC, in addition to the main activities to be carried out at the IWMC and within the island. The IWMC activities begin from collecting waste generated at source and transporting it to the IWMC. This collected waste will be pre-sorted into categories such as compostable waste, recyclable waste and hazardous waste. Compostable waste is used in making compost while glass, plastics and metals undergo volume reduction processes before being stored in their respective compartments. The hazardous waste is stored in the hazardous waste compartment.

2.4.1 Machinery and equipment proposed

The IWMC will require general equipment and tools needed to handle the waste. These include wheelbarrows, garden hoes, shovels, buckets and cultivators. This equipment will be used during the IWMC operation for handling as well as composting operations. A manual rotary compost screen is also included for the screening stage of the composting process.

Other equipment required includes waste volume reduction equipment such as a plastic shredder, metal can baler, vegetation shredder, and glass to sand crusher. Typical equipment required is detailed below.

Table 8: Typocal equipment proposed for waste management works

Waste Management Equipment
Chainsaw
Wheelbarrow
Heavy Duty Gumboots
Heavy Duty Hand Safety Gloves
Long Handled Flathead Steel Rake
Long Handled Cultivator
Garden Hoe
Round Point Shovel
Square Point Shovel
20L Bucket
40L Bucket
Polypropylene Surgical Mask
Weighing Bench Scale
Wheelie Bins
Glass to Sand Crusher
Plastic Shredder
Metal Can Baler
Vegetation Shredder
Manual Rotary Compost Screen

2.4.2 Waste Collection

During the consultation meeting with the Council, it was learnt that the IWMC operational works will be conducted by the Council. The waste will be collected from source using a vehicle.

2.4.2.1 Sorting of Incoming Waste

Incoming waste is required to be sorted to separate biodegradable and non-biodegradable waste. The separation of kitchen waste, yard waste and other types of waste at household level can streamline this process.

Table 9: Domestic Waste Categories

Incoming Domestic Waste			
Biodegradable materials	**Hazardous materials**	**Others**	**Recyclables**
Organics • Food waste • Garden waste • Animal waste Paper & Cardboard • Printed paper • Cardboard	• Paints & Solvents • Batteries • Cleaners • Expired medicine • Medical waste • Pesticides • Special (Nappies, tampons)	• Textiles • Wood • Inert (Dust/Dirt/Ash/Rock) • Liquid container	• Metal • Plastic • Glass

As per the IWMC site layout plan, a slab is dedicated for the sorting area. Here, the collected waste will be kept, and further sorted into their respective categories. The IWMC is designed to have separate storage areas for reusable waste, metal, paper and cardboard, plastic, glass, and hazardous waste. After sorting, the waste is stored in the respective location.

2.4.3 Composting

One of the main operations that will be conducted in the IWMC is the composting of the organic waste such as kitchen waste and green waste. Composting uses the process of the slow decomposition of the organic matter by various microorganisms, in an optimised and controlled process. The process is controlled in terms of parameters such as input materials, temperature, moisture and pH. The finished product of composting can be sold as fertilizer, thus enabling the reuse of the waste collected within the island.

The main constituents of a compost heap include kitchen and garden waste, along with water and air in the pore spaces between the constituent.

2.4.3.1 The Composting Process

After the incoming waste is properly sorted into compostable wastes and other wastes, mixing of the compostable waste is done. This mixing is done to provide an optimum Carbon-Nitrogen ratio for the process to occur. Prior to mixing, if the waste contains branches, twigs and such, they are fed into a wood chipper to reduce their size. After the mixing is completed, composting process begins on the composting slab as an open windrow compost. After the compost matures, screening is done depending on the particle size of the compost required. This compost is bagged and stored. These steps will be elaborated below.

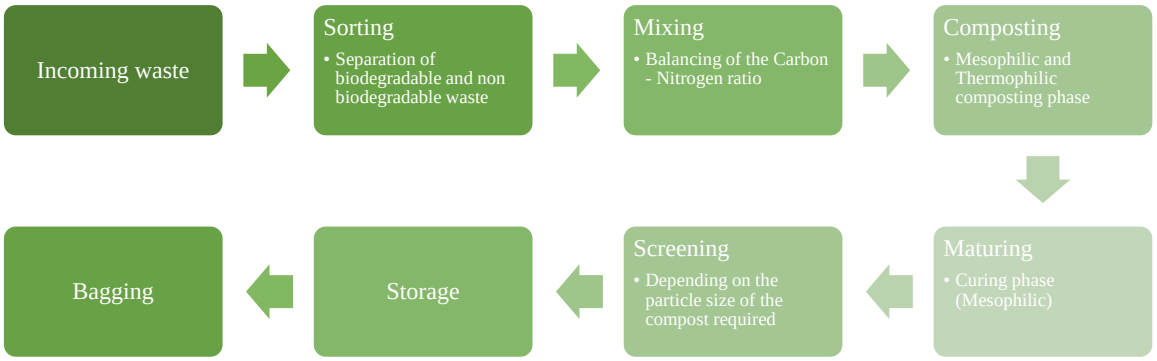

Figure 9: The composting process

2.4.3.2 Mixing (Carbon – Nitrogen Ratio)

One of the most important factors in the process of composting being successful is the Carbon – Nitrogen ratio. Carbon is used for energy by the microbes in order to continue with the decomposition, while Nitrogen is needed by the microbes to grow and multiply. The optimum Carbon – Nitrogen ratio is 25 - 30:1 (DEC NSW, 2004). If the ratio is less than 30:1, it would result in the loss of Nitrogen as ammonia gas which would result in undesirable odours. If the ratio is greater than 30:1, it results in the cooling of the compost and slow degradation of the pile.

Looking into the composition of compostable wastes from the Zone 1 Waste Audit, it is seen that the majority of compostable wastes constitute of garden (green) wastes. Garden wastes make up 64% of waste generated, while the second largest contributor to compostable wastes is kitchen wastes, at 28%. Printed paper and cardboard make up 5% of compostable waste while 2% of the category includes animal waste. This composition is important in determining the Carbon-Nitrogen ratio of the compost heap in order to provide optimum conditions for composting.

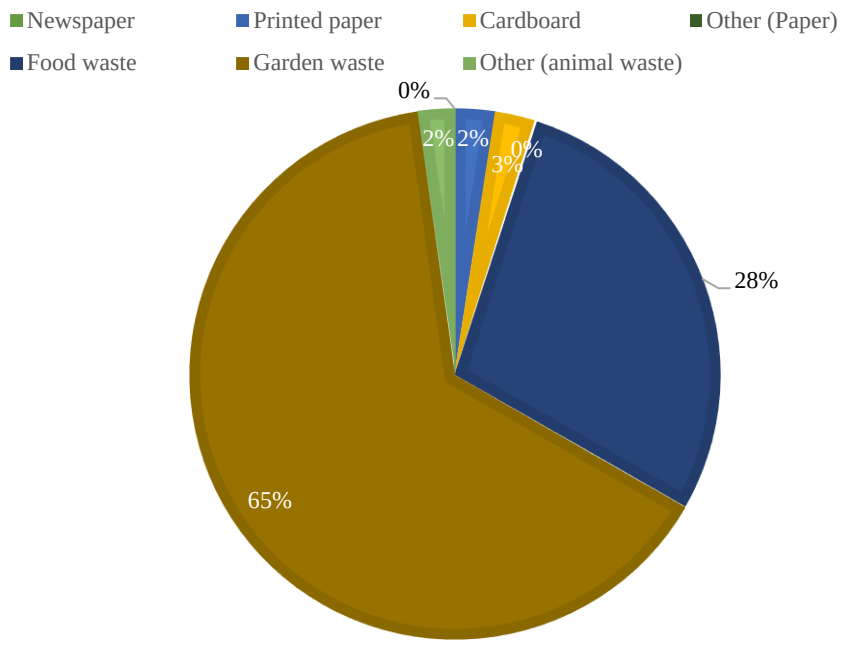

Figure 10: Composition of compostable waste for Zone 1

Table 10: Estimated compostable waste generation quantities of Zone 1

CATEGORY		Average Per Capita (kg/day)	Percentage
Primary	**Secondary**		
Paper & Cardboard	Newspaper	0.00	0.0%
	Printed paper	0.02	2.4%
	Liquid container	0.00	0.5%
	Cardboard	0.02	2.4%
	Other (Paper)	0.002	0.2%
Organics	Food waste	0.29	28.2%
	Garden waste	0.67	64.2%
	Other (animal waste)	0.02	2.2%
Total		1.04	100

Green wastes such as vegetable wastes (kitchen waste), and poultry manure have high Nitrogen values while brown wastes such as foliage, wood chips, bark and paper have high carbon values. From the waste audit, it is seen that 64.2% of the compostable waste produced is garden waste while 28.2% of the waste generated is food waste. Therefore, it can be said that the composition of compostable waste is in favour of providing a high Carbon content compared to Nitrogen.

2.4.3.3 Composting and Maturing

Thermophilic composting is the process of composting using thermophilic (heat-loving) bacteria. Thermophilic composting consists of three phases;

Table 11: The phases of composting

Stage	Temperature	Duration	Organisms
Mesophilic	Moderate, up to 40 °C	2 days	Initial decomposition is done by mesophilic organisms that thrive at moderate temperatures
Thermophilic	High, over 40 °C	Few days to several months	Mesophilic organisms become less competitive and replaced by thermophilic heat loving microbes. High temperatures break down proteins, fats, and complex carbs like cellulose and hemicellulose (major structural molecules in plants)
Mesophilic (curing or maturation phase)	Moderate, up to 40 °C	Several months	As the compounds decrease, compost temperature gradually decreases and mesophilic organisms take over again for the final curing of the remaining organic matter.

As seen from the **Table 11**, the composting process can prolong to several months.

2.4.3.4 Leachate Management

As the process of composting occurs, leachate will be produced from the organic waste within the compost pile. The composting will be done on the specially constructed compost slab. The bottom of the slab and ground beams in this area have an HDPE membrane between the reinforced concrete and the ground.

2.4.4 Volume Reduction

Prior to storage, volume reduction of the waste is conducted. This includes metal can baling using the metal can baler, plastic shredding using the plastic shredder, and glass bottle crushing using the glass to sand crusher. The resulting reduced volumes of the waste is then easily stored in their respective compartments.

2.4.5 Sewage management

The 'primary tank' facilitates 'primary treatment'. The separation of liquids and solids by gravity - to take place. Raw sewage flows into the tank and the heavy solids, 'sludge', sink to the bottom, lighter solids, grease and oils or 'scum' float to the surface. Some of the sludge is degraded by naturally occurring anaerobic (without oxygen) bacteria. The liquid effluent flows to the secondary tank which is filled up to 1 m with coral stone and white sand layer. This tank is perforated at the bottom 1 m to allow for discharge of liquid effluent into the land.

The most environmentally sound method for disposing the domestic sludge is allowing it for drying in a sludge drying bed. The dry sludge can be used following appropriate treatment, as part of compost. Sludge will be dried on a sludge drying bed.

2.4.6 Projected Capacity of the IWMC

The proposed IWMC is planned to manage a portion of the waste produced at the island level, with the unmanaged waste (approximately 30% of waste generated within the island to be transported to a central waste management facility). The projected capacity for 1 month's waste for the island of Madifushi is shown below.

Table 12: Projected waste management capacity for the waste generated in Madifushi in 1 month

Waste Type	Details	Amount	Unit
Organics	Composting capacity in IWMC. Assuming 1m height windrow with a width of 2m	67.5	m^3
	Organic waste generated per month	46.34	m^3
Paper waste	Storage capacity (4.3 by 4.15m compartment assuming height of pile 1.5m	26	m^3
	Waste generated bulk density after volume reduction 0.65 tons/m3	3.323	m^3
Glass	Storage capacity (4.3 by 4.15m compartment assuming height of pile 1.5m	26	m^3
	Waste generated bulk density after volume reduction 0.65 tons/m3	1.338	m^3
Plastics	Storage capacity (4.3 by 4.15m compartment assuming height of pile 1.5m	26	m^3
	Waste generated bulk density after volume reduction 0.65 tons/m3	3.323	m^3
Metals	Storage capacity (4.3 by 4.15m compartment assuming height of pile 1.5m	26	m^3
	Waste generated bulk density after volume reduction 0.65 tons/m3	0.646	m^3

Organic wastes make up the bulk of the waste stream in the island. The composting capacity of the proposed compost slabs (assuming a windrow of 1 m height and 2 m width at the bottom and 1m width

on top) is approximated as 67.5 m^3. The calculated volume for the organic waste generated in a month in Madifushi is 46.34 m^3 assuming waste is generated from the current population. Therefore; it is be expected that, 2 month's organic wastes produced in Madifushi would take up the composting capacity of the IWMC for the succeeding 4 – 6 months. There is no additional storage space for the organic wastes provided in the facility. Hence it is imperative waste from island is routinely transported to a regional facility.

2.5 PROJECT INPUTS AND OUTPUTS

The table below elaborates the approximate amount of resources that will be required for the project. These include workers, fuel, water, and construction materials.

Table 13: Project inputs

Stage	Input	Source / Type	Estimated Amount	Means of obtaining the resources
Construction	Workers	Local and foreign	10	Encourage the use of local / regional workers
	Fuel	Diesel		Local Suppliers
	Water	Groundwater for non-potable use	Average 150 l/p/d	Groundwater wells present in the island
	Materials	Concrete including reinforcement and formwork	68 m^3	Local Suppliers
		Masonry Works (150 mm bricks)	518.64 m^2	Local Suppliers
		Structural Steel		
		50mm GI Pipe for perimeter fence	53 m	Imported / purchased where available locally
		75mm GI pipe (structural columns)	10 Nos.	
		Truss	17.45 m	
		75mm GI pipe for flood light fixing poles	2 Nos	
		Paint		
		Emulsion paint coating	1037 m^2	Local suppliers
		Electrical Components		
		3 Phase power sockets	6 Nos.	Local suppliers
		20W LED lights	7 Nos.	
		18W LED lights	3 Nos.	
		Ceiling fan	3 Nos.	
		AC	1 Nos.	
		Exhaust fans	4 Nos.	
		Well water pump	1 Nos.	

		200W flood light	2 Nos.	
		Metal doors for		
		Equipment room	1 Nos.	Local suppliers
		Hazardous waste area	1 Nos.	
		Waste yard entrance	1 Nos.	
		Plumbing		
		Fresh water pipe network and plumbing fixtures		Local suppliers
		Roofing		
		Lysaght roofing sheets	254.5 m^2	Local suppliers
		Flashing sheets	80 m	
		Lysaght gutter		
		Timber beams 150x75mm	53 m	
		Timber beams 100x50mm	283 m	
		Timber beams 50x38mm	424.16 m	
		50x50 PVC coated mesh fence	130 m^2	Local suppliers
		HDPE membrane	306 m^2	Imported / purchased where available locally
		Timber top cover	3 nos.	Local suppliers
		600 x 900 5mm plastic sheet signboard	1 Nos.	Local suppliers
		Firefighting equipment and fire alarm system	1 Nos	Local suppliers
		Septic tank	1 Nos	Materials from local suppliers
Operation	Equipment and Materials	IWMC tools	1	Imported / purchased where available locally
		Weighing Bench Scale	1	
		Glass to Sand Crusher	1	
		Plastic Shredder	1	
		Metal Can Baler	1	
		Vegetation Shredder	1	
		Manual Rotary Compost Screen	1	
	Waste	Waste generated within the island	Approximately 1.4 ton of waste per day	Waste collected by vehicle from the waste bins within the island
	Fuel	Diesel	5000-15000 L/month	Local suppliers
	Water	Freshwater	200-1000l/day	Groundwater

Table 14: Project outputs

Stage	Output	Source / Type	Amount	Means of managing
Construction				
	Land plot for IWMC	Cleared land for construction of IWMC	825 m^2	N/A
	Soil	Excavation for substructure	8.30 m^3	To be used back in the levelling and backfilling of site.
	Construction Waste	Construction works	Moderate amount of construction waste	Transfer all waste to nearest Waste management facility
	Hazardous waste	Construction and clearing of vegetation	Moderate amount of hazardous waste	See **Section 2.3.15** for details
	Municipal waste	Workers	346.5 kg	See **Section 2.3.15** for details
	Dust	Excavation	Moderate amount of dust	
		Cement mixing	Moderate amount of dust	
	Greenhouse gases	Machinery	Moderate amount of GHG from direct and indirect emissions	
		Concreting works	Moderate amount of GHG from direct and indirect emissions	
		Reinforcement	Moderate amount of GHG from direct and indirect emissions	
		PVC Pipes	Moderate amount of GHG from direct and indirect emissions	
Operation (based on presumption the IWMC will be fully functional without major issue)	Compost	Open windrow composting	37.5 m^3 of compost per full batch	Sold as fertilizer
	Green waste	Residual		
	Crushed Glass	Glass crusher	0.87 ton per month	Crushed glass stockpiled in the IWMC compartment prior to sale. Unmanaged waste transferred to central waste management facility
	Compacted Metal	Metal baler	0.42 ton per month	Compacted metal stockpiled in the IWMC compartment prior to sale. Unmanaged waste transferred to central waste management facility
	Shredded plastic	Plastic shredder	2.16 ton per month	Shredded plastic stockpiled in the IWMC compartment prior to sale. Unmanaged waste transferred to central waste management facility
	GHG	Electricity usage		N/A

3 EXISTING CONDITIONS

3.1 DESCRIPTION OF THE ENVIRONMENT

Th. Madifushi has a natural land area of 20 ha. An additional 29.32 ha of land has been reclaimed. The island's community of 1336 people has a settlement footprint of 15 ha. This is 75% of the natural island's total land area. The land reclamation project at Madifushi is in its final stages. Harbour expansion works are ongoing at the island. Land allocated for construction of the IWMC is located in the newly reclaimed area

Figure 11: (A) Newly reclaimed area and coconut palms of the islands natural vegetation line (B) Boat building work (C) Area being developed as an artificial beach (D) Coastal protection of newly reclaimed area

The coastal area close to the project site has a protective revetment built during land reclamation. The revetment should provide sufficient protection, however, there have been reports of large swells breaching through the revetment and causing damage to its structure. As the land has been recently reclaimed and reclamation works in its final stages; there is no vegetation line or a protective vegetation belt present at the site.

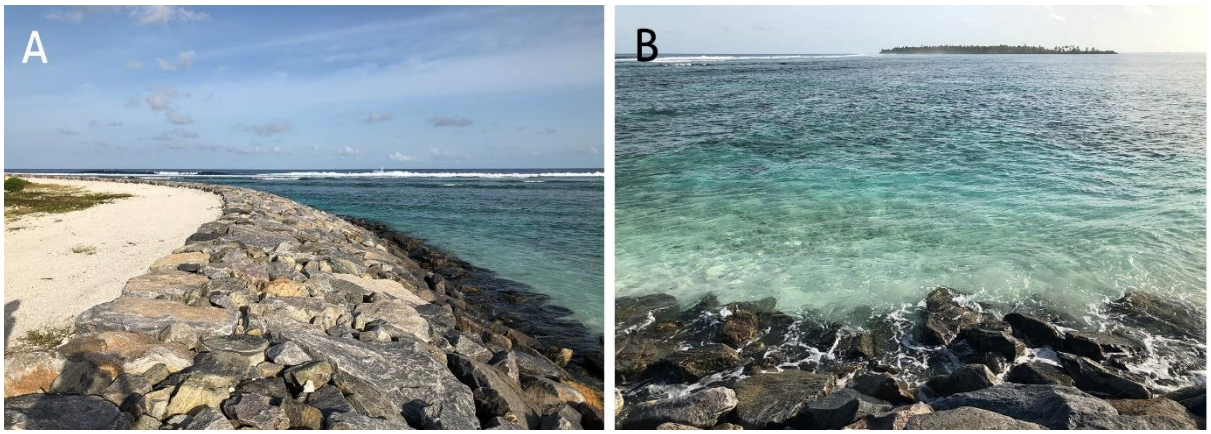

Figure 12: (A) and (B) Revetment close to the project area

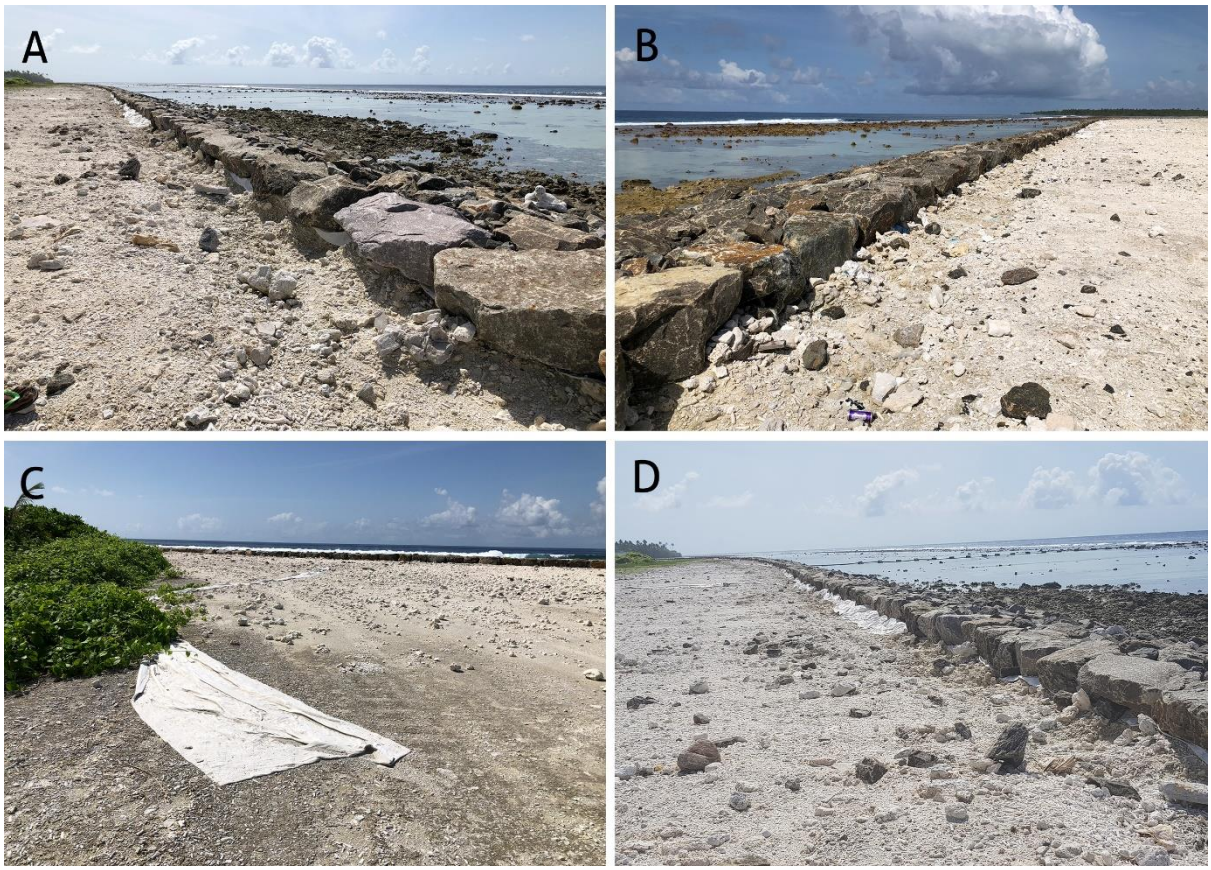

Figure 13: (A) to (D) Damage caused to the revetment and geotextile in recent 'udha' incident

3.2 PROJECT SITE

The proposed Island Waste Management Centre (IWMC) is located at the southern side of the island. The land has been recently reclaimed. There is no vegetation at the site. The site is easily accessible. The project site was selected by a process involving the Maldives Land and Survey Authority of the MHI. EPA's "Environmental Guideline for Site Selection of Waste Management Centers (Sep 2017) is referred to during the site selection process.

Figure 14: A, B, & C: Vegetation at the proposed site

3.2.1 Site zoning guidelines by EPA & MLSA

The EPA has provided recommendations for the optimum zoning of the IWMC site. The distances include, the site being at least 10-15 m from the revetment, at least 30 m from the nearest freshwater well, at least 40 m from the nearest recreational area. The field surveys done on the island recorded the locations of the aforementioned categories and the comparison table for the actual distances and EPA guidelines are provided below:

Table 15: Comparison between the proposed site location and EPA guideline distances

Location	Distance from site (m)	EPA Recommended Distance (m)
Revetment	21.69	10-15
Freshwater well	265.24	30
Recreational area	40+	40
Residential area	263.9	30

As seen on
Table 15, the site meets all the recommendations of the EPA

3.3 STAKEHOLDER CONSULTATIONS

Stakeholder consultations were held for the project with the Proponent MEE and the Island Council of the project island. Highlights of the meetings which apply to the ESMP islands are presented below. Consultation attendances are provided in **Annex 3.**

3.3.1 Meeting with Island Council

- Waste segregation is practiced at the island at household level and at the islands current dumpsite.
- Metals, glass and plastics are separated at the islands existing dumpsite. Kitchen waste is thrown into the sea and sanitary waste is buried at the dumpsite.
- The current dumpsite is operated by the islands women's committee and cleans public areas of the island.
- Waste is transported to the dumpsite by locals at times allocated by the women's committee
- There are 3 mini pickups that provide waste transportation services for a monthly fee.
- Accumulation of unmanaged waste, lack of financial capacity, difficulties in transportation and limited land resources are the main challenges in the current system according to the council.
- The islands Waste Management Plan has been drafted but not yet approved.
- The council reported that swell waves *'udha'* effected the islands newly reclaimed area and caused damage to the revetment on the south eastern side. The proposed site for the IWMC was no affected during this event.
- Hardcopies of the grievance form will be available from the Council Office. Council has selected a focal point for the GRM who's contact details will also be displayed at the Office as well as the IWMC site.

4 ALTERNATIVES

This section explores alternatives for the proposed project. The proposed options are compared with alternatives in detail. When comparing the alternatives, environmental, economic and social considerations were taken into account.

4.1 NO DEVLOPMENT OPTION

In the case of no project option, all foreseeable negative impacts as a result of the construction and operation of the IWMC can be avoided. However, no project option would also mean continuation of the current state of waste management in the island (See **Section 1.6**). The people would continue to engage in unsustainable waste management practices. The island would not have an approved demarcated waste management area, waste would continue to be burned in open areas, and kitchen waste would continue to be dumped on beaches, lagoons and reefs. Allowing existing practices to continue would also mean no resource recovery and ultimately all resources getting lost in the "waste". Allowing open dumping waste with no management would also mean increasing risks to human health, lowering aesthetic qualities and lowered quality of life. The aspiration of the people to move in the path of sustainable development would also be compromised. The positive effects of proceeding with the project far outweighs negative impacts associated with the project which can be managed and kept at an acceptable level. Hence, no development option of the project is rejected. **Table 16** below shows comparison of no development option with the development option at Th. Madifushi.

Table 16: Comparison of the no development option with development option

Option	Environmental	Social	Economic
No Project Alternative	All negative impacts associated with project avoided, however, the island environment may continue to slowly deteriorate due to pollution as a result of inadequate waste management. Land area will be rendered unusable or will be polluted by the residual waste remaining after burning and burying waste. Seepage of leachate into groundwater film as a result of burying waste in excavated pits. Risk of waste piles sliding as a result of heavy rain or flooding events. Increased pollution of beaches, lowered aesthetic values, pollution of the lagoon and coral reef.	Benefit to the society by the project will be missed and chances of polluting the island is high which could lead to health implications as well as visual negative impacts. Risk of waste coming into direct contact with children. Without a proper waste management system there is a risk of the island turning into a slum as a result of population increase and economic development.	No significant improvement to the local and regional economy. Jobs and income earning opportunities expected as a result of the project will not realize.
Project Alternative			
	The project will result in loss of alternative land use potential for the proposed site All impacts due to construction can be managed and maintained at acceptable level. The project will control and prevent further pollution of the environment, and thereby promote sustainable development of the island.	Increased direct and indirect employment opportunities for the locals during the construction phase in addition to when the IWMC and waste management system becomes operational. Knowledge transfer and development of technical capacity with regard to waste management and compost making. More resources and manpower to manage the island would become available as a result of the project. The aesthetic qualities of the island would improve and thereby promote healthy and more enjoyable life on the island.	Enhanced opportunity for locals to start and diversify tourism related services, since a safe and clean island would facilitate attracting visitors to island. Creation of job opportunities and development of skills. Potential to get income by selling compost etc. which would develop the island's economy.

		During the operational phase of the project, smell, dust and particulate matter especially from composting activities may be emitted from the IWMC. However due to the isolated nature of the site to the populated area of the island such impacts are not expected to be significant.	

5 ASSESSING THE LIKELY IMPACTS AND MITIGATION MEASURES

5.1 IMPACT METHODOLOGY, NATURE AND IDENTIFICATION OF IMPACTS

The main objective of this report was to assess all negative and positive impacts of the Project on the project on the environment in a logical and systematic manner and to describe actions that will be taken to avoid or minimize the significant impacts to enhance the benefits of the Project. As the first step, for effectively to determine and evaluate the impacts right mix of expertise in relevant disciplines was chosen. This was followed by a number of critical steps such as, defining the spatial boundary of the study area, identifying specific areas for detailed study to understand the baseline environment. It also included, a number of specific stages in the preparation of the EIA namely screening, scoping, characterization of baseline environment, determining project sequence, activities and methodology, alternatives evaluation and review of relevant laws and policies.

5.2 IDENTIFYING IMPACTS AND ANALYSIS

Impact definition used in the report has been adapted from the United Nations Environment Program (UNEP, 2002). Accordingly, an impact or effect used in the current assessment implies the change in an environmental parameter, which results from a particular activity or intervention relating to the proposed Project. Thus the change or the impact is the difference between the environmental parameter with the Project compared without the Project (baseline) measured over a specified period and within the Project location (UNEP, 2002). In identifying and predicting impacts 'best estimates', past experiences, professional judgments, references, and information collected from stakeholder discussions were the main methods used.

As explained, understanding the baseline condition of the Project environment and determining the extent of an impact were critical initial steps in impacts. The overall methodology applied in studying the baseline conditions included collecting information from the field and review of available relevant literature including reports, other related studies and data source. In addition, information obtained from discussions with the stakeholders was also used to characterise specific aspects of the study area. Spatial extent of the affected area/study area was determined by relevant guidance obtained during the scoping meeting, discussions with the stakeholders and professional judgment of the consultant's team.

A modified Leopold matrix was applied in evaluating the impacts identified. The Leopold matrix, which is widely applicable in carrying out an EIA for different types of projects has been chosen as a suitable method for predicting impacts of the proposed project. A clear advantage of using the matrix 'as a checklist or reminder' of the large scope of actions and impacts on the environment that can relate to the proposed actions (Leopold et al., 1971). According to the Leopold matrix method, EIA should consist of three basic elements: a) a listing of the effects on the environment that the proposed development may induce, including the estimate of the magnitude of each of the effects; b) an evaluation of the importance of each of listed effects (e.g., regional vs. local); and c) a summary evaluation, which is a combination of magnitude and importance estimates.

In order to achieve higher efficiency of the matrix, a starting point is to check each significant action listed in a horizontal axis. The experience often proves that 'only about a dozen actions will be important' (Leopold et al; 1971). Each checked action is evaluated in terms of magnitude of effect on environmental factors that are listed in the vertical axis. In the matrix, across each box where significant interaction is expected, a slash (/) is placed diagonally from upper right to lower left angle of the block. In the text which accompanies the Leopold matrix, the evaluator has to indicate whether the assessment is for short-term or long-term impacts. Then, in the upper left-hand angle of each box with a slash, the evaluator should place a number from 1 to 10, which indicates the magnitude of the possible impact, where 10 represents the greatest magnitude of impact and 1 the least (no zeros should be assigned). The scale of importance (placed in the lower right-hand angle of each box with a slash) may also range from

1 to 10, with the same principle applied – the higher the value, the higher the importance. Assignment of numerical value for importance is based on subjective judgment of a multi-disciplinary team working in the EIA. In addition to assigning the numerical values to each marked box, plus (+) or minus (-) sign can be used to show whether an impact is beneficial or adverse.

In this regard, for the analysis of possible impacts of certain activities and procedures during the construction and operation of the island waste management centre, 11 possible activities on the realization of the proposed project, have been identified from a wider list of potential factors of impacts that can be expected for such type of interventions in the environment. Although it is possible to partially determine aggregate, i.e. average assessment of impact factors for each of these components, it is sufficiently appropriate and functional to present them as a whole. The fact is that some of them are synergistic ones, mutually reinforcing their effects, so that this matching of information should be maintained in the analysis. A synthetic presentation of endangering factors is given through mean values and not through aggregate assessment, which will be later scaled.

Furthermore, physical, biological and socio-cultural environmental characteristics of the subject location have been separated and, within them, 14 environmental components have been defined.

The significance of impacts is based on the calculated magnitude score for total impact area and impact activity. The significance is assigned based on the following total impact magnitude ranges. For ease of identification these ranges have been colour coded as shown in the (***Table 19***)**.**

The steps involved are briefly summarised below:

- All Project related actions identified;
- associated environmental characteristics for each action identified;
- the magnitude of the impact was then determined by applying a number from 1 to 10 (1 is the minimum and 10 the maximum). This number is placed in the upper left hand corner in the corresponding box of the matrix, representing the scale of the action and its theoretical extent. A plus (+) was used for positive impacts and a minus (-) was used for negative impacts; in the lower right hand corner of each cell a number from 1 (least) to 10 (most) to indicate the importance of the impact was placed. It then gives an evaluation of the extent of the environmental impact according to the judgement of the EIA team; and
- the significance was then determined by the joint consideration of its magnitude and the importance (or value).

These two factors have been applied as per the definitions given below.

Importance

In comparing relative importance of environmental impacts, the impacts have been characterised by considering the following;

- Duration over which the impact is likely to occur (temporary, short term, long term, permanent);
- timing or when the impact is likely to occur;
- spatial extent of the impact (such as on-site, local, regional, or national);
- frequency or how often the impact is predicted to occur;
- intensity (negligible, low, medium, high); and
- likelihood (certain, likely, unlikely, likely or very unlikely).

Magnitude

Magnitude of the impact was expressed in terms of relative severity, such as major, moderate or minor/negligible. In determining severity other aspects of impact magnitude, notably whether or not an impact is reversible and the likely rate of recovery are also considered. Hence, the following equation was used to determine the impact significance (UNEP, 2002).

$$Impact\ characteristics\ (magnitude)\ \times\ Importance\ (value) = Impact\ significance$$

The scores obtained for the magnitude of each of the impacts (both positive and negative) were categorised as given in **Table 17**.

Table 17: Categorization of the significance

Total magnitude score	Category
> 40	Major positive
20 to 39	Moderate positive
1 to 19	Minor positive
0	Negligible
-1 to - 19	Minor negative
-20 to - 39	Moderate negative
>- 40	Major negative

Significance categories given in **Table 17** is defined as explained in **Table 18**.

Table 18: Impact characterization matrix

Significance	Characteristics	
Major	An impact of major significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. A goal of the EIA process is to get to a position where the Project does not have any major residual impacts that would endure into the long term or extend over a large area.	Requiring appropriate mitigation measures
Moderate	An impact of moderate significance is one within accepted limits or standards. The emphasis for moderate impacts is on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable.	
Minor	An impact of minor significance is one where an effect will be experienced, but the impact magnitude is sufficiently small (with and without mitigation) and well within accepted standards, and/or the receptor is of low sensitivity/value.	

Different colour codes have been used in the impact matrix to distinguish between positive and negative impacts as depicted in Table 19.

Table 19: Colour codes used for distinguishing positive and negative impacts

Significance categories	Colour code
Major positive	
Major negative	
Moderately positive	
Moderately negative	
Minor positive	
Minor negative	
Negligible	

Cumulative Impacts

Cumulative impacts which may be defined as impacts that result from incremental changes caused by other past, present or reasonably foreseeable activities together with the project are generally considered in the impact assessment studies. The environment where the proposed IWMC will be situated is relatively undeveloped area and no projects have been planned for the immediate future. Hence the proposed approach for assessing cumulative impacts was to consider those that had already been completed. In this regard, the only foreseeable cumulative impact of the project had been identified to be in relation to the electricity consumption. Power needed for the IWMC will be sourced from the island's existing power network. Considering the equipments that will require electricity at the IWMC, it is envisaged that it would not have a significant impact on the island's power system. Long term additional power usage will have a cumulative impact on the greenhouse gas emissions which can contribute to climate change. However such cumulative impacts on climate system are believed to be insignificant.

Impact Mitigation

EIA regulation requires practical and appropriate mitigation measures for significant impacts identified to be proposed in the ESMP. The Proponent is required to submit a letter of commitment in the ESMP report stating that all the mitigation measures proposed in the report will be implemented during all phases of the Project. Hence full implementation of the mitigation measures is considered an important condition for issuing the ESMP decision statement to proceed with the project. For each identified significant negative impact in proposing mitigation measures the priority was given to avoidance of a predicted impact by taking measures such as bringing changes to the design and/or work methodology. In cases where avoidance of an impact was not possible practical and cost effective measures have been proposed to reduce the impacts and enhancing positive impacts. Practical experience and lessons learnt by the ESMP team from projects of similar nature played a key role in proposing mitigation measures.

In addition to predicting impact of the project on the environment, impacts of the environment on the project components for ensuring sustainability of the project was also considered.

Gaps in Baseline Information

Accurate impact assessment demands accurate baseline information collected over a reasonable period of time. However, even with the best effort to collect all relevant primary data required, inherent challenges make it almost impossible to have all such information collected within a relatively short period of time available to complete the assessment within the contract period to complete the study. Hence in certain cases it becomes necessary to make assumptions when limited or no information is available.

Understanding of the baseline conditions in studying existing environment was limited to a short period of time. Collecting all necessary environmental information is rarely possible due to time and cost constraints and therefore, the data captured is representative of the conditions at the time of the surveys.

In the case of the present study, the data gaps have been adequately filled by experiences and lessons learnt from similar projects carried out in the Maldives.

Gaps in Understanding Impacts

Impact identification, characterization as well as significance analysis also involved uncertainties as ideally such an exercise should take place against a framework of criteria and measures established for the purpose in the relevant legislation which is not the case in the Maldives at present. Specified criteria necessary for impact evaluation such as environmental standards and thresholds are yet to develop in order to strengthen the EIA process in the country. In order to address these gaps, where impact magnitude cannot be predicted with certainty professional experience and scientific literature was used and adapting criteria and measures from elsewhere that are relevant to local circumstances was used. In cases where a greater degree of uncertainty is believed to exist precautionary approach had been adopted in which likely maximum impact was considered.

Lack of compressive baseline information on all aspects of the Project environment was a critical setback in predicting impacts. However, developing and operating island level waste management centers is not uncommon in the Maldives and a lot of experiences have been gained in terms of actual impacts associated. Hence, in the case of present project uncertainties associated with the most significant impacts could be considered relatively small.

5.3 POTENTIAL IMPACTS AND MITIGATION MEASURE FOR KEY IMPACTS

For every minor to moderate to major impact identified, a mitigation measure has been proposed and discussed below. The mitigation measures proposed would be strictly adhered to eliminate environmental impacts arising from the project, even before it occurs. The impacts and mitigation measures are detailed in the two stages, construction and operational stages as explained below.
The possible mitigation measures include:

a) Changes in work practices and increasing awareness;
b) Provision of environmental protection and health safety equipment; and
c) Environmental monitoring during construction phase and operational.

Mitigation measures suggested in the report will focus on the existing environmental conditions as well as impacts that may rise during operation of the IWMC.

Table 20: Impact matrix for Construction phase

	Envisaged impact factors	C1 Worker Influx and Settlement	C2 Transportation of materials	C3 Site Demarcation & Fencing	C4 Construction	C5 Waste Generation	C6 Resource Consumption (Water, Electricity)	Total (Impact Area)
Physical Components	Seawater	-2	-4			-5		-11
		1	3			5		9
	Ground water	-2			-4	-4	-5	-15
		1			4	4	5	14
	Air	-3	-4	-1	-3	-5	-3	-19
		2	4	2	3	4	3	18
	Noise	-2		-1	-3	-2		-8
		1		2	3	2		8
	Coastal Zone						-1	-1
							1	1
Biological Components	Flora	-1	-1		-1	-1	-3	-7
		1	2		1	2	2	8
	Endangered species/protected areas							0
								0
	Coral Reef					-3		-3
						4		4
	Fauna		-2		-1	-3		-6
			2		1	3		6
Socio-Cultural Component	Aesthetics	-2	-3		-7			-12
		2	3		5			10
	Accidents	-1	-6	-1	-6	-2	-1	-17
		1	5	1	4	2	1	14
	Landscape				-7		-7	-14
					7		8	15
	Health/Well being	-1	-6	-1	-5	-5		-18
		1	4	2	3	6		16
	Local economy	4	4	1	7		-2	14
		1	4	2	5		2	14
Total (Construction Activity/Risk)		-10	-22	-3	-30	-30	-22	
		11	27	9	36	32	22	

Summary of the multi-criteria analysis is given in **Table 21**

Table 21: Summary of multi-criteria analysis for construction phase

Activity	Impact Score	Overall Impact
C4 Construction	**-30**	**Moderately negative**
C5 Waste generation	**-30**	**Moderately negative**
C6 Resource consumption	**-22**	**Moderately negative**
C2 Transportation of materials	**-22**	**Moderately negative**
C1 Worker influx & settlement	**-10**	**Minor negative**
C3 Site demarcation & fencing	**-3**	**Minor negative**

5.3.1 Impacts and Mitigation from Construction Phase

5.3.1.1 C4 Construction

There are a number sub-activities that can affect the environment related to construction of the IWMC. Overall, the multi-criteria impact magnitude for this activity was -30, which meant that it will have a moderately negative impact.

Material Storage

At the initial stage all resources required for the construction of the site will have to be procured and stored. These include construction materials, vehicles, machineries, fuels, and tools required IWMC construction. Due to the nature of the project, even though a large volume of construction materials are not required care must be taking in storing materials to avoid any potential damages to the environment. The improper siting of stockpiles and storage of sand, gravel, cement, fuel, etc., at the construction sites could lead to fine materials being lost, damaged during heavy rainfall events. This would not only represent a waste of resources but could also be a cause of project delays. Hazardous and flammable materials (e.g. fuel, paints, thinner, solvents, etc.) improperly stored and handled on the site are potential health hazards for construction workers and spilled chemicals would have the potential to contaminate soil and inhibit plant growth in localized areas.

Mitigation for material storage impacts

- Safe storage area should be identified and retaining structures put in place prior to the arrival and placement of material;
- the stockpiling of construction materials should be done in a such a way that the materials are not exposed to weather conditions and are properly controlled and managed by the site supervisors; and
- hazardous chemicals (e.g. fuels) should be properly stored in appropriate containers and these should be safely locked away. Conspicuous warning signs (e.g. 'No Smoking') should also be posted around hazardous waste storage and handling facilities.
- equipment shall be stored in fenced areas and maintained appropriately during the course of the project and no new such facilities shall be developed for the purpose of the project;
- National Fire Code (NFC) shall be strictly followed while handling, transporting and storing fuel. Inflammable goods such as fuel drums, portable fuel containers and cleaning solvents and chemicals will be closed off from public access.
- portable extinguishers placed to be readily available when someone finds a fire;
- fuel should be stored in well contained barrels and place over a concrete. This is to contain oil spills during storage and to prevent infiltration of oil into soil; and
- tool shed shall be locked and all the equipment, vehicles and tools must be accounted for.

Noise and vibration

It is important to identify the sources of noise and vibrations and the intensity of such impacts on the project island. The noise and vibration impacts are expected to be minor as the nearest residential area to the project site is more than 264 m away.

The main source of noise from the construction phase of the project will be from the engines used in the machinery and vehicles. No high impact works such as pile driving or demolishing structures are part of the proposed construction, therefore the impact noise is not a major source of noise pollution for this project. Typical noise level of construction equipment are detailed below:

Table 22: Typical construction equipment and their noise levels 50ft from the source

Equipment	Typical Noise Level (dBA) 50ft from source
Concrete mixer	85
Concrete pump	82
Concrete vibrator	76
Pump	76
Saw	76
Shovel	82
Tie Cutter	84
Truck	88

Assuming the highest noise produced during construction is at 85 dBA, a noise decay calculation was done using initial assumptions without factoring for dampening effects due to obstacles and vegetation. From the initial calculations, the noise levels are projected to decrease down to less than 59 dBA at the nearest residential area.

Noise during construction is determined to be a short term negative impact. Due to the distance of the project site it is identified that noise impacts will be minimal to the residential zones, while the construction workers will be most affected by the noise impacts.

Mitigation Measures

- Confine construction activities to day time, from 8 am to 6 pm. Ensure no construction activities occur during night time; and
- Use of hearing protection by workers during the operation of heavy machinery.

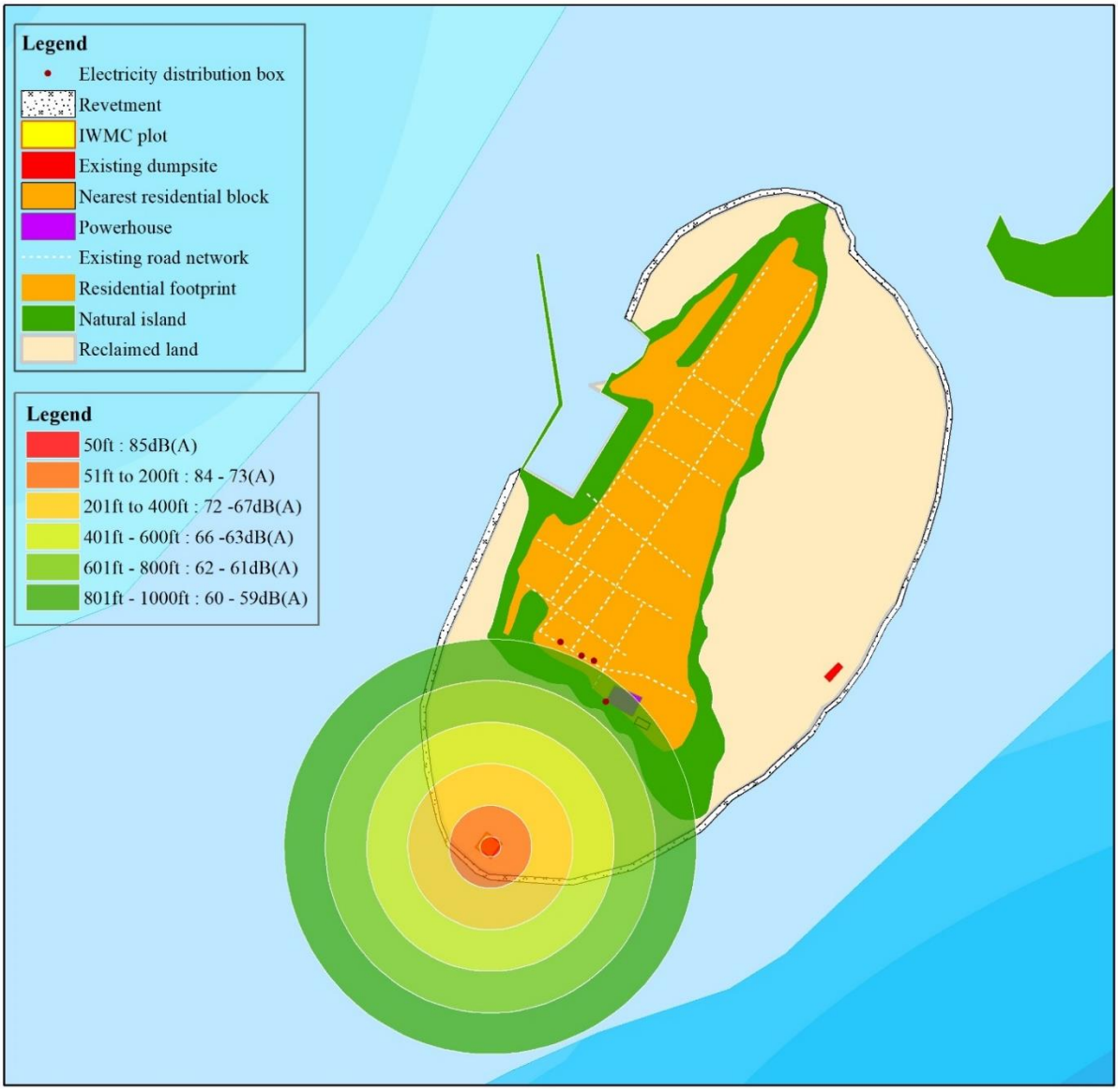

Figure 15: Noise range map for Th. Madifushi

Impact on vegetation

No vegetation is to be removed as part of this project. Careless workmanship may result in damages to the vegetation during movement of materials and other project related activities during the construction phase.

Mitigation Measures

- Workers shall be informed to avoid damaging trees and disturbance to animals and to generally avoid engaging in destructive activities to the environment intentional or unintentional.

Accidents and injuries

For a construction project of this nature there can be a number of causes that can result in accidents and injuries to workers. Hence it is imperative to identify and put in measures to avoid accidents and injuries to workers during construction phase. Some of the likely causes include:

- inhalation of cement during the site cast and pre-casting of concrete: inhaling high levels of cement dust during construction can be irritating to the nose and throat. Prolonged exposure to cement dust can result in silicosis (CSAO, 2001);
- contact with concrete mix: concrete has caustic, abrasive and drying properties and prolonged contact with concrete allows the alkaline compounds such as calcium oxide to burn the skin;
- wet concrete trapped against the skin can cause first, second, or third degree burns;
- falling of heavy objects: constructions sites are prone to falling of heavy objects which can be fatal to workers;
- falls: workers may be under the risk of falling into open pits, trenches and seriously injuring themselves;
- Bodily injuries due to manual lifting of heavy items; and
- being struck by moving equipment and vehicles.

Mitigation measures

For all works the following safety measures will be required during the construction phase.

- Appropriate PPE will be worn at all times. This will typically include hard hats, eye protection,
- protective trousers, gloves and reflective clothing, hearing protection, masks and wet weather clothing as appropriate;
- first aid kit will be on site at all times;
- all plant will be operated by competent certified operators. Plant to be inspected regularly and
- have the appropriate certification;
- manual lifting operations will be kept to minimum by the use of mechanical means;
- site visitors should not be generally allowed to work site except when its essential in such cases shall be accompanied at all times and required PPE shall be provided;
- provide first aid services in the site;
- proper signage and fencing should be provided around the site;
- carry out works during good weather;
- well trained personnel to use machinery and vehicles;
- avoid transportation during night; and
- aecuring any loads on vehicles during transportation.

5.3.1.2 C5 Waste Generation during Construction

Solid waste generated during IWMC construction work would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite. Overall, the multi-criteria impact magnitude for waste generation was -30, implying that it will have a moderately negative impact. Waste burned onsite would generate smoke, possibly impacting negatively on ambient air quality and human health. Solid waste, if allowed to accumulate, could cause localised conditions conducive to the breeding of nuisance and health-threatening pests such as mosquitoes. Poor construction waste management constitutes a short-term, possibly long-term, negative impact.

Vehicle, equipments and tools maintenance works will likely be the primary source of chemical wastes during the construction period. The majority of chemical waste produced is therefore expected to consist of waste oils, solvents and used batteries. Typical wastes may include the following:

- Solid wastes (Empty fuel/lubricant drums, used oil/air filters, scrap batteries, vehicle parts);
- and
- Liquid wastes (waste oils/grease, spent solvents/detergents and possibly spent acid/alkali from batteries maintenance).

However, the amount of chemical and hazardous waste produced will not be significant. Other construction waste includes, packaging, concrete, wood and steel in minor quantities.

Municipal wastes are also expected to be generated during the construction phase by the workers comprising of food wastes, packaging wastes and waste paper.

The amount of human waste generated per person is approximately 125 g/day, which means 1.9 kg will be produced daily if approximately 15 workers were active which equates to discharge of approximately 2,550 l/day of waste water. Sewage will be managed through existing septic tank systems that have been installed in the island.

Since there is no existing waste management system in the atoll and since there is no waste management practice in the island to accommodate the construction waste generated, the environmental receptors will have a significant burden from construction waste. Some of the hazardous oils if not disposed properly may cause health implications to the people and vegetation.

Mitigation Measures

- Ensure to manage waste as described in **Section 2.3.15** of the report;
- avoiding cooking and eating at work site to eliminate food waste and kitchen waste. Hence food for workers can be arranged with existing services on the island;
- reusable inorganic waste (e.g. excavated sand) should be stockpiled away from drainage features and used for in filling where necessary;
- regular sweeping of the of the worksite to collect litter, empty cans etc which could become breeding ground for mosquitoes and other pests;
- open defecation whether it's on land or on the beach shall be prohibited;
- appropriate general site cleanliness related signboards could be placed on the worksite to give workers reminders on good waste management practices;
- ensure to reduce waste by following the 3R steps; and
- waste collected shall be transported to nearest waste management facility after the construction works have ended.

5.3.1.3 C6 Resource Consumption

As shown in the BoQ for the project various types of construction related resources are required for the project. Consumption of goods impacts the environment in many different ways. For instance materials used for the project would contribute, directly or indirectly through the product lifecycle, to climate change, pollution, and biodiversity loss and resource depletion locally or elsewhere in the world. The most important resource as far as the current project is concerned would be the allocation of land for the site. For the purpose of developing the waste management center at least 735 m^2 of land would be required which represent 0.16% of the existing area. Allotting a plot of land for waste management with permanent concrete structures developed would essentially will result in a loss of the options for alternative land use and thus represents an irreversible commitment of land resources. The loss of optional uses for the allocated land although is inevitable is considered a negative impact. Other resources required would include sand, water, power and construction materials required for the IWMC development. Since the resource utilization is considered to be relatively small, and that it is not expected to significantly contribute to deplete the natural resources and would be a major source of GHG emission, the multi-criteria impact magnitude for this activity was -22, which meant that it will have a moderately negative impact.

Since it would be very difficult to precisely determine by how much exactly the current project would contribute to the depletion of each type of various natural resources required for the project at local and

global levels and by how much it would have contributed to global climate change, general impacts that are normally associated with natural resource use can be applied in relative terms for the project.

Mitigation

- Resource conservation shall be given a high priority in all stages of project development through bulk purchasing, putting in place measures to avoid wastage, encouraging reuse and recycling;
- initiate rainwater collection and storage as early as possible into the project construction;
- careful store management and record keeping on use of materials;
- reduce idle time for vehicles and equipments and switching off after use;
- use well maintained, energy efficient equipment and lights;
- sand shall not be mined from beaches and lagoons of the island for construction purposes, if coral sand is used it should be obtained from a government approved location;
- materials that are locally available shall be obtained as such instead of opting to bring those after a long haulage;
- materials shall be procured in bulk as much as possible;
- utilize day time hours for the construction when plenty of light is available; and
- FENAKA power supply will be used for electricity generating purposes.

5.3.1.4 C2 Transportation of Materials

Transportation of construction materials from the source to the project island is identified as an activity with climate impacts, through the transportation of sea vessels, as well the transportation of the materials on land. The use of vessels and vehicles would require burning of fossil fuels which result in the release of greenhouse gases (GHG) into the atmosphere. The fuel usage of a supply barge is estimated at 1.3 kWh /t. As a general rule the longer distance would mean more fuel burnt and more GHGs produced. As the resource sourcing hierarchy in **Figure 16** shows, the greatest importance shall be placed on sourcing any available materials from within the island, with the next option being from within the atoll, from islands such as Th. Thimarafushi. Next in the hierarchy is Male' and the industrial areas in the zone, from where majority of the remaining materials can be sourced. Lastly, in cases where a proposed material cannot be obtained from within the country, only shall the contractor procure the material from a neighbouring country which is not likely due to relatively small volume of material requirement and commonly available nature of those. The multi-criteria impact magnitude for this activity was -22, which meant that it will have a moderately negative impact.

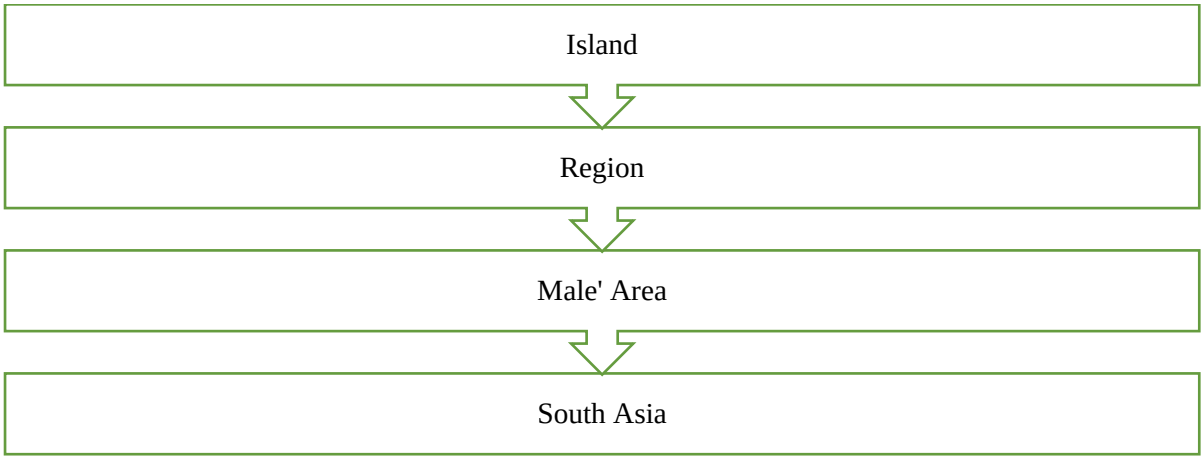

Figure 16: Material sourcing hierarchy proposed for the project

Along with the reduction in travel distances by choosing a close source, the number of trips to be made can magnify the distances travelled. The Proponent has produced the Bill of Quantities (BoQ) for the project works, which enables the contractor to purchase the required amount of materials in bulk, reducing the number of trips and wastage of materials. While the sea transport is expected to have the greatest impact of released GHG, the transport on land is expected to be minor, due to the short inland travel distances within the island.

The inputs of the project elaborated in the **Section 2.5** show the estimated amount of resources that will be used for the project. The use of resources for the project can have indirect impacts of GHG emissions from the production process. The main materials used in this project include concrete, reinforcing steel, structural steel, in addition to PVC pipes. Defra / DECC (2012) states that for every tonne of concrete casted, 135 kg of indirect CO_2 emissions result. Due to the small scale of the construction, the estimated indirect CO_2 emissions from material usage are minimal for this project.

The use of heavy vehicles on unpaved roads can cause compaction of the soil by the force applied by the tires of the vehicles. This can lead to the destruction of the soil structure, reduction of porosity, and thus reducing the water and air infiltration into the soil. The resulting soil is dense with few large pores and poor internal drainage (Wolkowski & Lowery, nd.). Roads impacted with the traffic from heavy vehicles can thus result in undulations and puddling.

Figure 17: Impact on roads from heavy vehicle transport in an island in Maldives

For the purpose of construction, no heavy vehicles are proposed. Although this is the case, a pickup truck will be used to transport the construction materials to the site, in addition to yard waste and construction waste from the site. The vehicle is not expected to cause major impacts on the road, force applied by the pickup truck is expected to be lower than heavy vehicles and plant. The number of trips required are also reduced in the case of the proposed project, due to the small scale of construction.

Other impacts on roads due to transportation include the generation of dust during transportation, which can lead to impacts on the local air quality especially during dry weather. In addition to this, littering of construction materials from uncovered transportation vehicles can cause terrestrial pollution and amenity impacts.

Mitigation for climate impacts

- Sourcing of materials shall be done according to the hierarchy presented in **Figure 16**. Materials shall be obtained from the closest source;
- The materials shall be bought in bulk and transported to the island within a single trip where possible;
- Detailed BOQ has been produced by the Proponent, which shall be followed by the contractor when purchasing materials in order to reduce wastage of materials as well as the number of trips;
- The materials shall be stored on the project site to eliminate transportation of vehicles within the island throughout the construction phase;
- Idle time of the vehicles shall be avoided in order to reduce emissions;
- contractor shall use serviced vehicles and plant equipment for the project;
- contractor shall only use the needed amount of vehicles and plant for project; and
- vehicle used for the purpose should comply with the roadworthiness requirements of the Transport Authority and display the compliance stickers.

Mitigation for impacts on roads

- The contractor shall only bring in the necessary number of vehicles and plant to the island for the project;

- it shall be stated in the contract that any damages to the roads from transportation of construction materials and machinery shall be assessed after the civil works are completed, and the damages shall be repaired by the contractor;
- use the closest route from the harbor area to the site;
- cover the materials being transported to and from the site; and
- spray water on the road surface during dry periods to suppress dust.

Mitigation for accidents and injuries

- Vehicle drivers shall be licensed and competent;
- loads being transferred shall be fully secured; and
- transportation shall be done during day time as far as possible; and
- speed limits shall be observed when operating vehicles especially in residential areas.

Mitigation for marine and terrestrial pollution

- contractor shall clean any littering on the terrestrial or marine environment caused during transportation; and
- contractor shall enforce strict policy against littering and appropriate penalties; and

5.3.1.5 C1 Worker Influx and Settlement

A large number of work force is not expected for the project. An estimated 10-15 workers will be required for this project. Since resource consumption, waste generation and behavior related impacts on the environment are likely to have an incremental increase with additional people to the island. However, even though minor workers related negative impacts can range from damage to flora and fauna of the island, impacts associated with resource utilization, waste generation and potentially negative social impacts. On the other hand, even though small, more people to the island could have a positive effect on the local economy. Multi-criteria impact analysis shows that this activity will have a overall minor negative impact with a score of -10.

For the duration of the project, the workers related waste output is detailed in **Section 2.3.15**. For this project, worker related impacts can be reduced through the following mitigation measures.

Mitigation for impacts on flora and fauna

- The contractor is required to keep the workforce as minimum as possible, and to not bring in any surplus workers for the project;
- the project island currently has vacant properties as well as rooms to let in houses, which can easily house the influx of 10-15 workers. Therefore no new facilities will be made for the accommodation of the workers in order to avoid clearing of land or spending resources unnecessarily for making worker quarters;
- all construction workers and persons on site must be given specific instructions not to catch or harm birds and animals allow them to retreat into undisturbed areas and prohibit damaging vegetation that are not;
- rules shall be formulated by the contractor and workers shall be oriented on the rules and conduct during the project works;
- enclosed containers shall be provided to dispose of waste oil and other hazardous waste;
- workers shall be given instruction not to catch or harm any birds or animals present on the island, and not to damage any vegetation that is not already sanctioned for removal within the demarcated site bounds;
- littering shall be prohibited; and

- waste bins shall be placed within the site.

Mitigation for impacts on resource use

- Reducing, reusing and recycling of resources shall be encouraged through proper monitoring of worker activities and awareness; and
- Keep workforce to the minimum required.

Mitigation for sociocultural impacts

- hire local workers where possible;
- orient foreign workers on communication, personal hygiene and sanitation and infectious diseases; and
- ensure all foreign workers have their legal permits.

5.3.1.6 C3 Site Demarcation & Fencing

Site demarcation and preparation involves surveying and setting the extents of the IWMC. This activity is considered to have minor environmental impacts with multi-criteria impact analysis score of – 3 as it is largely noninvasive.

However, improper or inaccurate demarcation could result in the IWMC plot being set outside the limits as proposed by the EPA. It is important to ensure that the buffers proposed by the EPA are followed during site demarcation.

With proper planning, engaging qualified people and use of proper equipment, and with proper protective measures these impacts can be avoided. This activity is expected to have a minor impact overall.

Mitigation measures

- Ensure that the surveyors and helpers engaged in site demarcation properly understand the scope of works and recommendations of this report;
- qualified surveyors shall be engaged in site demarcation;
- accurate and reliable equipment shall be used to minimize errors; and
- carrying out the works during the day time.

Table 23: Impact identification matrix for operational phase

Envisaged impact factors		O1 Waste collection and transportation	O2 Waste sorting, separating and composting	O3 Waste generation	O4 Resource consumption (water/electricity)	Total (Impact Area)
Physical Components	Seawater	9				9
		9				9
	Ground water	8	-2	-1	-3	0
		5	2	5	2	14
	Air	-3	-2	-2	-3	-10
		5	3	2	4	14
	Noise	-3	-1			-4
		4	2			6
	Coastal Zone					0
						0
Biological Components	Flora	6	7	-1	-3	9
		2	6	1	3	12
	Fauna	5	5	-1	-3	6
		5	5	1	3	14
Socio-Cultural Component	Aesthetics	9	8			17
		9	6			15
	Accidents	-4	-4		-4	-12
		4	4		5	13
	Landscape	9	6	-1		12
		6	5	2		13
	Health/Well being	9	-5	-2	-4	-5
		6	5	2	7	20
	Cultural heritage					0
						0
	Local economy	-3	8	-2	-1	2
		9	5	4	1	19
Total (operational Phase Activity/Risk)		**42**	20	-10	-21	
		64	43	17	25	

5.3.2 Impacts and Mitigation from Operational Phase

Since the overall objective of the project is to establish economic viability and environmental sustainability of the proposed waste collection, transfer and disposal systems to prevent impacts on human health and environment through approaches that are sustainable and locally appropriate, the operational phase of the project is expected to yield overall positive outcomes. In this regard, the proper management of waste sorting, collection, transport and disposal in the new system will reduce potential environmental and health impacts from waste. Furthermore, a safer and better environment will promote business, especially tourism, in the area and create better livelihood conditions. However, as summarised in **Table 24**, the operation of the waste management system itself will result in certain negative environmental impacts which will have to be managed properly through appropriate mitigation measures to ensure that those negative impacts are kept at an acceptable level. The paragraphs below briefly discusses the likely impacts and proposed mitigation measures.

Table 24: Summary of multi-criteria analysis for operational phase

Activity	Impact Score	Overall Impact
O1 Waste Collection & Transport	**42**	**Major positive**
O2 Waste sorting, separation, and composting	**20**	**Moderately positive**
O4 Resource consumption	**-21**	**Moderately negative**
O3 Waste generation	**-10**	**Minor negative**

5.3.2.1 O1 Waste Collection and Transportation

As stated in this report, a demarcated area has been built in Madifushi with compartments for separated metals, glass and plastics. During the visit it was observed that this area was completely filled up during the two year's of its operation. The operation of the dumpsite as well as cleaning of the public spaces is being conducted by the Women's Development Committee. The council stated that the dumpsite has filled up due to there being no way to reduce the volume of the waste, nor there being any way to transport the waste out of the island. As the dumpsite has been filled, waste is now being dumped in the open area next to the demarcated area. The practice of open burning of waste also takes place resulting to potential respiratory issues from the inhalation of smoke. Hence a reliable, affordable and locally appropriate transport system is critical to collecting waste from houses, businesses and institutions. Equally important is an arrangement for marine transport to remove residual waste from the island in order to make the system complete and effective. The successful implementation of the IWMC together with land and marine transfer arrangement are two important aspects to implement Waste Management Plan to make the island cleaner and healthier for the people to put a stop to littering and burning of waste in the island. This will lead to the improved health and psychological well-being of the residents and visitors of Madifushi. It has been identified as a long term positive impact on the residents and visitors of Madifushi.

A vehicle will be obtained for the purpose of collecting and transporting the waste within the island daily, at a set schedule. At the moment there is no specific arrangement for marine transfer of residual waste from the island although by the time IWMC is complete it is expected to have this arrangement

in place. The multi-criteria analysis shows waste transport arrangement will have a major positive impact with an overall score of 42.

While both land transport and marine transfer of waste are expected to have significant positive impacts, unregulated transport arrangements can result to environmental issues. If not properly managed likely environmental impacts include, noise, hardening of road surface, creation of puddles during wet season, and littering on the roads, bad odour during transport, and health issues to workers, vehicular emission, dust generation as a result. In the case of marine transport, there can be chances of dumping of waste intentional or unintentional en-route to the final disposal site in addition to engine emissions. However, these impacts can be effectively managed and negative impacts can be kept at an acceptable level.

Measures to ensure and enhance the positive impacts

- Proponent and Island Council shall follow the management plan provided with the ESMP in order to monitor the operations of the IWMC, and bring about any necessary changes to the operations and policies, in addition to providing any needed technical assistance for the island;
- proponent shall review the waste management operations within the island regularly and update the National Waste Database;
- Island Council shall review and update the IWMP by consulting relevant stakeholders;
- Island Council shall conduct awareness programs to the residents of the island regarding the best practices in waste management, as well as conduct programs to familiarize the residents with the gazetted regulations and guidelines to manage the waste within the island;
- regular awareness programs conducted to minimise waste generation and Polluter pays principle established in order to reduce the waste generation within the island;
- proponent shall provide resources in terms of required equipment, machinery, and technical expertise to ensure the operation of the IWMC; and
- Proponent shall assist in creating markets / avenues where the IWMC's can generate income through selling compost and recycled metals, plastics and glass.

Mitigation for terrestrial pollution

- Implement rules within the IWMC workers to impose penalties for any littering within the island due to improper handling of the waste and improper transport practices;
- the status of the vehicles used shall conform to the Waste Management Regulations 2013/R-58 and provide cover to the waste being transported in order to avoid littering;
- during waste collection instead of stopping the vehicle at every house, the residential area can be divided into blocks and vehicle stops can be pre-determined and from where waste containers can be hand carried by the workers from respective houses to be loaded to the vehicle.

Mitigation for accidents and injuries

- Waste collecting workers shall wear appropriate clothing and PPE to avoid injuries in handling waste;
- vehicles should be driven by licensed drivers;
- records of the vehicle trips shall be properly maintained;
- speed limits shall be observed; and
- a strict schedule shall be stated in the IWMP and followed in order to reduce the transportation frequency thus reducing the probability of accidents.

Mitigation for air quality impacts

- Vehicle speed shall be kept appropriately to suppress dust;
- vehicles used shall be regularly washed and kept clean; and
- The waste being transported shall be covered to minimise the impact of odour on the public.

Mitigation for climate impacts

- Regular servicing of vehicles used to transport waste;
- ensuring the vehicle has roadworthiness certification from the Transport Authority;
- restricting the use of the vehicle only for the stated time in the IWMP;

Measures to prevent marine pollution

- Wastes destined to the nearest waste management facility will require to keep logs of waste being loaded from the island and unloaded at the nearest waste management facility. The records to be signed by the vessel captain and a copy returned to the waste management supervisor;
- vessels used shall have a certified captain and vessel should have valid seaworthiness certificate;
- vessels shall not be overloaded and waste containers shall be kept closed and shall not be allowed to flyaway due to wind and sea conditions; and
- Waste shall not be transferred during extreme weather conditions.

5.3.2.2 O2 Waste Management Activities

Assuming that operations of the IWMC will be properly resourced and functioning properly, the waste sorting, separating storing and composting will have an overall positive impact as shown by the multi-criteria impact assessment with a score of 20. On top of reducing the volume of waste, these activities, will make resource recovery and ultimately a significant proportion of the waste becoming a valuable resource. These activities will be carried out in the IWMC where employees will be trained to undertake these activities.

In general, the operational phase of the project will greatly improve the existing waste management condition of the island preventing pollution and spread of diseases. These activities would prevent pollution of groundwater, coastal areas and forested areas which would prevent impacts to biodiversity, health and wellbeing of the public.

However, if these activities are not properly implemented there is a risk of IWMC being deteriorated into a dump site where mixed waste are disposed, burned and buried. This means without proper mitigation measures and regular transportation of waste out of the island to a central facility, there is a greater risk of IWMC being overfilled. This entails a loss of investment and a greater impact to environmental receptors as some sites are moderately close to public areas. Moreover, impacts associated with composting sorting and storing waste has inherent impacts which will have to be properly managed, identified and mitigated to enhance and ensure the positive impacts of the proposed IWM. Propensity of these impacts are greater for the following environmental receptors:

- Groundwater;
- Climate/air; and
- Health and wellbeing: noise, odour and accidents/injuries

The following Sections describes the factors influencing these impacts and proposes measures to mitigate negative impacts and to ensure the overall positive impact of the IWMC during operational phase.

Impacts on health

While overall positive impacts on public health are identified from this project, the negative impacts of running a waste management centre (especially one where composting is to be done) shall be highlighted. Composting can be a source of particulate matter in the atmosphere. The highest concentration of particulate matter in the air occur during the pre-treatment phase where the fresh organics are shredded and mixed. Particles also become airborne during the turning of the biodegrading compost heap to regulate the temperature.

Certain pathogens may also be transmitted via air during the composting process. These include *Legionella longbeachae, Aspergillus fumigatus, Mycobacterium tuberculosis* and *Hantavirus* (DEC NSW, 2004). Harrison (2007) has done a comprehensive literature review on the health effects of composting operations, which show increased concentrations of bio-aerosols within the vicinity of the composting facilities and related health effects to workers as well as affected public. Bunger et. al (2006) states that exposure to organic dust at composting workplaces is associated with acute and chronic respiratory health effects. Muller et. al (2006) and Wouters et. al (2006) agree with these findings, stating that changes were found in white blood cell counts, increase in neutrophils, decrease in oesinophils were measured in healthy subjects.

As for the association between the health symptoms and the distance from the site, Herr et. al (2004) showed that total bioaerosols were found at > 10^5 CFU / m^3 close to the composting site and dropped to background levels within 550 m from the site. Herr et. al (2004) also showed from another study where higher than background concentrations were found within 200 m from an outdoor composting site (> 10^5 CFU / m^3), and dropped to background concentrations at 300 m.

Wheeler et al (2001) stated that composting activities do not emit bio aerosols at levels that can be of a hazard to the public. Wheeler et al suggests a buffer zone of 250 m. The conservative values for the concentrations given by Wheeler at al includes:

Table 25: Background concentrations of bio aerosols (Source: Wheeler et al (2001))

Bio aerosol	Concentration
Total Bacteria	1000CFU/m3
Total Fungi	1000 CFU/m3
Gram-negative bacteria	300 CFU/m3
Inhalable dust	250 µg /m3

Wheeler et. Al; (2001) states the concentrations of bio aerosols exceed this limit where 10^5 – 10^6 of bacteria and 10^3 and 10^4 of fungi have been measured, the concentrations drop to background levels at 250m distance from site. Although it should be noted that the expected composting operations in the IWMC are not as large scale as the studies cited above. Therefore, the health impacts of the bio aerosols can be minimised by following the mitigation measures provided.

Other potential health effects can arise from the introduction of vermin or pests, putrescible wastes attracting flies, puddles allowing the breeding of mosquitoes. Impacts that may arise from the IWMC becoming a makeshift waste dumpsite for organics are also addressed in the subsequent Sections of the report.

Impacts on groundwater

When organic waste is stockpiled for composting, there is potential for leachate production from the waste. This is especially prevalent in cases where the waste includes food, meat, fish and fatty sludges. This leachate can infiltrate into the ground and mix with the freshwater lens of the island, thus polluting

the lens with high amounts of nutrients, which can introduce bacteria and other microbes. If the conditions are anaerobic, the resulting leachate can be acidic and cause the corrosion of metals and introduction of metallic compounds in the groundwater. If the conditions are aerobic, alkaline leachates will result with a low carbon – high nitrogen ratio. The main parameter in leachate that is considered to have a negative environmental impact is nitrogen that results from biodegradable waste.

Leachate production can increase during the rainy season, with the additional water from rain causing leachate from garden materials, wood and fibrous materials. Rain can also cause the stockpile to become anaerobic, thus resulting of undesirable odours.

The operation of the IWMC is identified to have an overall positive impact of the groundwater of the island. While the aforementioned infiltration of leachate would still be an issue (if improperly managed at the IWMC), it should be noted that the same waste has been dumped throughout the island without any measures, enabling the pollution of the groundwater with the leachate. Therefore, the proper operation of the IWMC and the proper management of the collected waste will result in the reduction of the pollution of the groundwater from waste sources, thus improving the status of the groundwater in the island.

GHG emissions

The waste management activities will require power consumption for operation of the machines, lighting and pumping. Since the island's power system is fossil fuel based incremental increase in electrical energy consumption at the IWMC will result in GHG emissions. However, the power consumption at IWMC is expected to be small and therefore is not considered a significant issue. In addition, CO_2 which a GHG will be the main gas produced during the composting process in aerobic conditions while in anaerobic conditions, methane is released into the atmosphere, which has even a higher greenhouse warming potential compared than CO_2. In open systems, methane is not released in large quantities as long as the aerobic environment is maintained. (USEPA 2002). If the composting is well managed and kept in aerobic conditions, the methane production is reduced, which contributes to the reduction in global warming, as such waste would otherwise produce methane in a normal oxygen poor landfill or dump. It has been debated that, the CO_2 produced from the degradation of the compost pile would have been produced anyway, in the longer term if kept in a landfill or dump.

Amenity impacts

The IWMC operations can cause various negative amenity impacts from inappropriate management. This issue is especially exacerbated through improper handling of raw organics as well compost windrows. The potential negative impacts include:

- Odour pollution;
- Particulate matter;
- Vermin and pests;
- Litter;
- Fire; and
- Noise

Biodegrading organics as well as compost heaps can attract birds such as crows which can lead to noise problems, and the littering of organic waste scraps within the site as well as away from the site. The unprocessed organic wastes as well as the compost heaps can be an attraction to pests and vermin. These pests can be environmental as well as health hazards. Airborne dust from a poorly managed site can have a visual impact as well as public health impacts including respiratory issues.

Wind can blow the materials off the compost heaps as well as the other stockpiled waste types out of the IWMC, which can degrade the local amenity. This impact is mitigated through the design of the IWMC perimeter walls which include a perimeter fence made of 50 × 50 PVC coated mesh.

Littering inside the IWMC can cause amenity issues such as tracking of litter on the wheels of the waste transport vehicles leaving the IWMC. The litter can be deposited out on the roads of the island, which leads to issues such as visual impacts, odour, and possible contamination of groundwater from leachate.

Air quality impacts

Odour

Composting odours can originate from sulphur compounds, nitrogen compounds and volatile organic compounds. Ammonia is also commonly associated with unpleasant odour resulting from composting. If the composting is done under aerobic conditions, the main gaseous product is carbon dioxide. Gas compounds contributing to the odours of composting organics containing bio solids include dimethyl sulphide, dimethyl disulphide, dimethyl trisulphide, carbon disulphide and benzothiazole. These chemicals, while potentially toxic, are not present in high concentrations in open air composts. The gas methane is generated when the microbes do not get enough oxygen, and anaerobic biodegrading occurs. Methane gas has a strong and foul odour. The generation of ammonia, volatile amines, hydrogen sulphide and volatile organic compounds cause these odours.

Table 26: Odours generated from the composting process (Source: Goldstein (2002)

Compound	Description of smell	Detection limit for a particular odour panel (µg/m^3)
Sulphur compounds		
Dimethyl disulphide	Rotten cabbage	0.1
Dimethyl sulphide	Rotten cabbage	2.5
Carbon disulphide	Rotten pumpkin	24
Hydrogen sulphide	Rotten egg	0.7
Methane thiol	Pungent sulphur	0.04
Nitrogen compounds		
Ammonia gas	Medicinal	27
Trimethyl amine	Fishy	0.11
Volatile fatty acids		
Acetic acid	Sour (vinegar)	1019
Propionic acid	Rancid	28
Butyric acid	Putrid	0.3

This site is 264 m away from the nearest residential area, therefore the impact of odour on the residential areas are deemed minimal.

Fire hazards

There is a possibility of fire hazards at the IWMC coming from biogas emissions and human activities. Fires can pose a risk to the workers through explosions and suffocation from smoke, in addition to damage to equipment.
Possible fire hazards are caused by the following (DCE NSW, 2004)

- Spontaneous combustion;
- Sparks from welding;
- Lightning strikes;
- Cigarettes; and
- Arson

The most common causes of fire during composting activities are reported to be cigarettes, welding activities and spontaneous combustion (Rynk 2000). The cause of spontaneous combustion is when the decomposing organics self-heat to ignitable temperatures (DCE NSW, 2004). Although Rynk (2000) states that spontaneous combustion is more prevalent within large undisturbed piles containing raw organics, curing compost or finished compost rather than active composting. Therefore it is important to limit the storage of organics (meant for transport to a central waste management facility) on the IWMC.

Noise and vibration impacts

The main sources of noise from the operation of waste management centres come from the material recovery machineries used and the operation of vehicles. According to the Health and Safety Executive UK, most material recovery facilities have noise levels exceeding 80 dBA and 85 dBA. Assuming a maximum noise level of 85 dBA, the noise decay map in **Figure 15** can be used for this purpose too. From the initial calculations, the noise levels are projected to decrease down to less than 59 dBA at the nearest residential area. Therefore, the long term negative impacts of noise would be borne by the employees of the IWMC, and the effects of noise to the residential areas are minimal

Workplace safety and accidents

The group of people most likely to be impacted by the IWMC operations are the workers at the site. The various operations such as transportation, collection, handling, sorting and storing of the wastes, in addition to the composting and volume reduction operations all pose different risks to the worker onsite. The impacts discussed above and their proposed mitigation measures can provide a level of safety to the workers. Even with these mitigation measures put in place, a proper workplace safety guidelines shall be formulated by the contractor for all workers onsite to follow.

In addition to the impacts discussed above, other work related safety issues include falling stock or during lifting activities, moving vehicles and falls from height. The accidents can result in injuries of varying nature.

Mitigation for health impacts

- A distance of 374 m is available between the IWMC and the nearest residential area, which is greater than the buffer zone proposed by Herr et al (2004) and Wheeler et al (2001), it is expected that bio aerosol concentrations will reduce to background level at the stated distance;
- site is located in such a way that winds from both monsoons blows the airborne particles from the IWMC away from the residential zone;
- handling of compost will be minimized;
- compost turning will be done based on temperatures and not on schedules;
- compost turning will be done using windrow turning equipment;
- adding moisture to the compost to minimize dust;
- placing a geo-fabric cover over the compost windrow to minimize release of bio aerosols; and
- workers will wear appropriate safety clothing, follow the workplace safety mechanisms and guidelines set by the contractor and practice safety and personal hygiene when handling the compost.

Mitigation for impacts on groundwater

- The composting area has a dedicated composting slab made of reinforced concrete, along with an HDPE lining between the soffit of the slab and the ground. Concrete is an inert and highly impermeable material, and with the combination of HPDE lining, the possibility of leachate leaking directly from the compost slab is low;

- The composting slab is designed to have a slope towards the centre from both sides, which will propagate any leachate produced towards the 100 mm PVC pipe, which in turn drains into the leachate collection tank;
- Regular turning of the compost pile can help minimise the quantity of leachate produced; and
- The leachate collected shall be reused to provide moisture to the compost heaps.

Mitigation for rainfall related leachate production

The current design of the IWMC consists of a composting slab is an open windrow composting system. The compost windrow is kept on the compost slab which is sloped in such a way that the leachate from the compost will collect at the pipe in the centre, which will propagate the leachate into the leachate collection tank. While this scenario is ideal during fair weather, heavy rainfall and strong winds should also be considered. There is a possibility of heavy rainfall increasing the produced leachate, as well as the water collected over the composting slab propagating to the leachate collection tank. This can cause an overflow of the leachate collection tank, releasing its contents into the ground and subsequently the groundwater aquifer.

The rainfall can also cause the scattering of the compost materials, the increased water content in the compost windrow can cause another issue: the saturation of the windrow can decrease the available oxygen within the compost windrow, leading to anaerobic conditions.

- A valve is placed at the inlet pipe which can be closed in instances where the leachate tank may overflow from heavy rainfall onto the compost slab;
- compost slab is raised through design, to avoid any ingress of water which may otherwise be possible from puddles and possible inundating due to heavy rain; and
- windrow cover shall be used to mitigate the impacts from rainfall. The cover shall be made of geofabric and allow for the air circulation while protecting the compost. The advantages of the cover include moisture control, which reduces leaching and nutrient loss, as well as reducing water loss from the sun and wind. In order to keep the cover in place during strong winds, weights attached to ropes shall be placed on top of the cover at regular intervals.

Figure 18: Windrow cover being utilised in an open composting system (source: Midwestbiosystems.com)

Keeping stockpiles of raw organics low

Stockpiles of raw organics (waiting to be processed or transported) can cause impacts such as foul odour from the biodegrading organics, leachate reaching and contaminating groundwater, issue of vermin and pests, and visual impacts from the stockpiles.

As per the design of the IWMC, there are compartments for the storage of all major waste types other than organic wastes. A dedicated slab is provided for the composting of the organic waste materials. As per the calculations in **Section 2.4.6** it is seen that the composting slab has the capacity for composting 2 month's organic waste produced in the island. As the composting process may take between 3 – 5 months (Halliburton, 2002), the remaining months' organic wastes can accumulate unmanaged and without any means of transport.

The consultant proposes the following mitigation measures:

- Arrangements to regularly transport the unmanaged waste to a central waste management facility; and
- in cases where the waste cannot be transported due to delays and unforeseen circumstances, it is not recommended to stockpile the unmanaged waste on the ground in the open. Covered bins shall be provided to store unmanaged organic wastes. It is also recommended to separate the putrescible waste from the green waste while storing in the wheelie bins. While this mitigation is not the most ideal, it is seen as the option with the least impact, pertaining to the resources available to the island and the difficulty in transportation. Alternative transfer arrangements shall be made within this duration.

Keeping pest and vermin populations low

- An area where waste (especially raw organics) is concentrated will naturally be an attraction to pests and vermin. In order to reduce the possible health hazards from such pests, their population shall be kept low with the following mitigation measures;
- unprocessed waste (including those waiting to be processed and unmanaged waste awaiting transportation) shall not be kept uncovered. Bins are provided to store such organic wastes. The bins are lidded, which controls both the possibility of odours emanating and the means of access to pests. The bins are also watertight in order to avoid the infiltration of water both into and out of the bin. The bins shall be designed to resist the action of organic acids and facilitate washing;
- covering the compost heap;
- ensure that the IWMC surfaces are adequately drained to prevent the occurrence of ponds; and
- establish deterrence and eradication measures to control the outbreaks of pests or vermin.

Control of wind-blown litter

Wind-blown litter control is incorporated in the design of the IWMC, with the provision of PVC coated mesh fence. Even with this mitigation measure in place, there is a possibility of wind-blown littering occurring. Such litter shall be cleaned by the occupier of the IWMC. It is recommended to implement procedures to clean up the wind-blown litter after strong winds; and
clear all litter within the premises daily and any litter that has been blown out of the IWMC.

Mitigation for odour impacts

- Covering of rapidly biodegradable organics. Rapidly biodegradable organics include grass clippings, food and animal organics and organic sludges. The exposure of such organics to the atmosphere should be kept at a minimum. In open air composting such as the proposed technique for the IWMC, piles of compost can be covered by a 15 cm thick layer of fresh

compost in the curing stage. The microbes present in this layer of compost help reduce the odour of the compost pile underneath;
- keep the moisture levels of the compost pile optimum, which promotes free airspace and results in aerobic respiration;
- avoid uncontrolled emissions of biogas from the compost pile by keeping the pile well aerated;
- keep the carbon – nitrogen ratio at an optimum level (this is achieved at the mixing stage) to decrease the amount of ammonia produced; and
- keep records of complaints about odours, and correlate with weather conditions and categories of organics used.

Mitigation for fire hazards

- A fire management plan shall be developed by the IWMC occupier;
- Adequate firefighting equipment shall be provided at the IWMC, and placed at locations easy to access. The current design of the IWMC includes a fire alarm system as well as firefighting equipments;
- the IWMC occupier shall be able to show that firefighting capacity of the IWMC is sufficient to suppress and minimize the incidence and impact of fires;
- training and awareness raising on firefighting shall be conducted on a regular basis for the workers; and
- signs shall be kept on the premises stating that open flames are not permitted on site.

Mitigation for noise impacts

- Obtain noise data from supplier prior to purchase of machinery;
- enclose the noisy machinery with sound insulating enclosure;
- reduce duration of exposure by implementing job rotation; and
- provide employees with hearing protection if required.

Mitigation for workplace accidents

- The IWMC occupier shall be required to develop occupational safety management plan, and safety guidelines shall be displayed in the work site at all times;
- provide clear instructions to the workers on:
    - The possible risks
    - Measures in place to control risks
    - Follow emergency procedures;
- provide proper training including manufacturer's safety instructions to employees on how to operate machinery;
- conduct proper and regular maintenance of machinery used;
- prior to maintenance, make sure the equipment is made safe and prevent access to dangerous parts. Make sure others are aware that maintenance is being carried out;
- machinery and vehicles should only be handled by employees with the proper credentials and training; and
- proper PPE should be provided at work. PPE should be used after all possible risks have been eliminated as much as possible and to manage any remaining risks.

Figure 19: Recommended protective clothing for waste management employees. Adapted From: Ministry of Health, Thailand. Bangkok, 1995. *noise cancelling headphones and safety glasses during use of machinery

Table 27: Operational phase hazards and suitable PPE

Hazard	Suitable PPE
Stock movement and falling items	• Safety shoes • Hard hats
Moving vehicles	• High-visibility jackets
Slips	• Safety shoes with slip resistant soles
Sharp edges	• Gloves • Forearm protection • Aprons • Hand pads • Thumb guards • Head protection
Noise	• Noise cancellation headphones

5.3.2.3 O3 Waste Generation

Not considering the waste collected from the island, waste generated as a direct result of operations at IWMC during the operational phase of the IWMC will be relatively low. These will include waste oil/batteries for waste management equipment, yard cleaning waste, used spare parts, used clothes, etc. Since eating and cooking inside the IWMC will be prohibited, no mixed municipal waste will be generated during the operational phase of the project. Hence overall impact for this activity would have a minor negative impact on environmental receptors. The multi-criteria impact analysis shows it would have a minor negative impact with an overall score of -10.

Mitigation Measures

- All wastes generated as a direct result of the waste management activities shall enter the waste management stream and managed as prescribed for different waste types; and
- prohibit eating/cooking in the IWMC.

5.3.2.4 O4 Resource Consumption

Electricity, fuel and water will be directly required for the operation of the IWMC. Water will be mainly sourced from the ground while electricity will be obtained from the island's mains.

Water will be mostly required for cleaning purposes and moistening compost piles and volume of water required for these will be relatively small. As most of the moisture required for the compost pile will be sourced from the leachate collected from the leachate tank the volume of water required will be significantly less. It is estimated that approximately 200 -300 l/day of ground water will be required during the operational phase of the project. Since the volume of water required is relatively low, it is not expected to have a significant impact on groundwater.

A compactor and shredder/crusher can be used to reduce the volume of waste streams. The waste weight will remain the same so there will be no savings from the total amount of waste produced. However, savings will occur because waste volume will be reduced by approximately 80% which will decrease the number of times the storage area is required to be emptied, therefore resulting in lower transportation costs.

Depending on the type of equipment's used such as chainsaws will require small volumes of fuel for operations. Most of these equipment's, however, are run very infrequently when enough waste has been separated and stored and are relatively efficient when run, meaning the amount of energy consumed by the compactor will be low. The running wattage mid-range compactors and shredders may range from 700 – 2000 watts, which means approximately 30-60 kW will be required to power all equipment simultaneously. However, this will not be the case since many of these equipment don't need to be switched on daily and at the same time. There may be periods where the only electricity required will be for switching on the lights at the IWMC. Therefore. Electricity consumption of the IWMC during the operational phase will be relatively low. The activity would have a minor negative impact on environmental receptors.

However, the following mitigation measures shall be implemented to reduce water and electricity consumption.

Mitigation Measures

- It is strongly encouraged to install solar panels on the IWMC roof to generate required power for the IWMC;
- use solar lights in the premises;
- work shall be planned to be carried out during day times;
- ensure that the compost pile is shaded during dry periods to avoid rapid loss of moisture content;
- use a spray hose so that the surface area of water droplets is increased which would reduce the amount of water consumed;
- ensure that all equipment is serviced and kept clean daily, to reduce the amount of water required for cleaning;
- prepare a plan to switch on the compactors and shredders depending on the incoming waste stream to conserve electricity and
- make sure all equipment are properly serviced and maintained.

Table 28: Impacts and proposed mitigation measures for the construction and operational phase of the project

No	Potential Risk/Impact Description	Receptor Description	Nature	Reversibility	Significance Major negative Major positive Moderately positive Moderately negative Minor positive Minor negative Negligible	Mitigation Description	Cost USD
CONSTRUCTION PHASE (C)							
C1	Impacts from worker influx and settlement (flora and fauna, resource use and sociocultural impacts)	People of Madifushi, and terrestrial and marine environment	negative	Reversible	**Minor**	• **See Section 5.3.1.5**	Included in the construction costs.
C2	Impacts from transportation of materials. (climate impacts, and impacts on roads)	Residents of Madifushi, terrestrial and marine environment, global environment	negative	Reversible	**Minor**	• **See Section 5.3.1.4**	Included in the construction costs.
C3	Impacts from site demarcation and fencing (Impacts on flora and fauna)	Workers and residents of Madifushi	Negative	Reversible	**Minor**	• **See Section 05.3.1.6**	Included in the construction costs.
C4	Impacts from construction works (, noise and vibration, accidents and injuries, pollution from material storage)	Workers and residents of Madifushi	Negative	Reversible	**Moderate**	• **See Section 05.3.1.1**	Included in the construction costs

C5	Terrestrial pollution from construction waste generation	Residents of Madifushi, ecosystem	Negative	Reversible	**Moderate**	• **See Section 5.3.1.2**	Included in the construction costs
C6	Impacts from resource use	Residents of Madifushi, ecosystem	Negative	Reversible	**Moderate**	• **See Section 5.3.1.3**	Included in the construction costs
OPERATIONAL PHASE							
O1	Waste collection and transportation (Climate impacts, air quality, amenity impacts)	Residents and visitors to Madifushi	Positive	Reversible	**Major**	• **See Section 05.3.2.1**	Cost borne by IWMC occupier
O2	Waste management activities (Public health, noise, groundwater, fire, accidents, odour impacts)	Mostly IWMC workers, residents and visitors to Madifushi	Positive	Reversible	**Moderate**	• **See Section 5.3.2.2**	Cost borne by IWMC occupier
O3	Waste generation (terrestrial pollution, groundwater contamination)	Residents and visitors to Madifushi	Negative	Reversible	**Minor**	• **See Section 5.3.2.3**	Cost borne by IWMC occupier
O4	Resource consumption (water and electricity)	Residents and visitors to Madifushi	Negative	Reversible	**Moderate**	• **See Section 5.3.2.4**	Cost borne by IWMC occupier

6 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT PLAN

6.1 SCOPE

This chapter would present in detail the management measures put in place by the Proponent and the contractor to mitigate the environmental impacts that would arise from the project activities. The assessment of impacts and mitigation measures that would be put in place had been discussed in detail in the previous chapter. The main scope or objectives of the Environmental and Social Management Plan are to:

a) Produce a framework for anticipated impacts, including practicable and achievable performance requirements and systems for monitoring, reporting and implementing corrective actions during pre-construction, construction and operational phase; and
b) provide evidence of conformity to laws and regulations and requirements of enforcement agencies.

6.2 ENVIRONMENTAL MANAGEMENT SYSTEM

The environmental management framework for the proposed project is based on the standards and policies set out by the Environmental Protection Agency of the Maldives under EIA Regulation 2012, as well as the ESAMF by MCEP.

a) Environmental Management Planning and establishment of key performance indicators: The ESMP specifies environmental management measures and required performance standards;
b) IWMC construction and operations: The aspects of the construction and operation will be established and operated according with the ESMP;
c) Monitoring and corrective action: The implementation of ESMP measures will be monitored during operational stage and will be reported. Any inconsistencies between the ESMP and its on-site implementation will be identified and addressed through corrective actions; and
d) Auditing, reviews and enhancement: The ESMP will be reviewed. Improvements to the ESMP will be made as necessary to achieve desired environmental outcomes.

6.3 ENVIRONMENTAL MANAGEMENT STRUCTURE

This Sections detail the various parties involved in the implementation of the environmental plan and their responsibilities.

6.3.1 The Proponent, Ministry of Environment and Energy

MEE will be responsible for the execution of the project activities within the required timeframe. MEE is also responsible of policy level decisions and provision of support regarding the waste management works undergone in the island as well as the regional level. MEE will also be responsible for leading the discussions with the Island Council and other relevant organisations on capacity development, training and facilitating resource acquisition for the sustainable management of the IWMC. In addition, MEE will be responsible for the following:

- Environmental monitoring according to the proposed framework; and
- Management of grievances received at tier 2 (those that are not resolved at tier 1 by the Island Council). See **Table 34** for details.

6.3.2 Island Council

During the construction phase the Island Council will be primarily responsible for the following:

- Facilitating all activities related to the Project at island level;
- implementation of the Waste Management Plan (WMP) for a period of 5 years.
- implementation waste Management Regulations for the island;

- implementation of Waste Management Guidelines for the island; and
- overseeing the operations of the IWMC.
- The Island Council is responsible to ensure the progress of the Waste Management Plan and achievement of the set goals through implementing the plan. The island council is also responsible for the compilation of the IWMC reports submitted by the occupier as well as producing an IWMC monitoring report as well as reporting of public grievances. These reports shall be submitted to the MEE bi-annually for review. This also includes management of grievances at tier 1. See **Table 34** for details.

6.3.3 The Contractor

The contractor will undertake the project in accordance with the ESMP and will report to the Proponent and environment consultant about any unexpected environmental impact or health and hazard issues. During the construction stages, the contractor will follow all mitigation and management measures proposed in the report, mainly waste management, pollution control, accident prevention and work methodology proposed.

6.3.4 Environmental Consultant

The environmental consultant would prepare the ESMP based on field visits and surveys and based on past project experiences in similar settings. If there are any modifications to be made to the ESMP during any stages of the project, the consultant would do the modification.

6.3.5 Environmental Protection Agency

The Environmental Protection Agency would review the monitoring reports submitted by the Proponent and would continue with regulatory monitoring visits to the project site upon their needs.

6.3.6 IWMC Occupier

The IWMC occupier will be responsible in running the operations in accordance with the guidelines set by this ESMP and the approved IWMP of Madifushi Council. The responsibilities of the IWMC occupier include producing the IWMC operations reports and submitting the reports to the Island Council at the proposed regularities.

6.4 REPORTING

Reporting will be carried out on a timely manner to implement the Environmental and Social Management Plan and will cover details of site conditions, and operations. A detailed reporting mechanism for the IWMC operational works is provided in **Section 6.10**. Monitoring reporting shall be carried out during the stated time frames and frequencies in **Section 6.6**.

6.5 ENVIRONMENTAL MANAGEMENT PLAN

A practical plan taking into consideration available resources is proposed to meet the aims and objectives of the ESMP. One of the major risks to the investment and operation of the IWMC and island level waste management is the centre itself which can be converted back into a dumpsite due to mismanagement as often seen in island level waste management endeavours all across the Maldives. This is partly due to the fact that a lot of linkages connecting island level waste management with regional level waste management are absent or unknown until it is much too late. As described in **Section 5.3.2.2**, one of the main risks facing the current project is rapid accumulation of organic waste at the IWMC. Hence the proposed IWMC management plan aims to control and mitigate such risks without severe negative impacts.

Table 29:Details of Environmental and Management Plan proposed for the IWMC

Activity	Phase	Measures	Time frame	Responsible person
Training of workers and contractors	Pre-construction, Pre-operation	Contractor and project workers are provided with detailed information on the project, impact mitigation measures, compliance with environmental permits and the ESMP. Workers are also provided with the information on sensitive areas of the island and other environmental issues. Training of staff involved in the monitoring of the construction phase Training shall be provided to the workers of the IWMC on the waste management practices and mitigation measures in order to ensure the operations are run efficiently and effectively.	Prior to construction works Prior to operational phase	Proponent Environmental Consultant Contractor
Documenting non-conformances and corrective actions	Construction Operation	Non-conformances to the environmental regulations, permits and the ESMP is monitored and documented. Corrective measures are taken and follow ups are done. MCEP has established a Grievance Redress Mechanism. See **Table 34** for details.	Construction and Operation phase	Proponent Environmental Consultant Island Council
Supervision of activities	Construction Operation	The project activities are to be supervised by the Proponent throughout the construction and operational phase to ensure the activities are carried out accordingly and the impacts are minimised. The Proponent shall review the IWMC operations reports from the island councils, and provide the required support, bring about any necessary policy updates	Construction and Operation phase	Proponent Environmental Consultant Island Council

6.6 ENVIRONMENTAL MONITORING PLAN

The Environmental Monitoring Plan has the following objectives;

- To ensure that the environmental and social mitigation and enhancement schemes, are well understood and communicated to all involved parties.
- To evaluate the effectiveness of environmental and social remedial measures and procedures.
- To evaluate if the intended benefit of the project is realised

The intended positive impacts of the project can only be accurately determined by the post-project monitoring scheme. In order to ensure effectiveness of the proposed project it is essential to monitor, collect information, evaluate the information collected and information disseminated.

Table 30: Monitoring plan for the construction and operation phase of the project

Objective	Activity	Parameters to be monitored	Location	Method	Frequency	Responsible Agency	Verifiable indicator	Cost (MVR)	Phase[1]
Ensuring that the project activities does not affect the quality of the groundwater	Groundwater quality observation	Visual observation, smell.	Project site	Physical observation and surveying IWMC workers and nearby households	Twice during construction phase and 1 year after operation commences	Proponent ESS Officer	Water quality observation report	12,000 per monitoring trip	

[1] C = construction phase, O = Operational phase

Ensure waste generated at work site is audited and managed responsibly	Management of waste generated as described in **Section 2.3.15** of the report	Estimation of waste generated at project site and recording these data routinely. This includes quantifying and recording the amount of yard waste, hazardous waste and general waste stacked and stored for transportation.	**Work site & IWMC**	Keep records in a log book, or data sheet	Every two months	IWMC occupier Construction Contractor	Record sheets, photographs and quantity of waste processed at nearest waste management facility and IWMC. If there are no significant discrepancies between the quantity of waste generated on site and processed at nearest waste management facility, it can be safely assumed that impacts of waste on the environment was reduced.	Included in the project costs	**C&O**

Monitoring Health and safety of workers and the public	Accidents during construction of IWMC, operation of IWMC and maintenance of IWMC. Fire hazards and natural disaster events. Noise and smell complaints during operation and construction phase. Compost condition, output and quality	Type of accident/complaint Cause of accident/complaint Date and time. Physical inspection of compost. Determination of input feed and output product. Rate of compost production	**IWMC**	Keep records in a log book, or data sheet	Biannually	IWMC occupier Construction (phase) contractor Island council MEE See **Section 6.3** for responsibility of each stakeholder.	Measures to adapt and prevent accident and risks. Health assessment reports published or available from the local health centre. Policy changes and upgrades. Compost quantity and quality. Income from selling compost.	Included in project cost.	**C&O**
Grievance redress	Addressing public grievances regarding proposed project activities	N/A		Log of records of number of complaints received and actions taken	Throughout the construction phase and once when the project is completed and one year after project completion during operational phase	Council MEE	Grievance Redress Report	Included in project cost.	**C&O**

Spillage assessment	Monitoring spillage during the operational phase	Waste collection arrangements, littering around the island, spillage during transfer to IWMC, spillage within the IWMC, proper use of IWMC, spillage during transfer to regional waste facility.		Spillage assessment records	Once when the project is completed and one year after project completion	MEE	Spillage Assessment Report	Included in project cost	O

6.7 RESOURCE REQUIREMENT FOR MONITORING

For the monitoring program to be successful, it is important that adequate financial and human resources are available and strong coordination among the key stakeholders is maintained.

The primary function of implementing the mitigation and monitoring plan will lie with the Proponent and environmental consultant. Since the project at developmental and operational stage will be engaged by the Proponent it will be the responsibility of the Proponent to take care of the environmental safeguards at all stages of the project during implementation and at operational phase. The Proponent should prepare an Environmental Action Plan, which states all measures for mitigation and enhancement and monitoring as described here in the ESMP with their responsible organisation and person, planning, methodology, timing and other relevant aspects.

Environmental and Social Safeguards (ESS) Officer of MCEP will undertake and audit the monitoring program prescribed in this report. Following each monitoring visit the ESS Officer will prepare a report with clear recommendations and corrective measure if necessary. The report will have to be submitted to EPA for their review and actions.

6.8 MONITORING SCHEDULE

Table 30 highlights the monitoring plan in which responsibilities of main stakeholders has been assigned. In order to track and compile the findings of these measures, ESS Officer shall be tasked to audit the projects ESMP. This is to

- identify gaps in monitoring and mitigating impacts arising from the project;
- determine the challenges and resource inadequacies to implement the proposed ESMP; and
- determine the current environmental condition and propose modification/upgrades to the initial ESMP.

Monitoring frequency for various individual components **Table 30** shall be followed by all responsible parties. **Table 31** gives indicative timeline for the monitoring visits by ESS Officer.

Table 31: Monitoring visit schedule

Visit	Indicative timeline	Indicative parameters to monitor	Reporting	Cost (MVR)/per report/island.
Visit 1	During construction of IWMC	Monitor work method, waste management, monitor health and safety of workers. Monitor impacts to nearby vegetation and ensure vegetation removal is as per set out survey. Review reports prepared by contractors.	Submit monitoring summary report 2 to Proponent (MEE) within 2 weeks. Proponent will compile and submit monitoring reports to EPA after completion of construction phase	10,000.00
Visit 2	Two months into operation of the IWMC. One year after start of operations	Monitor water quality through observation and noise. Monitor IWMC. This includes review of reports dated in **Table 33** or	Submit summary report 2 (1-2.) Proponent within 2 weeks Additionally, the proponent will undertake monitoring	25,000.00

		determine condition of IWMC. Monitor compost condition as described in **Table 33**and **Table 30.**	and compile the reports received by the IWMC occupier and Island Council and develop a monitoring report, which will be submitted to EPA 1 year after commencement of operations.	

As indicated, during the course of the Project implementation summary reports following each trip is expected to be submitted by the ESS Officer. These environmental audits will provide a basis for assessing at least the shorter-term efficacy of the environmental measures and thereby provide lessons to be learned for future monitoring sessions and other projects with similar impacts. The ESS Officer will prepare and submit the reports to Proponent. Based on the findings of the report, the management approach may be adapted and its efficacy will be determined in the consecutive monitoring trip.

6.9 MONITORING REPORT

Reporting will be carried out by the ESS Officer assigned for the purpose by the Proponent.
The report will include among other information;

- Details of what was being monitored;
- Methodology of data collection and data analysis;
- Major findings;
- Effectiveness of the mitigation measures in place and
- Recommendations and conclusions.

A detailed environmental monitoring and management report is required to be compiled and submitted to the EPA. In addition to this, regular site monitoring would be carried out by the Proponent that requires maintaining logs of events as explained in this report. Enforcement officers from EPA may also visit the site for inspection from time to time.

6.9.1 Monitoring Report Format

The environmental monitoring report outlined in **Table 32** below will be used in reporting environmental monitoring to be carried out as given in the monitoring plan.

Table 32: Monitoring report format

Project Title:
Name of the Island:
Monitoring Date:
Period Covered:
Prepared by:
Contributions:

A. Introduction
Give a brief introduction about the project and the monitoring carried out
B. Methodology
Brief detail of the methodology applied for undertaking the monitoring assessment
C. Environmental Monitoring
a. Groundwater quality
Parameters given in the monitoring plan need to be assessed
b. Waste generation and management at IWMC
These include monitoring for pests and diseases as described.
D. Risks and Mitigations
Please indicate any critical unresolved risks that affect the course of the system operation, analyse the cause, assessing the potential impacts on the environment providing the proposed mitigation strategy
E. Problems Encountered
Indicate any problem areas encountered and any corrective measures that will have to be taken.
F. Recommendations and Adaptations as Solution
If specific recommendation is noted during the monitoring phase, specify it in the report
G. Conclusions
Reference
Appendix

6.10 IWMC OPERATIONS REPORTING MECHANISM

Table 33:Details of the reporting mechanism proposed for the IWMC

IWMC (Occupier)

Reporting	Details	Frequency
General report	Logs of the incoming waste	Monthly
	Classified by type and weight	
	Vehicle maintenance details	
	Machinery maintenance details	
	Machinery fuel usage details	
	Workplace injuries	
IWMC capacity	Details of the utilized and remaining capacity of IWMC	Every two months
	Leachate tank maintenance and capacity	
IWMC inventory status report	Details of the status of IWMC equipment	Bi-Annually
	Details of the status of emergency kits and firefighting equipment	
	Details of amount of input waste materials	Bi-Annually

Island Council (Municipal Unit, Waste Management Committee)

Components	Details	Frequency
Public grievances	Grievance Redress Mechanism developed by MCEP. See **Table 34** Public grievance records and actions taken shall be compiled into a report submitted to MEE bi-annually	
IWMC monitoring	Monitoring report of the IWMC operations	Bi-Annually
Compilation of IWMC reports from IWMC occupier		Bi-Annually
Income report	Summary of IWMC operations income	Bi-Annually

MEE

Components	Frequency
Review of IWMC Reports from Council	Bi-Annually
Update National Waste Database	
Policy updates from findings	
Provision of support to IWMC	
Overview of the waste management system on island level and regional level	
Public grievances	Grievance Redress Mechanism developed by MCEP. See **Table 34**

Compost output report	Details of compost output in weight	
Noise and odor complaints	Log of noise and odor complaints	Every two months
	Complaints to be provided along with weather conditions and incoming waste details coinciding with the dates of complaints	

6.11 GRIEVANCE REDRESS MECHANISM

Based on the ESAMF, MCEP has formulated a Grievance Redress Mechanism (GRM). GRM is established to receive and facilitate grievances of the affected persons during the implementation of the project.

Island Councils were consulted on the progress regarding setting of focal points and availability of the GRM forms at the Council. Madifushi Council stated that the Council would make the forms available physically at its office as well as publicly displayed. The Council has nominated a waste management focal point for this purpose (Shinan, 7926566). The Council does not have a website, although work is underway on creating a Facebook page, in which a link to the GRM forms will also be provided.

Following are the details of the GRM developed by the MCEP. GRM at tier 2 will be managed by the ESS Officer of MCEP. Tier 2 GRM forms will be made accessible from the respective council office and MEE front office and is published in MEE website. Below are the links.

English page:
http://www.environment.gov.mv/v2/en/download/7189

Dhivehi page:
http://www.environment.gov.mv/v2/dv/download/7191

Table 34:Details of the Grievance Redress Mechanism developed by the MCEP

Tier of Grievance Mechanism	Nodal Person for Contact	Contact Communication and other facilitation by the project	Timeframe to address grievance
First Tier: Island Council	Island Council will be the first point of contact for any grievances. The staff designated as the waste management focal point by the island council will manage grievances on behalf of the council.	GRM should be publicly displayed in the construction site as well as the council office. GRM should also be outlined in official website and/or social media pages of Council, MEE (and/or the project), including contact details of the nodal person in each tier. Grievances can be addressed informally by contacting the council through email / telephone / in person. If the grievance cannot be resolved informally, an aggrieved party must submit a complaint on the Tier I Complaint Form. A copy of the form (with the council seal) should be provided to the aggrieved party as evidence of receipt. Electronic version of the complaint form should be available from the websites and/or social media pages of MEE and the council. Physical copies of the form should be	15 working days

		available from the council front office. Council will provide assistance to fill the form for those who cannot write. The council should keep separate registries for informal and formal complaints and maintain records of all complaints received. The council will discuss the matter with the Women's Development Committee and other relevant stakeholders (Farmers, Fishermen, School, Health Center etc.), where deemed necessary and attain views of them. If such meetings are arranged, the date, time, location or venue, list of participants (with contact details) and a summary of the main outcome of the consultation must be annexed to the written decision issued by the council. If the complaint is resolved within 15 working days, the council must communicate the decision to the aggrieved party in writing. The aggrieved party must acknowledge the receipt of decision and submit their agreement or disagreement with the decision within 10 working days. If no acknowledgement is submitted from the aggrieved party within this period, then the decision will be considered as accepted. If a complaint requires more time to address, this requirement must be communicated to the aggrieved party in writing and the aggrieved party must consent and sign-off the request for the extension to take effect. An extension can be made to an additional 15 working days. The staff designated as the waste management focal point by the island council will manage and provide feedback	

		for grievances submitted to the council.	
Second Tier: Ministry of Environment and Energy (MEE)	Environmental and Social Safeguards officer at the Project Management Unit (PMU) will be the focal point.	If the grievance cannot be resolved through Tier 1 to the satisfaction of the aggrieved party or if the issue is outside the jurisdiction of the council (issues related to RWMF), an aggrieved party may submit a complaint on the Tier 2 Complaint Form. A copy of the form (with MEE seal) should be provided to the aggrieved party as evidence of receipt. Electronic version of the complaint form should be available from the websites and/or social media pages of MEE and the council. Physical copies of the form should be available from the council and MEE front office. A copy of the Tier 1 Complaint Form should be submitted with the Tier 2 Complaint Form. MEE will forward the grievance to PMU. PMU screens the grievance and determine if its related to MCEP. If it is unrelated, the aggrieved party must be notified in writing and the way forward must be outlined to them including the necessary government institutions to follow up. Environment and Social Safeguards Officer at the PMU will be the contact person in processing a grievance through the Second Tier. PMU will discuss the matter with EPA and other relevant institutions, where deemed necessary and attains views of them. PMU will also arrange site visits and hold onsite discussions and meetings if necessary. The PMU will be responsible to ensure that there is no cost imposed on the aggrieved person, due to the grievance mechanism at the second tier. If the complaint is resolved within 15 working days, the PMU must communicate the	15 working days

		decision to the aggrieved party in writing. The aggrieved party must acknowledge the receipt of decision and submit their agreement or disagreement with the decision within 10 working days. If no acknowledgement is submitted from the aggrieved party, then the decision will be considered as accepted. If a complaint requires more time to address, this requirement must be communicated to the aggrieved party in writing and the aggrieved party must consent and sign-off the request for the extension to take effect. An extension can be made to an additional 15 working days. If the grievance is not resolved to the satisfaction of the aggrieved party within 15 working days of submission of the grievance to tier 2 then the aggrieved party may notify the MEE, in writing, of the intention to move to tier 3.	
Third Tier: Judiciary Power / Assistance to Vulnerable Persons beyond the Project's Grievance Redress Mechanism	Judiciary system is an option for an aggrieved person and/or community in case that the other tiers have not been effective	The legal system is accessible to all aggrieved persons. Assistance from the PMU of MCEP is available only for vulnerable person(s)* as per this grievance mechanism. In cases where vulnerable person(s) are unable to access the legal system, the Attorney General´s office will provide legal support to the vulnerable person(s). The PMU must assist the vulnerable person(s) in getting this support from Attorney General´s Office. PMU must also ensure that there is no cost imposed on the aggrieved person if the person belongs to the vulnerable groups. The list of vulnerable groups is as defined in the footnote but may be further defined by MEE. The verdict of the Courts will be final.	As per established Judicial Procedure

*Vulnerable person(s): A vulnerable person(s) for the purpose of this project is a person who is poor, physically or mentally disabled/handicapped, destitute, and disadvantaged for ethnic or social reasons, an orphan, a widow, a person above sixty years of age, or a woman heading a household.

7 RECOMMENDATIONS AND CONCLUSION

The construction and development of the IWMC at Th. Madifushi is a much needed project to provide waste management services to the island. The IWMC will be an improvement to the current waste disposal practices conducted in the island, while reducing the environmental pollution and providing health and economic benefits to the island.

Although the project is perceived to yield significant environmental and human health benefits and contribute towards achieving sustainable development goals, it should be understood that these benefits as outcomes would depend on smooth operations of the waste management system as a whole. In order for the system to function sustainably adequate resources in particular financial resources shall be made available. Part of the required funding could be obtained through introducing a fee structure for the service and sale of metals and compost. However these revenue sources are not likely to be adequate enough for the entire operation. Hence, support from the government will be critical to maintain the system functional. Unavailability of the funds could mean breakdown of the transport system which could ultimately collapse the waste management service. Regular removal of residual waste from the island will have to be ensured as a key aspect of the project implementation. A RWMF and a regional collection and transport system in Zone 4&5 will be established under MCEP. Regional collection and sea transport will be through WAMCO in agreement with the Council once the regional system is established. Location and technology used for RWMF will be determined through the Feasibility Study and BPEO Study.

Based on past experiences gained from projects of similar nature, it is also important to undertake a one off clean up activity of the island that includes removal of existing stockpile of waste. Failing to undertake this could lead to overloading of the waste management centre resulting failure to carry out the operational activities in the planned manner.

The construction and operational impacts that might arise from the project should be managed, mitigated and monitored on a continuous basis and should adhere to the EIA regulation all throughout the construction and operation of the project. Strict considerations are to be given to the pollution control as well as health and safety measures

The consultant's recommendations for the project include:

- Plan a one off clean up activity prior to the official opening of the waste management centre;
- plan and have in place a sea transfer arrangement to remove residual waste from the site on a regular basis;
- carryout necessary training for the waste management personnel in particular in the area of composting;
- adequate awareness raising of the general public on the operation and functioning of the new waste management centre and sensitising the public on the rules and procedures that would come into effect with regards to the new waste management system;
- implementing fee for service system;
- strengthening enforcement capacity of the local authorities;
- provision of adequate financial and technical support at least for the initial 3 years into the project implementation to the island council;
- determine an operational plan for the centre that takes into account details of all aspects of operating, managing and sustaining the service;
- conduct supervision and monitoring of the project works by the Proponent;
- enforcement agency to make an effort to make at least one visit to the project site during the construction phase to ensure environmental compliance of the project activities; and
- proponent appoints a focal point to coordinate activities relating to monitoring and reporting.

This ESMP has looked into the key factors that need to be considered during construction and operational stage and identified all likely environmental impacts. Among other temporary and highly localised minor negative environmental impacts, the study has identified the following unavoidable moderately negative terrestrial impacts due to proposed development works:

- Almost an irreversible change the overall terrestrial environment as a result of the placement of the IWMC footprint;
- generation of construction waste as a result of construction works.

The study also found that through the implementation of the proposed practical and cost effective mitigation measures almost all identified impacts can be brought to an acceptable level. The study found no evidence of the project resulting loss of endangered or protected species or habitat.

Thus based on the findings, it is concluded that the benefits on the environment and human health greatly outweighs the negative effects resulting from the implementation of the project.

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ANNEX 1: DECLARATION & COMMITMENT OF PROPONENT

ANNEX 2: APPROVED CONCEPT PLAN

ANNEX 3: STAKEHOLDER ATTENDANCE

ANNEX 4: A3 SITE LOCATION

ANNEX 5: CV'S

ANNEX 6: DECLARATION OF AUTHORS

ANNEX 7: WASTE MANAGEMENT PLAN

ANNEX 8: IWMC SITE SELECTION FORMS AND EPA DS