ENVIRONMENTAL MANAGEMENT PLAN
FOR
THE ESTABLISHMENT OF ISLAND WASTE MANAGEMENT CENTRE
IN
SH. NOOMARAA

PREPARED FOR
MINISTRY OF ENVIRONMENT AND ENERGY

PREPARED BY
MALDIVES ENERGY AND ENVIRONMENTAL COMPANY (MEECO)

FEBRUARY 2018

PROJECT SYNOPSIS

Name of the Project: Establishment of Island Waste Management Centre in Sh. Noomaraa
Project Proponent: Ministry of Environment and Energy
Project Value: -
Expected Duration: 10 weeks
Consultant: Ahmed Saleem (MEECO)
Date: February 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
EMP	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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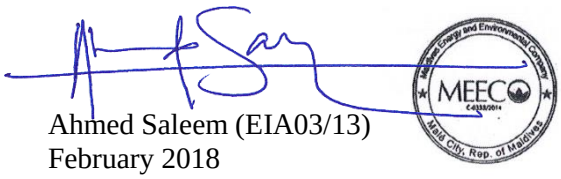
DECLARATION OF THE CONSULTANT AND PROPONENT

I certify that the statements made in this Environmental 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)
February 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.**

CONSULTANT TEAM MEMBERS

This EMP report was prepared by a multi-speciality team of local experts. The team consisted Mr. Ahmed Saleem and Mr. Ali Hammadh registered EIA consultants with the Maldives Environment Protection Agency (EPA). The team members, their respective field of expertise and areas of contribution to the assessment is given in **Table 1**.

Table 1: The EMP Team

Name	Qualification	Designation/Field of Expertise	Contributing Area
Mr. Ahmed Saleem	MSc. Ecology & Environment	Lead EIA Consultant	• Overall administration of the EIA • Contributed to the various chapters • Report review
Mr. Ali Hammadh	BSc. Environmental Management	EIA Consultant	• Deputy Team Leader • Report writing and compile • 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 • Contributed to the various chapters of the report.
Mr. Dinal Shalika		Surveyor	• Preparation of maps and charts
Mr. Muslih Mujtaba		A.Surveyor	• GIS analysis

NON-TECHNICAL SUMMARY

1. The Ministry of Environment and Energy has proposed a project to establish an Island Waste Management Centre (IWMC) in nineteen (19) islands of Zone One (Haa Alif, Haa Dhaal and Shaviyani) in order to manage waste generated, on an island level. This project is funded by the OPEC Fund for International Development (OFID) under the "Provision of Water Supply, Sanitation and Solid Waste Management Project". The proponent has requested consultancy services of MEECO for the preparation of an Environmental Management Plan (EMP) for the proposed project. Of the nineteen (19) islands. Maldives Environmental Protection Authority (EPA) screening process resulted in 14 islands being classified as requiring an EMP. This EMP includes 1 of the 14 islands, namely Sh. Noomaraa.

2. Sh. Noomaraa council pointed out that there are 3 areas used frequently for dumping and burning waste. However, the areas are not demarcated or established to dispose waste. There is currently no waste management system in place in Sh. Noomaraa. Therefore, residents have also been dumping waste at the periphery of the residential zones. These include plastic, organic waste, metals, and glass. Kitchen waste and nappies are thrown on the beach areas around the island. Sh. Noomaraa had no WMP formulated at the time of visit.

3. The proposed Island Waste Management Centre (IWMC) is located in the south eastern side of the island at 6°26'1.15"N, 73° 4'18.14"E. The site is accessible by a cleared road adjacent to the plot. The road has a width of 5 meters and can be used by vehicles. Land clearance works are required as the plot is vegetated with Pandanus (Kashikeyo), Guettarda speciosa (uni), cocos nucifera (Dhivehi ruh) and some undergrowth. It is estimated that 6 coconut palms and 25 other trees will require removal from the site.

4. The main activities involving the construction of the IWMC include vegetation clearance, 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 and plumbing. The construction phase of the project is expected to be completed within 10 weeks. The IWMC is made up of an equipment room, and separate areas to store metal waste, paper and cardboard, plastic waste, glass waste as well as hazardous waste.

5. The operational phase of the project includes waste collection from households, institutions, and public spaces, sorting, volume reduction and stockpiling of recyclables, composting of organics, and storage of hazardous waste. The IWMC has a capacity of 39 m^3 for composting, and approximately 7.9 m^3 capacity compartments for glass, plastic, metals and hazardous wastes.

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	Orient workers on sensitive sites, against catching birds and animals, damage to flora, workforce kept at minimum, littering prohibited.
	Impacts on resource use	Encourage choosing of local contractors,
	Sociocultural impacts	Encourage choosing of local contractors, ensure work permits, worker orientation.
Transportation of Materials	Marine and terrestrial pollution	Cleaning of litter, hazardous waste management and spill kits, secure loads.
	GHG Emissions	Obtain materials from closest source, buy materials in bulk, reduce wastage, use of well serviced, efficient, vehicles conforming to regulations.
	Roads deterioration	Include in agreement to repair any damages after project, Use the shortest route for transportation, only the required amount and size vehicles shall be used.
	Accidents & injuries	Licensed drivers, avoid transportation at night, secure loads being transferred.
Site Demarcation and Fencing	Impacts on flora and fauna	Surveyors understand scope of works, qualified surveyors, accurate equipment used.
	Accidents & injuries	Protective clothing, works done during daytime, insect repellent to be available
Site clearing and earthworks	Loss of vegetation	Vegetation targeted for removal/relocation marked, efficiently clearing site, thorough tree survey done, procurement of trees
	Social impacts	Privately owned trees to be identified compensated prior to removal
	Soil and groundwater impacts	Follow prescribed steps to remove trees, fill bulb cavities with sand sourced by buyers, level and compact site after removal, fill the bulb cavity as soon as possible
	Untargeted species impacts	Relocate bird nests if any
	Air pollution	Well serviced vehicles used, machines switched off when not in use and idling stop used
	Economic impacts	Relocating trees, sale of coconuts / trunks for timber
	Aesthetic impacts	Careful surveying and planning to limit number of trees removed, replanting trees by relocation.
	Accidents & injuries	Carry out work in fair weather, PPE provided, “heads up” practiced, all machinery and equipment inspected and maintained.
	Noise	Provide PPE equipment, use well serviced plant and machinery, reduce vehicle idling time.

Construction	Material storage	Equipment fenced off, no new facilities developed, National Fire Code followed for handling fuel, firefighting equipment available.
	Terrestrial pollution	Temporary storage area set onsite, cleaning of litter, hazardous waste and spill kits, transfer all waste to nearest Waste management facility
	Noise	Provide PPE equipment, use well serviced plant and machinery, and reduce vehicle idling time.
	Impacts on flora and fauna	Setting out survey, demarcate the plot, fence off site.
	Accidents & Injuries	Occupational safety plan, orientation, PPE provided.
Waste Generation	Marine and terrestrial pollution	Waste management plan followed, follow 3R steps, municipal and sanitary waste managed, waste transported to nearest Waste management facility after works are completed.
Resource Use	Water	Initiate rainwater harvesting and storage, practice water conservation.
	Electricity consumption	Use well maintained and efficient equipment

Out of the construction phase activities, vegetation clearance was identified to be a major negative impact if not properly mitigated. The remaining activities we identified 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	Terrestrial pollution	Covered vehicles, littering is prohibited and impose penalties on littering.
	Climate impacts	Regularly service vehicles. Restrict use of vehicles only during stated time in WMP
	Accidents and injuries	Occupational safety plan, orientation, well trained personnel to use vehicles.
	Air quality	Well serviced vehicles, vehicle covered, spray water to suppress dust.
Waste management activities (sorting, reduction and composting)	Health impacts	Regular transport of unmanaged waste to a central waste management facility, provision of temporary storage for untransported waste, reduction of bio aerosol release to the atmosphere by best practices, siting of IWMC, provide protective clothing to workers.
	Groundwater impacts	HDPE linings provided through design, leachate collection system, usage of windrow covers, waste not stockpiled on the ground.

	Amenity impacts	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 low.
	Air quality impacts	Cover putrescible wastes, follow composting best practices
	Fire hazards	Formulate fire management plan, provide firefighting equipment and training, naked flames shall not be allowed at IWMC, placing awareness signs at the premises.
	Noise and vibration impacts	Provide PPE, equipment well maintained and use scheduled
	Accidents and injuries	Formulate occupational safety plan, worker training, provide PPE, use licensed drivers and operators, placing a first aid kit at IWMC.
Waste generation	Groundwater pollution	Hazardous waste managed in closed containers, spill kits provided.
	Terrestrial pollution	Prohibit eating and cooking in IWMC
Resource consumption	Water	Ensure compost windrow is shaded during dry periods, use a spray hose to decrease water consumption,
	Electricity consumption	Ensure the equipment are properly serviced and maintained, use the shredders and compactors under a plan

Positive impacts are expected from the operation of the IWMC, which includes positive impacts to the overall health and well-being of the island community, and positive impacts on the groundwater, terrestrial and marine environment. 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 20 - 30% of the waste generated within the island can be managed at the IWMC. Therefore, in order to avoid the IWMC reaching capacity for storage and composting, it is recommended to conduct regular trips to transport unmanaged waste to a central waste management facility. In contingency for cases where transportation is delayed, it is recommended to provide 660 L wheelie bins within the premises to temporarily store the unmanaged organic waste. Within the given size of the IWMCs, 25 nos. of wheelie bins can be kept on site, which can store unmanaged organic waste while alternative transportation options are arranged.

8. It should be noted that without the proper assistance, financially (in terms of budgetary allowances) 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 Waste Management Regulations and Guidelines is seen as crucial in achieving proper waste management within the island. The report proposes intermediary waste management steps to be following during the stage where the IWMC has been constructed and a WMP has not been formulated yet. 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 EMP, 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 EMP shows that the proposed activities for this project has major negative impacts due to land clearance, minor to moderate negative impacts during the construction works, and minor negative impacts as well as 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 facilitated the "Provision of Water Supply, Sanitation and Solid Waste Management Project" financed by OPEC Fund for International Development (OFID) to establish Island Waste Management Centres (IWMC) in nineteen islands in Zone 1 (which consists of Haa Alif, Haa Dhaal and Shaviyani atolls).

The completion of the proposed project will result in the establishment of an IWMC in these nineteen islands (19), and the operation of the IWMC will be facilitated under the Waste Management Plan devised by the respective Island Council and approved by EPA.

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

1. Reduce the amount of waste produced and discarded;
2. reuse, items discarded as waste;
3. recycle waste to create value added products;
4. use waste to generate energy; and
5. dispose waste in an environmental responsible 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 without pollution.

In order to achieve the objectives of *Saafu Raajje Policy* MEE has plans to implement a regional waste management system together with Island Level Waste Management systems based on previous studies that has been done on waste management in the Maldives. In this regard, the Ministry had procured consultants to conduct the feasibility study of the regional waste management system which would work congruently with the Island Waste Management System.

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 planned to be transported to the proposed Regional Solid Waste Management Facility (RSWMF) of Zone 1. At the time of the report, design of the Regional Waste Management System (RWMS) had been commissioned by MEE and was ongoing.

The proposed IWMC will be financed by OFID and constructed by contractors procured by MEE locally. Prior to construction of IWMC, preliminary studies such as site selection/approval, environmental impact assessments and environmental 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 14 islands listed below was classified as requiring an Environmental Management Plan (EMP).

- HA. Muraidhoo
- HA. Molhadhoo

- HA. Thakandhoo
- H. Dh Nolhivaram
- H. Dh Neykurendhoo
- H. Dh Makunudhoo
- H. Dh Kurinbi
- H. Dh Hirimaradhoo
- H. Dh Kumundhoo
- H. Dh Vaikaradhoo
- H. Dh Finey
- Sh. Noomara
- Sh. Feevah
- Sh. Bileffahi

This report includes one (1) of the aforementioned fourteen (14) islands, namely:

- Sh Noomaraa

Sh. Noomaraa is an island located in the administrative region of Miladhummadulu Atoll. The island has an area of 50.1 ha and is home to a community of 462 people. The island is accessible by a harbour located on the southern side of the island. The island is highly vegetated with 21 ha of natural vegetation identified. Approximately 1.3 ha of the island's vegetated areas are wetlands.

The island has 24-hour electricity services but lacks water supply and a central sewerage system. There are 3 areas which locals use regularly to dump and burn waste. Terrestrial pollution caused as a result of bad waste management practices such as dumping of inorganic mixed waste at the periphery of residential areas, dumping putrescible waste and nappies into the beach areas is widespread throughout the island. There are 3 areas where waste is regularly dumped and burned. The island council states that waste management is the most pressing issue in the island, and that they have included waste management as the highest priority in the council's 5-year plan.

No waste audit specific to the island has been carried out in the past nor had the waste situation of the island been properly assessed. A waste audit for Zone 1 (which includes HA, HDh, and Sh. Atolls) conducted by MEECO in 2016 showed an average of 1.30 kg/capita/day of waste generation within the islands. The waste audit showed that in Zone 1, 72.2% of the waste generated was organic waste, of which the majority constituted of yard waste. The next highest categories include plastics and paper / cardboard wastes which contributed to approximately 5% of the total waste. In order to manage the waste situation at the island level, the Proponent, Ministry of Environment and Energy (MEE) has proposed the project to establish an Island Waste Management Centre (IWMC) in Sh. Noomaraa.

The proposed project is facilitated by MEE and financed by the OPEC Fund for International Development (OFID) under the "Provision of Water Supply, Sanitation and Solid Waste Management Project". The completion of the proposed project will result in the construction of an IWMC, and the operation of the IWMC will be facilitated under the Waste Management Plan devised by the Island Council and Approved by EPA.

The scope of the IWMC is to facilitate island level management of the waste generated within the island, which includes sorting, volume reduction and stockpiling of recyclables, composting of organics, and storage of hazardous waste. The waste that is not manageable in the island level shall be transported to a central waste management facility.

Maldives Energy and Environmental Company (MEECO) who was contracted for the task after being the successful bidder, prepared this document in accordance with the EIA Regulation 2012 to obtain the required environmental clearance for the proposed construction of IWMC accordance with the Regulation enforced by Environmental Protection Agency (EPA). This EMP 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 literature, site visit, professional expertise and judgements. For site investigations, a field visit was conducted during the months of April and May 2017.

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 EMP 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 Sh. Noomaraa. The term Project means 'Establishment of IWMC in Project Island' and the developer shall be interpreted as the company undertaking development works of the Project. IWMC occupier shall be interpreted as the company undertaking the operational works of the IWMC.

Nearest Waste Management Facility shall be interpreted as Thilafushi. If in the future, waste from zone 1 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 EMP

The objective of the EMP 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; and
c) to provide necessary information to EPA applicable to the proposed development in line with the EIA Regulations.

1.4 EIA AND EMP IMPLEMENTING PROCESS

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

The aim of the EMP 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 EMP 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 EMP has been developed within the framework outlined in the EIA regulations 2012. This EMP establishes the environmental management controls to be followed by the developer, 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 EMP and matters highlighted in the decision note.

1.5 PROJECT SETTING

Sh. Noomaraa is an inhabited island belonging to the administrative atoll of Miladhummadulu. Situated in the eastern rim of the atoll basin at 6°26'2.67"N, 73° 4'8.64"E, the closest island to Noomaraa is Sh. Neyo, an uninhabited island located 2.16 km northwest of Noomaraa. The nearest inhabited island to Noomaraa is Sh. Feydhoo, located approximately 8 km south of Noomaraa. The island is fairly SW - NE oriented. Sh. Noomaraa is 254km from capital Male' City. The closest airport is located at Hdh. Hanimaadhoo 35 km to the north of Noomaraa.

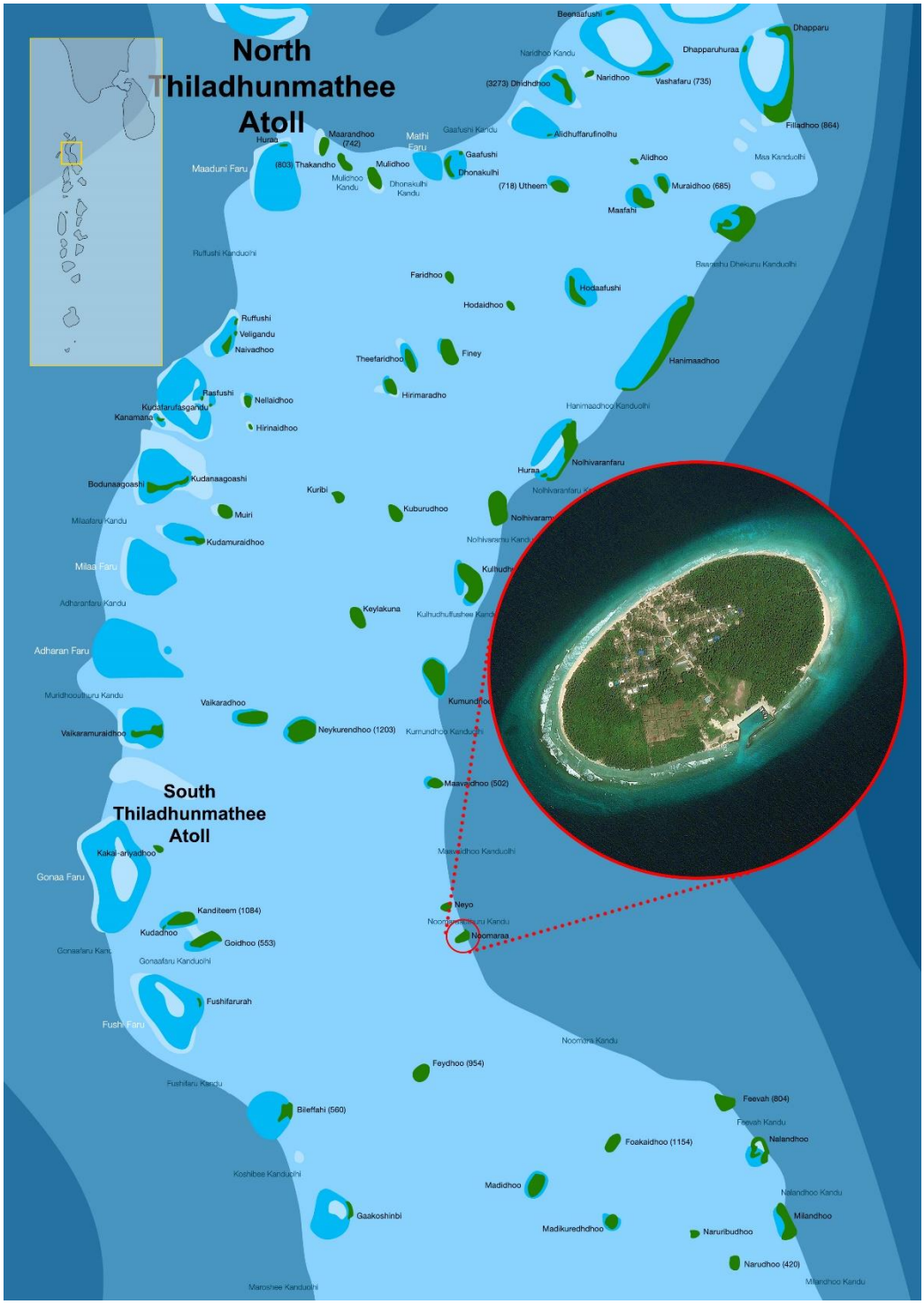

Figure 1: Project setting

1.5.1 Site Location

The proposed Island Waste Management Centre (IWMC) is located in the south eastern side of the island at 6°26'1.15"N, 73° 4'18.14"E. The site requires vegetation clearance and is accessible by a cleared road adjacent to the plot. The road has a width of 5 meters and can be used by vehicles. Land clearance works are required as the plot is vegetated with *Pandanus* (Kashikeyo), *Guettarda speciosa* (uni), *cocos nucifera* (Dhivehi ruh) and some undergrowth. It is estimated that 6 coconut palms and 25 other trees will require removal from the site.

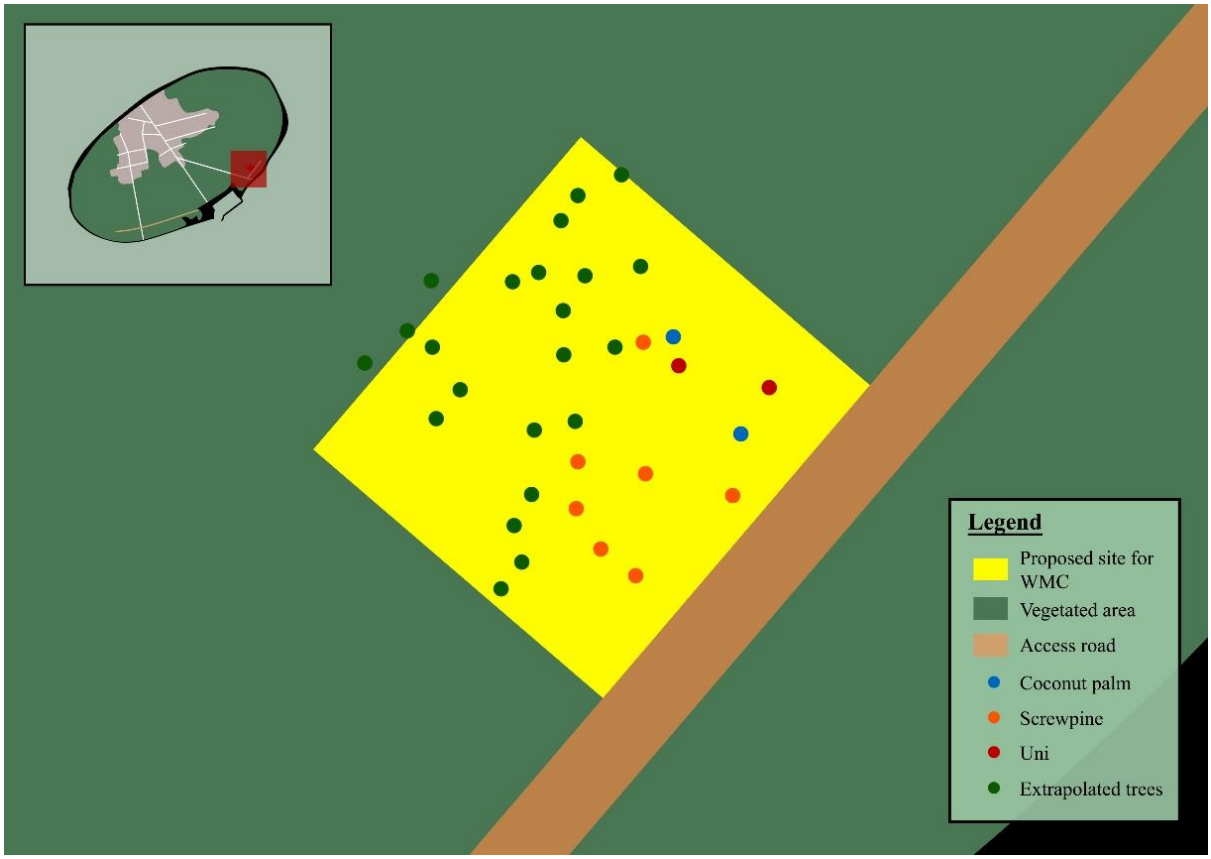

Figure 2: Proposed location for the waste management site on Noomaraa Island

1.6 CURRENT STATE OF WASTE GENERATION AND WASTE MANAGEMENT

1.6.1 Waste Generation in Zone 1 and Sh. Noomara

A waste audit conducted by MEECO in 2016 showed that the average waste generation of the islands in Zone 1 was 1.30 kg/capita/day.

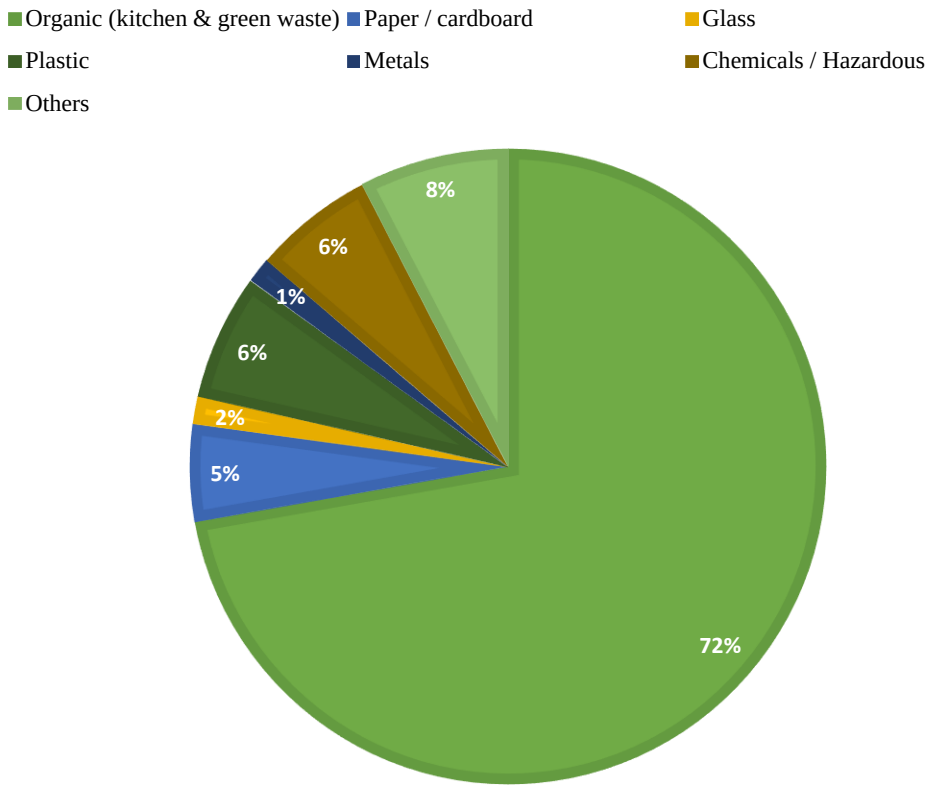

Figure 3: Waste Composition of Zone 1 (Source: MEECO, 2016)

The analysis shows that the majority of the waste generated includes organic wastes at 72%, which include kitchen and green wastes. This waste can be used in composting in addition to paper and cardboard wastes which are at 5% of the total waste generated. Recyclable materials such as plastic, metals, and glass make up 9% of the composition. Approximately 6% of the total waste generated is chemicals and hazardous waste. Using Sh. Noomara's current population, the daily waste generated can be deduced from this data.

Table 4: Waste generation quantities of Sh. Noomaraa

Waste Type	Zone One Average (%)	Noomaraa Waste Generation (Kg/Day)
Organic (kitchen & green waste)	72.2	433.6
Paper / cardboard	4.94	29.7
Glass	1.42	8.57
Plastic	6.4	38.47
Metals	1.3	7.87
Chemicals / Hazardous	6.15	36.97
Others	7.58	45.57
Total	100	600.6

1.6.2 Current state of waste management in Sh. Noomaraa

The majority of sources of waste in Sh. Noomaraa are households, in addition to farming activities. The council pointed out that there are 3 areas used frequently for dumping and burning waste. However, the areas are not demarcated or established to dispose waste. There is currently no waste management system in place in Sh. Noomaraa. Therefore, residents have also been dumping waste at the periphery

of the residential zones. These include plastic, organic waste, metals, and glass. Kitchen waste and nappies are thrown on the beach areas around the island.

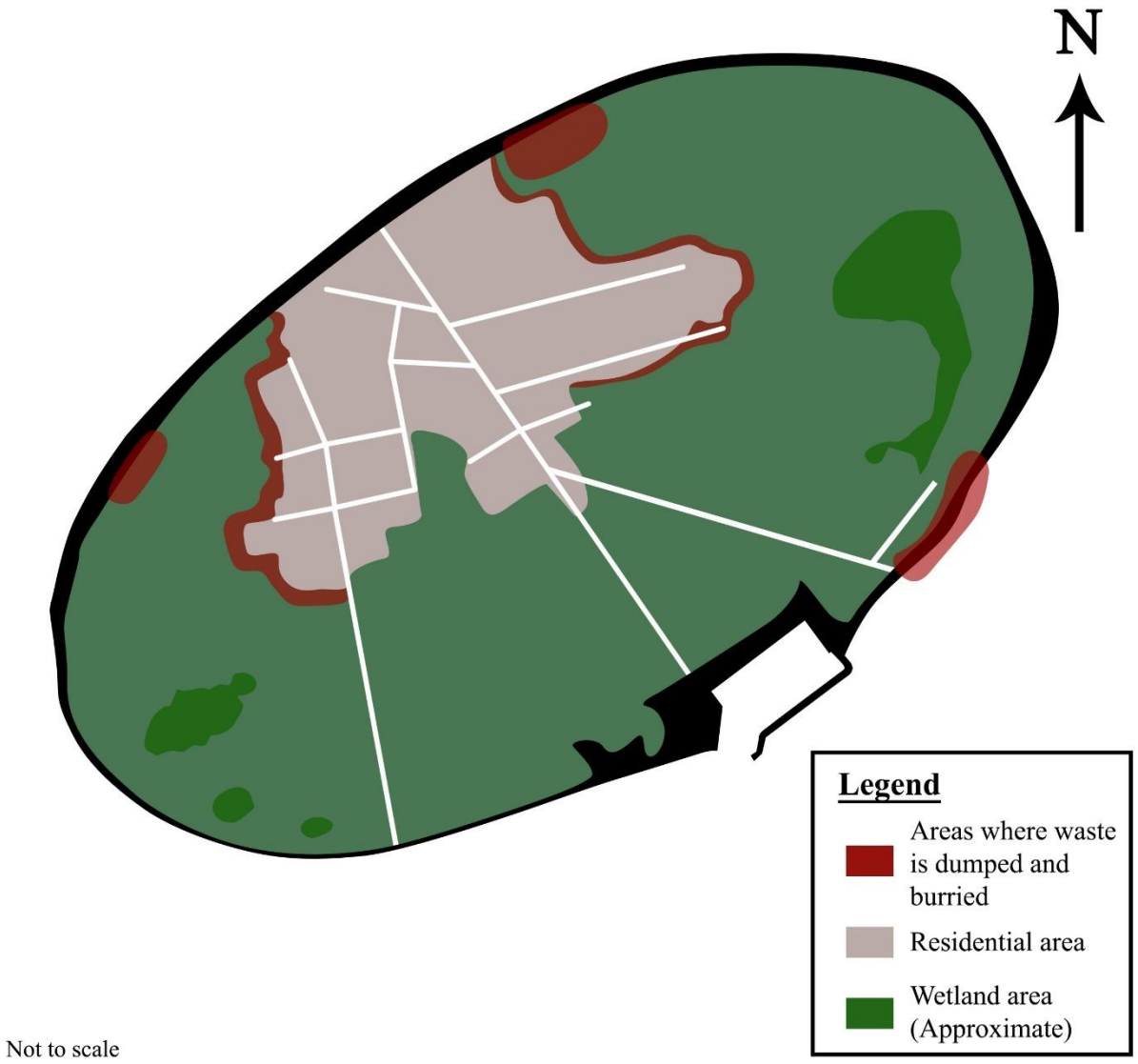

Figure 4: Areas where waste is currently disposed at

Table 5: Current waste management system of the island

Parameter	Yes	No	Number	Description
Harbor (accessibility)			-	• Determined to be accessible. • Prone to shoaling
Waste transportation			-	• No waste collection systems or services provided in the island
Vehicles for waste transportation			-	• No vehicles.
Waste management equipment			-	• No waste management equipment
Presence of dumpsites			3	• Three dumpsites are present
Dumpsites demarcated			-	
Dump site 1			-	• The site is not demarcated
Dump site 2			-	• The site is not demarcated
Dump site 3			-	• The site is not demarcated
Separation of waste at dumpsite			-	-
Dump site 1			-	• Waste is not separated
Dump site 2			-	• Waste is not separated
Dump site 3			-	• Waste is not separated
Burning waste			-	-
Dump site 1			-	• Waste is burnt regularly
Dump site 2			-	• Waste is burnt regularly
Dumpsite 3			-	• Waste is burnt regularly
Burying waste			-	-
Dump site 1			-	• Waste is buried to reduce volume
Dump site 2			-	• Waste is buried to reduce volume
Dumpsite 3			-	• Waste is buried to reduce volume
Dumping waste into the beach/sea			-	• Mainly to the areas illustrated in **Figure 4**
Presence of large waste piles			-	• Both dumpsites contain piles of waste mainly consisting of burnt residue, construction waste and mixed waste.
Risk of waste piles failing due to weather			-	• Have not been highlighted
Pollution of inland/other areas			-	• Terrestrial pollution is widespread
Clinical waste management			-	• Clinical waste is managed at the Health Centre
Public area waste collection			-	• Council contracts a local party to clean and collect waste from public areas, sometime locals take the initiative and clean themselves.
Presence of waste bins			-	• No
Presence of workers			-	• No
Electric connection at the dumpsite			-	• No

Figure 5: Current state of waste disposal in the island. (A)and (B) Waste disposed at public areas of the island, (C) Remnants of burned waste (D) Waste disposed at eastern coastal zone of the island.

Table 6: Type of waste separated, burnt, buried and dumped at the island

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 WASTE MANAGEMENT PLAN

Sh. Noomaraa had no WMP formulated at the time of visit. Various consultations to project islands has revealed numerous challenges exist to formulate and implement the WMP. These challenges and risks are listed in **Table 7** with their immediate risks categorised.

Table 7: Risks and challenges to draft and implement Island WMP

	Risk Categorisation	Description	Adaptive Measures
Formulation of Waste Management Plan			
Lack of technical staff	High	Technical experts with knowledge of waste management and waste management planning	• MEE to train pool of people from the island with regard to waste management. • MEE to conduct capacity building workshops and island specific training programmes.
Lack of reliable information	Moderate	Information with regard to amount of waste generated from the island, including type of waste generated etc.	• Review of previous waste management studies. (See **Section 1.6.1** for waste generation estimates)
Understating regional and local waste management concept	High	Lack of knowledge regarding the *Saaffu Raajje* waste management framework and strategy.	• MEE to conduct workshops briefing and lecturing council and relevant stakeholder with regard to nation-wide waste management framework. • MEE to utilise public media to conduct waste management awareness programs. • Share information with regard to past experience. • MEE should train selected members from the council and community on how to operate and trouble shoot machineries. It is recommended to train a diverse group (Teachers, members from NGO's, Hospital etc.) of people (at least 5 from the island) so that students may be able to teach in the future. This will be important to address risk of losing technical staff during operational phase of the IWMC.
Lack of knowledge with regard to IWMC operation	High	Poor understating of the activities undertaken at the IWMC. Poor understanding of the roles and responsibilities of IWMC workers and stakeholders.	
Poor knowledge of waste management progress/failure indicators.	High	Describes indicators such as volume/weight of incoming waste, compost output, equipment operation frequency, complain logs etc which can be tracked to better understand and strengthen waste management plan	
Unfamiliarity with the proposed waste management equipment	High	Inability to trouble shoot and operate proposed waste management equipment. Poor knowledge of when/how to operate the equipment.	
Lack of knowledge with regard to local businesses and household expendable income.	Minor	Poor understanding of the type and size of waste generated from	• Council shall take initiative and conduct island wide surveys to

		businesses/industries. Poor understanding of the willingness to pay by the public. Poor understand of incentives to enable source separation.	determine the willingness to pay and type of waste generated from local business and industries if any. • Previous studies shall be referenced when drafting the waste management plan.
Implementation of Waste Management Plan			
Lack of vehicles	High	Lorries and pickups required for waste collection and transportation within the island.	• Council to raise funds to procure vehicles through better planning and budget control. • MEE to provide aid in procuring vehicles for waste collection. • Council to make contracts with vehicle leasing companies or individuals who own vehicles, for waste management. • Granting agencies or charities may be approached.
Lack of budget and financial capacity for start-up.	Moderate	In order to operate the IWMC, employees shall be hired. Initial start-up cost of operation will be significant.	• Council to make better financial plans and to raise funds to start up waste management. • MEE to provide aid to start-up the waste management operations. • Obtain assistance/grants from charities and international authorities. • Council to make contracts with private/state companies to operate the IWMC.
Operational cost and income from waste services not feasible	Moderate	If the dwelling households and enterprises are low, operating a waste collection service and managing the IWMC may not be feasible to sustain.	• Council/MEE to identify feasibility of waste collection services. • Council to conduct intensive willingness to pay surveys. • MEE to review WMP and categorise island based on feasibility of implementing a waste collection and IWMC management plan with regards socio-economic condition of the island. • Council to increase fees in case income does not meet operational cost.

			• Lowering operational cost through effective management. • Devise a cost sharing scheme in the form of subsidies for island. • Create a market to sell compost to increase income. • Plan regional waste management plans to encompass limitation at island levels waste management.
Lack of knowledge with regard to composting	High	Composting is the most significant aspect of island level waste management, hence knowledge regarding compost management will be vital to sustain island level waste management. Many of the councils do not have experience with regard to composting.	• Awareness and capacity building as described above. • MEE to invite experts from related fields to share knowledge and past experience.
Unfamiliarity with the proposed waste management equipment	High	Same as above	
Poor knowledge of waste management progress/failure indicators and roles/responsibility of stakeholders	High	Same as above	Same as above

The analysis showed that, significant risks exist to draft/design the island level waste management plan and implement the waste management plan once the IWMC is constructed. This entails a higher risk for the overall failure of the IWMC during the operational phase which would result in accumulation of negative impacts detailed in **Section 5.2.1**. Hence, design and implementation of a thorough island specific waste management plan is identified to be crucial for the successful operation of the IWMC.

A standard operation procedure of the IWMC is not available for implementation in cases where an adequate WMP has not been prepared and approved by the time IWMC construction is completed. Hence the risk of IWMC's failing during the operational phase are very high.

In order to prevent conversion IWMC's into waste dumpsites as commonly observed in the Maldives, the report recommends to follow the intermediary management steps as described in **Section 1.7.1**, until a workable and effective IWMP is prepared and approved.

1.7.1 Intermediary Waste Management Steps

Based on the analysis of prepared Waste Management Plans (WMP) in the project islands and challenges faced by councils to draft and implement WMP's, it is recommended to follow the intermediary waste management steps as a guideline in order to:

1. Prevent the IWMC from becoming a dump site. Uncontrolled waste disposal into the IWMC will quickly overfill the IWMC causing damage to the structure and resulting in burying and burning waste at the IWMC and
2. act as a contingency in case WMP is not prepared by the time IWMC's are constructed.

The intermediary waste management steps shall be used as guideline to achieve the objectives described above. **Table 8** notes important aspects which shall be considered during the intermediary phase of IWMC implementation by significant stakeholders. It highlights the relative potential risk of IWMC failure as a result of not fulfilling the activity.

Table 8: Intermediary waste management plan

Activity	Responsible stakeholder	Recommendation	Activities potential risk contributing to IWMC failure
1. Establish IWMC management team	Island council	Waste coordinator and 2-3 laborers	Major
2. Awareness and training	MEE	At least 5 selected people including assigned waste coordinator, council employees, teachers etc shall be trained to manage the IWMC, operate and troubleshoot waste management equipment. The aim of the sessions shall be to equip participants with enough knowledge so that they can train other people. In order to accomplish this, a training course shall be designed where industry experts shall share knowledge and past experience.	Major
3. Assign IWMC operating times	Island council/ IWMC Management team/MEE	During the intermediary phase it is recommended to operate the IWMC for at least 6 hours.	Moderate
4. Establish waste collection criteria	Island council/ IWMC Management team/MEE	Since, a waste collection system is unlikely to be designed during this stage, waste shall be taken to the IWMC by individuals during the IWMC operating hours. Waste shall be accepted when it has been separated into three constituent categories as follows: 1. Kitchen waste 2. Yard waste 3. Plastics metals, glass and others. Category 3 shall be sorted by the laborers and stored at the respective compartments while organic waste shall be used for composting or stored in bins.	Moderate
5. Install organic waste collection bins	MEE	The IWMC has enough space to store approximately 20-25 660L bins which will hold organic waste for approximately 1.5-2 weeks. These bins shall be provided prior to starting waste management operations	Major
6. Waste management activities			
a) Sorting	IWMC management team	Daily	Major
b) Metal compacting	IWMC management team	Rarely. Waste audits show that percentage of metals are very small hence it is likely that this activity will have to be performed rarely. An exact schedule for these	Minor

		activities, shall be drafted after assessing incoming waste streams for each island.	
c) Plastic shredding	IWMC management team	Occasionally	Moderate
d) Bottle crushers	IWMC management team	Occasionally	Minor
e) Compost management	IWMC management team	Daily	Major
f) Determine amount of waste generated	IWMC management team	Weekly. This could be done using scales or by estimating volumes. This information will be useful to take preventive measures before the IWMC runs out of storage space. The reporting plan described in **Section 6.10** shall be followed during this stage as well.	Major
g) Maintenance of IWMC	IWMC management team	The IWMC shall be cleaned and maintained daily	Moderate
h) Regular transportation of waste from IWMC to Regional Centre	MEE/Island Councils	MEE shall make the necessary arrangements to transport waste from the IWMC to a central waste management facility. MEE shall regularly monitor reports from respective IWMC's and plan ahead before the IWMC's run out of storage space. Inability to transport waste from the IWMC's during this phase of the operation could result in failure of the nationwide waste management concept. See **Section 1.6.1** which estimates monthly waste generated in the island.	Major
7. Enforce rules to stop disposal of waste into areas other than IWMC	Island council	The island council shall enforce rules and penalties to prevent pollution of the environment. Public announcements shall be made to inform IWMC operating hours etc.	Moderate

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 "Provision of Water Supply, Sanitation and Solid Waste Management Project" financed by the OFID.

2.2 PROJECT DURATION AND SCHEDULE

The proposed project is planned to be carried out in 10 weeks. A tentative schedule of the work is found in **Table 9**.

Table 9: Work plan for IWMC

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

2.3 PROJECT DESCRIPTION

The proposed site plan is presented in **Figure 6.** Engineering details are provided in **Annex 2**.

The construction of the IWMC consists initially of mobilization and site clearing. 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 IWMC is made up of an equipment room, and separate areas to store metal waste, paper and cardboard, plastic waste, glass waste as well as hazardous waste.

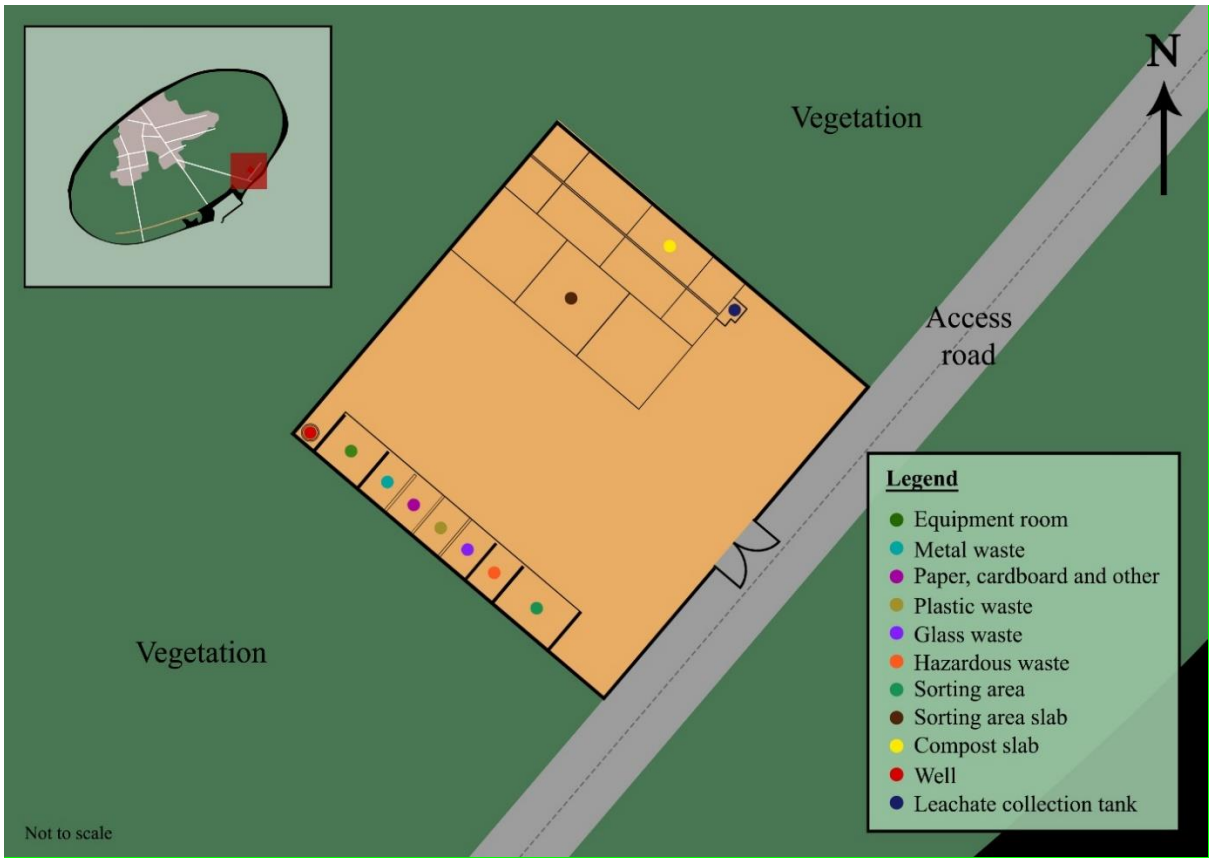

Figure 6: The site plan

2.3.1 Machinery

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

a) 20t hydraulic excavator for vegetation clearance;
b) Lorry crane for placing of well;
c) Truck for transportation of materials;
d) Vibratory plate compactor;
e) Concrete mixer;
f) Concrete supply pump and piping; and
g) 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

2.3.3 Demarcation and Site Clearance

Prior to beginning construction works, a survey shall be done by the developer to demarcate the limits of the site, determine exact number of trees intersecting with the plot. The site shall be fenced off and work shall be conducted within these limits. The island council is responsible for this component of the project, which include site demarcation and land clearance and its associated waste management.

The site in the project island requires removal of vegetation and palm trees. This Section highlights the site conditions of proposed location in the island. Results include actual data and data that have been extrapolated which may have uncertainties.

Before the site clearance activities begin a professional surveyor will mark the boundaries of IWMC using pegs. These control points will guide the construction crew during the entire process. The survey will include a tree survey which will list all tree species within the footprint of the project, including the type, height, diameter and the estimated age. Following the set out survey all trees will be marked as per its final use using a letter code; ***RI (number) – relocation within the project island***, ***RO (number) – relocation outside the project island, T(number)*** – ***timber*** **and** ***W(number) – waste***. Hence trees needing removal can fall into any of these four categories. Abbreviation shall be used to code for the location and batch, as well which would make tracking and distribution easier. The final outcome of the set out survey will be a detailed inventory of all trees (not including shrubs, herbs and vines) requiring removal appropriately labelled.

At the time of the field survey; the proposed site contained 6 coconut palms and 25 other large trees. The site is vegetated with common coastal shrubs and other common Maldivian flora. Common tree species in the area include screw pine (Kashikeyo), nit pitcha (uni) and coconut palms (Dhivehi ruh).

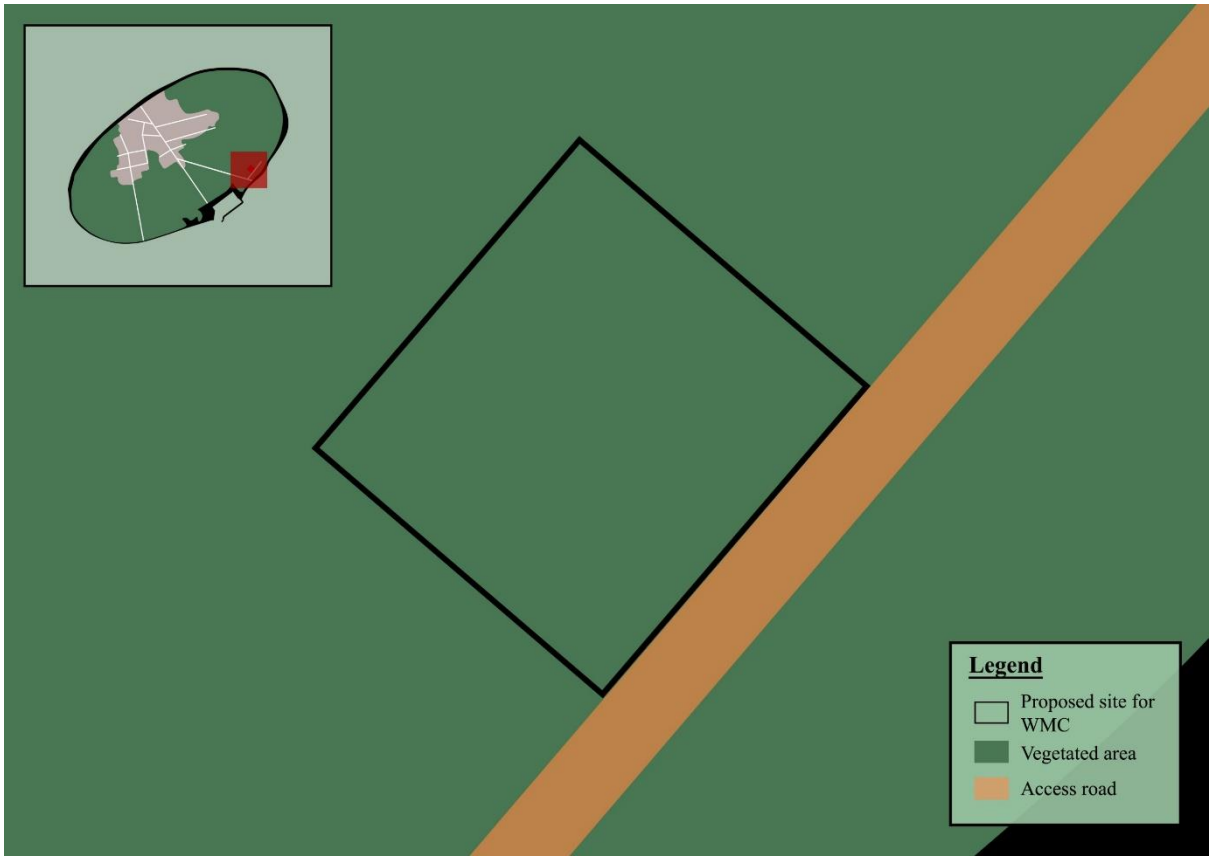

Figure 7: Site condition

2.3.4 Uprooting Trees

All trees within the will require removal using hydraulic excavators (20 tonnes or higher) by direct pulling. The excavator will have a lock-out mechanism fitted to the hydraulics so that the boom does not drop if a hose bursts. During the felling process, the excavator will be directly behind the tree. This is the position from which it can apply the most leverage. The excavator should contact the tree with

either the bucket or live heel. Holding the tree with the grapple is not considered the best practice. The grapple can knock bark down on to the faller and even the smallest boom movement will alter the forces on the tree. Stump pullers may also be attached for removing dead stumps. In areas where undergrowth is found, the process of removing larger trees will begin by clearing undergrowth using machete or chainsaw which will be necessary for making tree access and creating work space also for enhancing visibility of the tree crown and removing obstructions in the landing zone. All the private trees that have been marked shall be compensated prior to removal.

Site clearance will be conducted responsibly aimed at removing only targeted trees that are pre-labelled and identified. Work will be done under strict supervision and clear record keeping by the site supervisor. Work can progress in multiple sections simultaneously depending on availability of workers, supervisors and equipment. Within a given section, trees removed for timber will be uprooted using excavator arm, the trees will be pushed from the mid-section until the root bulb detaches from the ground and falls down. The uprooted trees will be set aside until all the trees in the surveyed section has been removed.

i) Trees for relocation

Trees identified for re-location shall be removed with extreme care as palms are not very tolerant of extreme root disturbances. According to literature, for palms less than fifteen feet in height, a root ball of shovel-width radius from the trunk is a common industry average for size of root ball that needs to be carefully extracted. This would provide for adequate root survival chance once the tree is replanted elsewhere (Broschat & Meerow, 1997).

Soils that cling to the root ball are the most amenable to mechanized harvest. Prior to digging, the soil around the root system will be thoroughly wetted to help keep the root ball together. Palms grown on sandy soils will usually need to have their root balls burlapped after digging, while palms grown on soils with greater structural integrity may not require burlapping. Excess sand shall be removed prior to burlapping. However, since trees will be stacked for some time before being transported to replanting site, it is recommended to burlap all palm trees removed for relocation. A supporting splint will be required to tie each trunk and this will extend up to the foliage to protect the bud.

The greatest loss of water in newly dug palms occurs from transpiration through the leaves. To minimize this, one half or more of the older leaves will be removed at the time of digging. The remaining leaves will be tied together in a bundle around the bud with a twine.

Once the palm tree is carefully extracted it will be transported and stacked at the harbour area, where it will be transported out of the island by concerned parties. The root ball cavity will be filled and levelled. Sand shall be used as a fill material for the root cavities before levelling. (See **Figure 8** for an illustration of uprooting method)

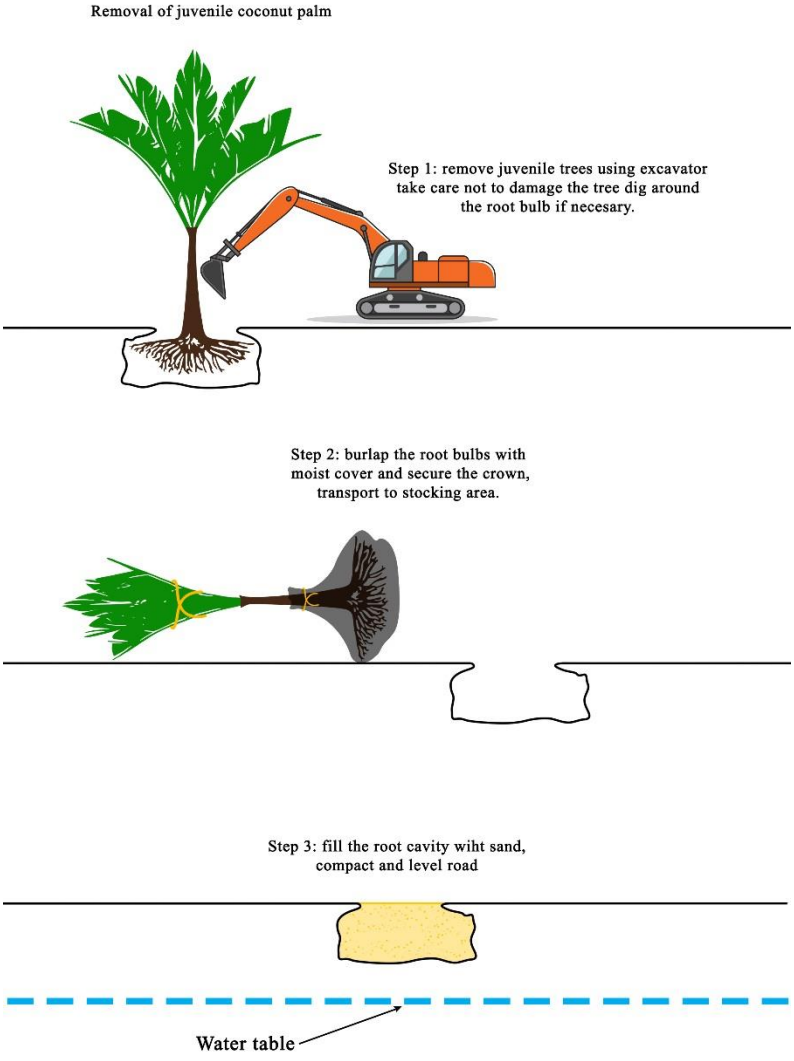

Figure 8: Illustration of uprooting palm trees for re-plantation

If the water table is reached during removal of trees, sand shall be used to cover up before adding organic material. Trees removed for relocation out of the island shall be stored at the designated areas illustrated in **Section 2.3.12**.

ii) Trees for timber

All fronds and root bulb and base of the trunk of the tree that is felled for timber or firewood shall be cut using a chainsaw and only trunk will be transported to the stockpiling area to be sold. Parts of the root bulb will be used for backfilling of the depression created (See **Figure 9** for illustration of removal method). The use of root bulbs for backfilling or grinding the stump of the root bulb will minimise waste generated during site clearance, maintain original soil conditions as well as minimise additional sand needed for filling. All fronds and nuts will be removed from the terminal bulb and piled up separately. Nuts will be sold and fronds will be left to dry and eventually burned. All residual waste shall be disposed of as described in **Section 2.3.12**.

Similarly, all the undergrowth and other trees will be removed and depending on the size of the tree, excavator or chainsaw shall be used. Branches of shrubs and other types of trees will be cut to manageable pieces to be stockpiled for firewood and smaller branches and leaves will be left for sun drying after which they will be burnt.

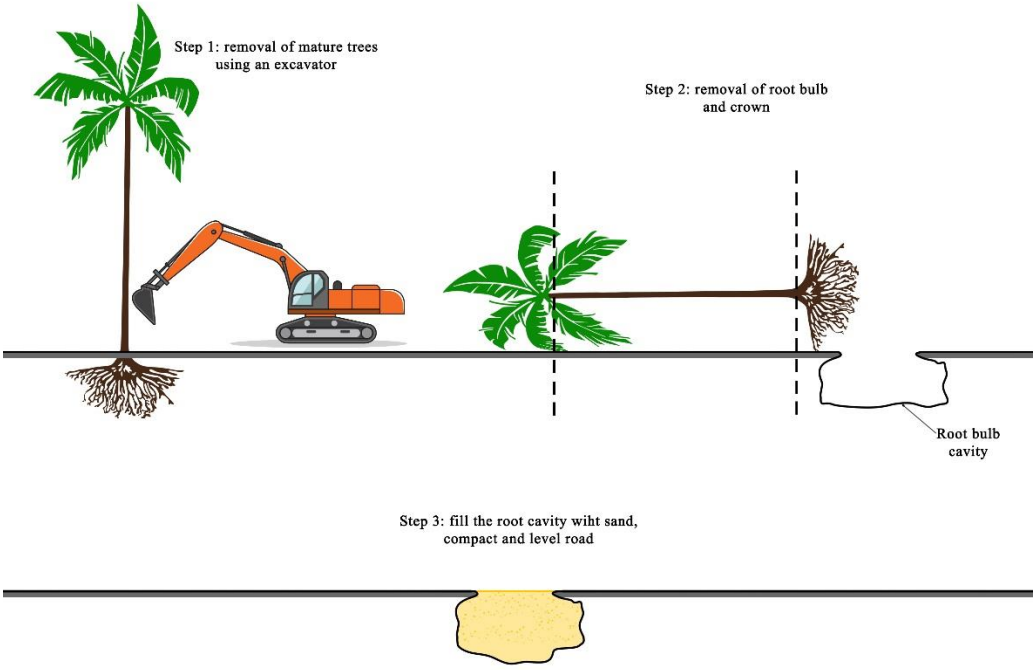

Figure 9: Illustration of removal of trees for timber

2.3.4.1 Alternative options for removed trees

Number of trees intersecting with the proposed and approved IWMC plot based on the vegetation survey undertaken for the EMP are summarized in **Table 10.**

Table 10: Summary of trees intersecting with proposed plot for IWMC

Name of Island	No of trees intersecting with proposed plot	Total no. of trees to be removed
Sh. Noomaraa	31	31

The baseline scenario involves removal of all trees intersecting with the project area. There are not many options available for the councils other than removal of trees using manual labour. This is due to the lack of resources and specialized contractors available in the island. Under the baseline scenario, most of the trees intersecting with the project area will be lost, Furthermore, due to the limited resources and financial capacity of the council there is a significant risk of the project being hindered under the baseline scenario.

The alternative options for trees intersecting with the project site is proposed with the aim of conserving bio-diversity loss by saving as many trees as possible while avoiding delays and hindrance to the proposed project. The three main alternatives are:

1. **Option 1:** Procurement of parties that are willing to buy and replant the trees intersecting with the project area.
2. **Option 2:** Relocating trees within the source island.
3. **Option 3:** Removal of trees to be used as timber/firewood and compensating for trees lost by replanting 2 trees elsewhere

A. Option 1: Procurement of parties that are willing to buy and replant the trees intersecting with the project area which include the IWMC

Vegetation clearance is a crucial step in the construction phase. It is also the activity which will result in the most significant negative environmental impact during construction phase. Since vegetation clearance is not within the scope of project works by MEE, it is identified as a progress limiting activity of the project. This is because, vegetation clearance is expensive and requires specialized equipment. Completion of this activity during construction phase falls within the scope of the island council.

However according to consultations with the council undertaking this activity during the construction phase of the project would place additional pressure on the council financially. Moreover, the island does not have specialized equipment or contractors equipped to undertake significant land clearance.

These constraints are further magnified since private trees will have to be compensated for before its removal and re-plantation of trees by relocating them are environmentally more preferred in order to mitigate negative environmental impacts (See **Section 5.2.1.4)**

In order to solve these limitations and challenges that could hinder project progress, it is highly recommended to procure parties who are willing to buy and relocate trees intersecting with the footprint of the project area. The approach will result in the following advantages.

- Prevention of bio diversity and biomass loss;
- proper management of site during vegetation clearance;
- means of income to the island council and
- clearance of vegetation by specialized equipment will be highly efficient which would result in land clearance within a short period of time.

When procuring potential buyers, the council shall reference the steps highlighted in the flowchart below (see **Figure 10).**

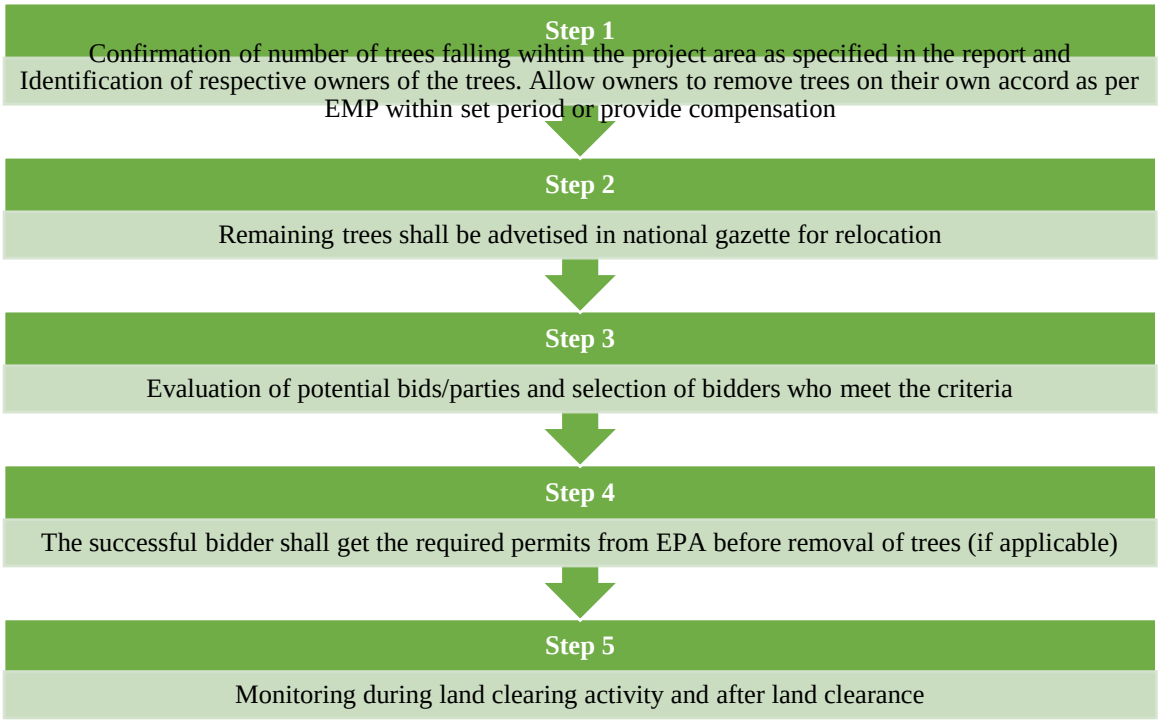

Figure 10: Steps involved in procuring vegetation buyers

Prior to selecting buyers, it is important to define the roles/responsibility of selected parties and the council (state) in terms of contract administration, contract terms /conditions, contract structure, main contract activities, termination/cancellation, records/inspection, financial provisions and project plan.

The Contract must in all respects be governed by, and construed according to, the substantive laws of the country.
In general, as a minimum the bidder shall provide the following details for effective evaluation of the proposals:

1. Proposed work schedule (work method shall follow that provided in this Section);
2. details of key members including project manager;
3. signed power of attorney letter to respective individual. Representatives of the bidder must have the authority to make binding commitments within the bounds set forth in the contract; and
4. financial provisions, which shall include bidding price for individual trees in accordance to the gazetted advertisement.

The successful bidder shall follow the guideline given below when removing trees and vegetation.

- All trees designated by the council in the gazetted advertisement as per vegetation survey shall be removed. Trees designated for removal shall be marked distinctly at Diameter Breast Height (DBH). A list of trees to be removed and their locations shall be supplied by the Island Council. Only those trees so marked and on the list shall be removed. The Island council reserves the right to increase or decrease the quantity of trees at any time based on the vegetation survey and approved EMP;
- trees shall be removed for relocation, hence removal methodology described in **Section 2.3.4** of the report or any similar methodology evaluated to be acceptable shall be followed;
- all brush less than three (3) inches in diameter within a two-meter boundary of the major tree being removed shall be chipped immediately and removed from the work site within three (3) days of being cut as described in **Section 2.3.12**
- all wood and brush disposed of during removal of tree must be in accordance to **Section 2.3.12** of the report;
- trees shall not be dropped or placed across road ways;
- for any plant or tree that had been cut during the removal process the successful bidder shall grind stumps and brace roots so that soil can be returned to the hole and levelled;
- for root bulbs cavities created after removal of trees for relocation the successful bidder shall cover it up using soil or mixture of soil and debris as described in **Section 2.3.12** These cavities shall not be filled with waste or left without levelling;
- tree trimming shall be performed on trees that have been designated by the island council and
- the successful bidder shall remove all chips, grinding and trimming residue from the site and dispose it according to the waste management plant proposed.

Following option 1 could theoretically save all the significant trees that intersect with the project area, which would have been lost otherwise. Loss of trees have been identified as a major negative impact due to its eco system services, economic and cultural value.

B. <u>Option 2: Relocating trees within the source island</u>

The second option for trees which need to be removed is relocating them within the source island. Relocating within the island was not deemed feasible due to space constraints. There are no viable areas in the island that could be used to relocate trees. The process of successfully transplanting trees requires proper equipment and resources currently lacking. Unconventional removal of trees will likely result in the majority of plants getting damaged during the process.

C. Option 3: Removal of trees to be used as timber/firewood and compensating for trees lost by replanting 2 trees elsewhere

Removal of trees for timber or firewood is the least preferred option due to its numerous negative impacts which has been describe in **Section 5.2.1.4**. Those trees that cannot be replanted still needs removal, shall be checked for suitability for use as timbre or firewood and sold. Coconuts and dried branches shall be cut into manageable sizes and may be sold. Root bulbs shall be grinded and waste generated during vegetation clearing shall be managed as explained in **Section 2.3.12** Undergrowth vegetation and other parts of the tree shall be cut into manageable sizes using chainsaw or wood chipper and allowed to dry and burned.

2.3.5 Construction of Sorting Area Foundation

The proposed site has a storage area which consists of a 3.15 m by 18.85 m area. The proposed foundation below the masonry walls of the structure is a line (strip) foundation.

2.3.6 Construction of Compost Slab and Sorting Area Slab

The compost slab and sorting area slabs has an area of 15 m by 10 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 0.4m. 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.

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 1.1 m by 1.5 m and a depth of 1.09 m extending below ground. The valve junction of the leachate tank has a size of 0.8 m by 0.55m, and has a depth of 0.63 m. 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 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 2.8m from ground level. The mesh is held together by 50 mm diameter GI pipes vertically 2 m centre to centre which are welded to three evenly spaced 38 mm GI pipes horizontally. The strip foundation below the masonry wall has a depth of 0.3 m with a 50 mm thick lean concrete placed below. Each vertical GI pipe is fixed to a 300 × 300 mm concrete footing with a depth of 0.6 m. The GI pipe is welded into a 200 × 200 mm plate. Therefore, the excavations done for the masonry wall strip foundation and GI pipe footing will be at 0.35 m and 0.6 m respectively. The trenches required to receive the strip foundation and footings will be excavated manually.

2.3.9 Construction of Well

A well is proposed to be constructed at the eastern corner of the IWMC. This well is 900 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. A lorry crane will be used to lower the body into position.

2.3.10 Construction of Superstructure

The superstructure of the IWMC consists of the sorting area, storage area and the equipment room. The structure consists of a 3 m high wall separating the compartments. The roofing is supported by GI Pipes of diameter 38 mm and 75 mm. The roofing is made of LYSAGHT roofing sheets.

2.3.11 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 in vacant houses.

2.3.12 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 disposed in closed containers.

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, paper, and materials collected from cleaning of the public areas will be stored as describe in **Figure 11.** Only organic waste generated during site clearance shall be burnt to reduce its volume. Large wood stumps shall be cut into smaller pieces and sold to locals to be used for firewood or carpentry. If not sold they shall be stored in bins or sacks and transported to nearest waste management facility.

B. Non-biodegradable waste

Materials such as plastics and glass will have to be collected separately and transported to nearest waste management facility during waste transfer. 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.

D. Waste from Site Clearance

Most of the waste is expected to be generated during the site the clearance process. Since the project involves removal of trees and shrubs, a large volume of yard waste will be generated during construction phase. The project also involves removal of coconut palms. Waste produced by removal of coconut palms will consist of parts of palm tree which cannot be utilised for a meaningful purpose, such as the crown and root system of the palm that are bulky, heavy and occupies a large volume, which makes their management even more challenging.

For those trees that are not suitable for re-planting but may be useful as timber the crown and root bulb of the coconut palm will have to be removed and those residual parts generated will become waste elsewhere. This is mainly because the root section of the coconut palm trees comprises of soft pith that cannot be used as timber. This means the Project's negative impact will be extended, beyond project

island. Transportation of these waste will not be viable hence; the following waste reduction strategy shall be applied.

1. The highest priority shall be given to reduce the number of trees removed during the site clearance. Careful surveying and strict supervision shall ensure that the trees removed are absolutely essential;
2. trees that are removed because they fall on the footprint of the IWMC shall be attempted to relocate;
3. those trees which require removal but are not suitable for replanting shall be assessed for their suitability for use as timber or firewood;
4. only once these uses have been thoroughly exhausted can a tree be considered as "waste"; and
5. yard waste generated after relocation of trees shall be managed at the island level by burning them as described below. Those that cannot be managed at the island shall be transported to nearest operational waste management centre.

E. Burning of Site Clearance Waste

Yard waste shall be burned only after attempting to reduce site clearance waste as described in the report.

The crown parts of the palms, tree branches, shrubs, stumps produced as residual waste can be cut into smaller pieces using a chainsaw or wood chipper can be left to dry on the island, while the root system shall be used to fill the root bulb craters together with sand**.** Using root bulbs from coconut trees removed as timber, to fill the craters would significantly reduce the amount of bulky waste required for burning and transportation. This would significantly reduce transportation cost and associated GHG emissions. Furthermore, the soil will be nourished by the biological activity facilitated by the buried root bulb and the amount of fill material required for levelling will be significantly reduced.

Since transportation of all the yard waste from the island will be prohibitive in terms of costs and other resources required, residual yard waste at the site, shall be left to dry and burnt them at a designated safe area away from residential areas. Burning shall be carried out in an open area that would not impact unintended vegetation. Care should be taken to contain fire within the area of burning to prevent fire becoming uncontrolled. Plastics, metals, fabric and other inorganic wastes shall NOT be mixed with yard wastes while burning. Wood ash contain calcium, potassium, and a variety of trace minerals important for plant health. They also work well as a lime substitute to raise the pH of acid soils. They can also be stored in sacks and used for composting once the IWMC becomes operation. In effect this means, majority of yard waste generated from land clearance can be managed at the island level avoiding the costlier transportation of these waste to the nearest waste management facility.

F. Hazardous waste

Hazardous waste 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 11**. prior to transportation. It is essential to ensure that hazardous waste is fully contained and transported as quickly as possible. It is recommended to install signs in the designated temporary storage area.

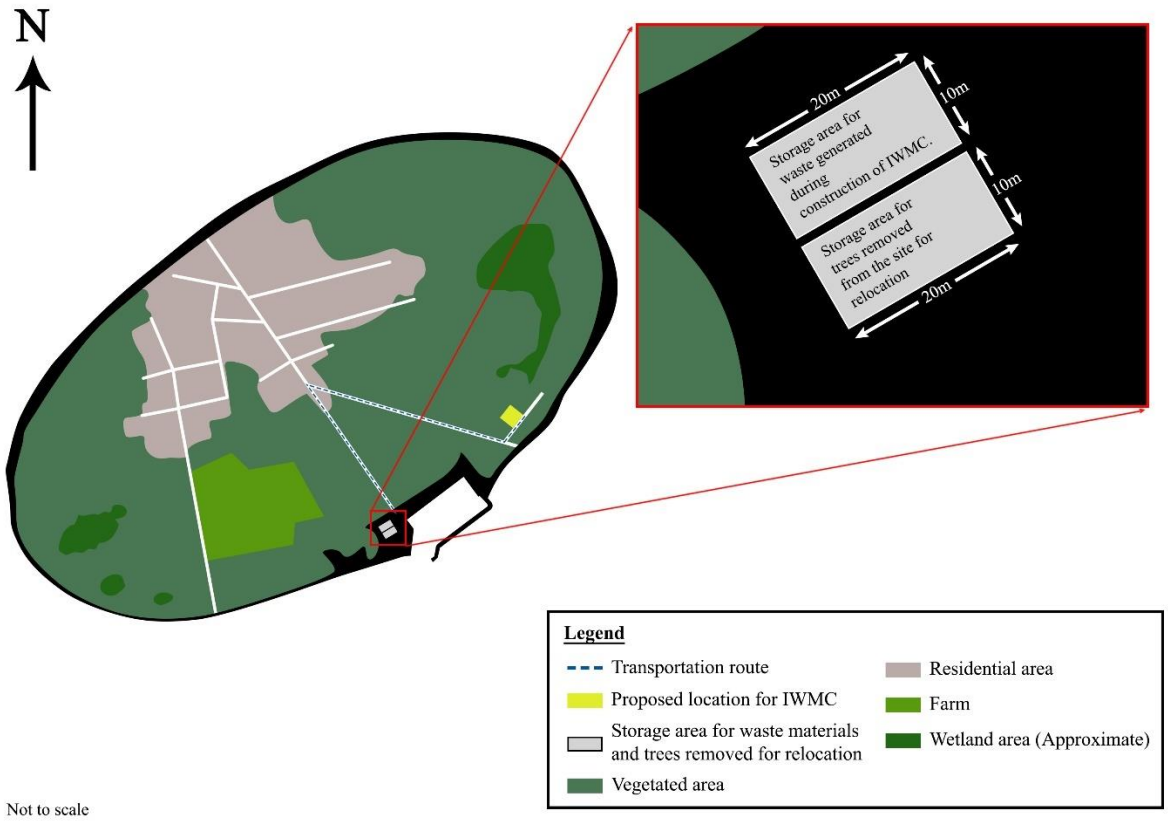

Figure 11: Transportation route and storage area

2.3.13 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.

2.3.14 Health and Safety Measures

The proposed project involves transportation as well as construction of the IWMC at the site. These works will include use of vehicles, machinery, and heavy materials, and the workers may be put in situations where there is a risk of injury. These risks need to be identified and managed through the implementation of health and safety guidelines for the site. Health and safety measures for the construction phase include and are not limited to:

a) The developer would be briefed regarding the laws and regulations that need to be followed regarding the proposed works and would ensure that Health and Safety procedures are complied with at all times;
b) There would be a construction supervisor at the site;
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) The work force would be equipped with all safety gears and warning signs would be provided;
f) Fire extinguishing equipment would be available at the site;
g) PPE should be provided to all workers and the use of PPE enforced;
h) Operation of any heavy machinery will need the assistance of a banksman as all times;

i) All heavy lifts must be supervised and slings inspected; and
j) All other similar environment personal safety and quality control measure to be in place and checked by a qualified personal and approved and maintained at all times.

2.3.15 Demobilization

The demobilization plan will commence in the last week of the contract.

2.4 OPERATIONAL PHASE

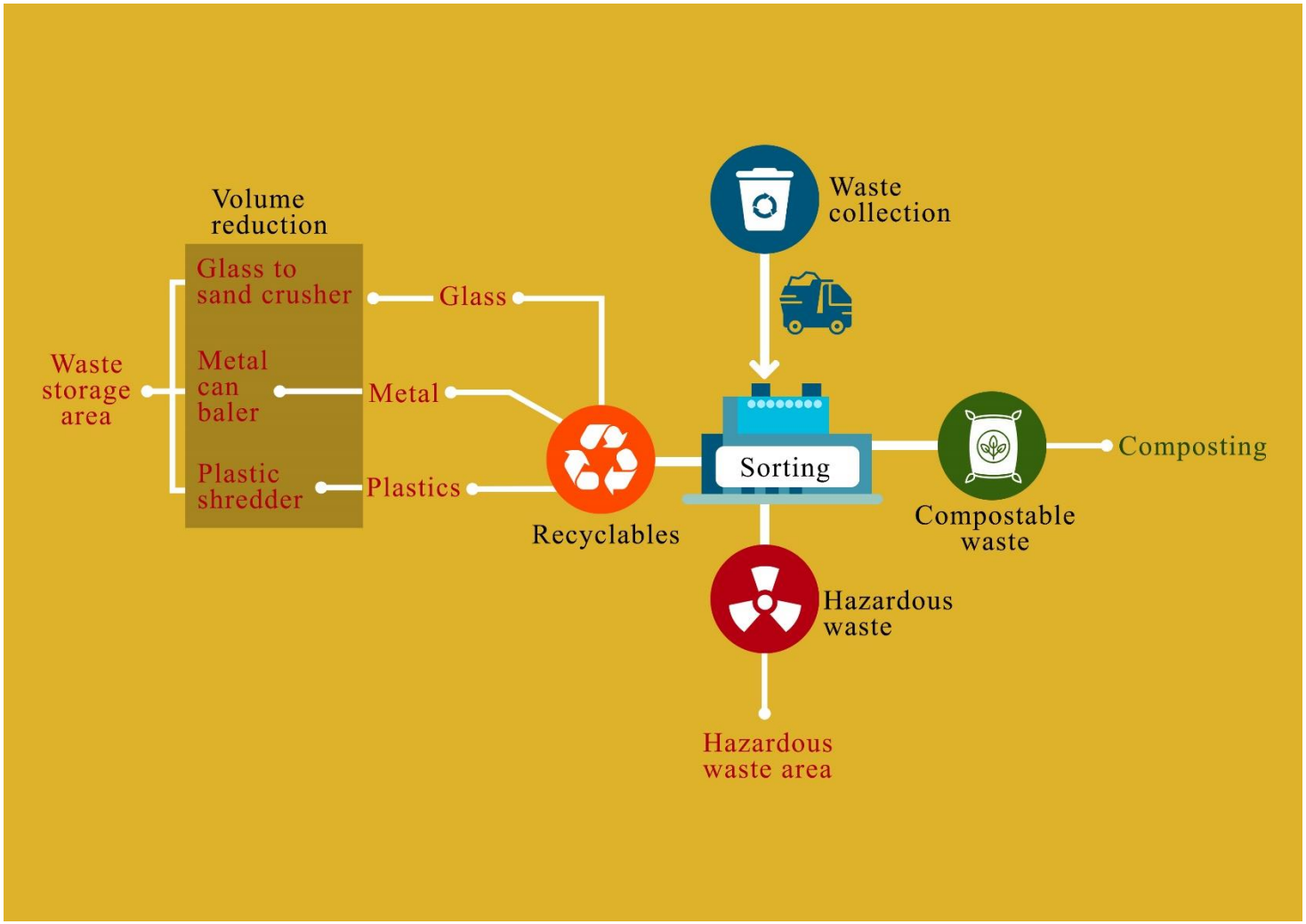

Figure 12: Operational phase flowchart of the IWMC of Sh. Noomaraa

The following Section will 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 activities begin from the sources. Waste is collected and transported to the IWMC. This collected waste is 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

During the operational phase of the IWMC, in addition to the collection of the waste and sorting, different activities such as composting, and waste volume reduction will be done. The proposed equipment for the IWMC include general equipment needed to handle the waste such as 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 includes waste volume reduction equipment such as a plastic shredder, metal can baler, vegetation shredder, and glass to sand crusher. The equipment and their specifications are detailed below.

Table 11: Equipment proposed for waste management works

Equipment	Details
Chainsaw	
Wheelbarrow	HDPE 6 cub. Ft.
Heavy Duty Gumboots	PVC or rubber
Heavy Duty Hand Safety Gloves	Rubber or Latex
Long Handled Flathead Steel Rake	Steel, 54 inches length
Long Handled Cultivator	Steel, 54 inches length
Garden Hoe	Steel, 57 inches length
19” Round Point Shovel	Steel
48” Square Point Shovel	Steel
19” D-Handle Square Point Shovel	Steel
20L Bucket	HDPE
40L Bucket	HDPE
Polypropylene Surgical Mask Box (50pcs)	Polypropylene
Weighing Bench Scale	50-75 kg capacity
Wheelie Bins	HDPE
Glass to Sand Crusher	0.5 to 1.0 tonne/ hr, output 0.5mm and less, 2-5HP motor
Plastic Shredder	30-100Kg/hr Output material less than 10mm
Metal Can Baler	3 to 5 HP, 2m2 or more inside volume
Vegetation Shredder	Petrol / diesel driven multi vegetation shredder / chipper
Manual Rotary Compost Screen	1m to 1.5m drum

2.4.2 Waste Collection

During the consultation meeting with the Noomara Council, it was learnt that the council plans to conduct the waste collection and IWMC operational works by a third party under contract. The waste will be collected using a vehicle during a set time frame.

2.4.3 Sorting

As per the IWMC site layout plan, a ground slab is dedicated for the sorting area. This sorting area is located next to the compost slab. Here, the collected waste will be kept, and sorted into their respective categories. In addition to this, a dedicated sorting area is also provided alongside the storage areas. The IWMC is designed to have separate storage areas for metal, paper and cardboard, plastic, glass, and hazardous waste. After sorting, the waste is stored in the respective location.

2.4.4 Composting

The IWMC is designed in order to facilitate the storing, sorting and reusing of the waste generated in the island. One of the main operations that will be conducted in the IWMC is the composting of the organic waste such as kitchen waste and garden 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.

2.4.4.1 The Composting Process

After the incoming waste is 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.

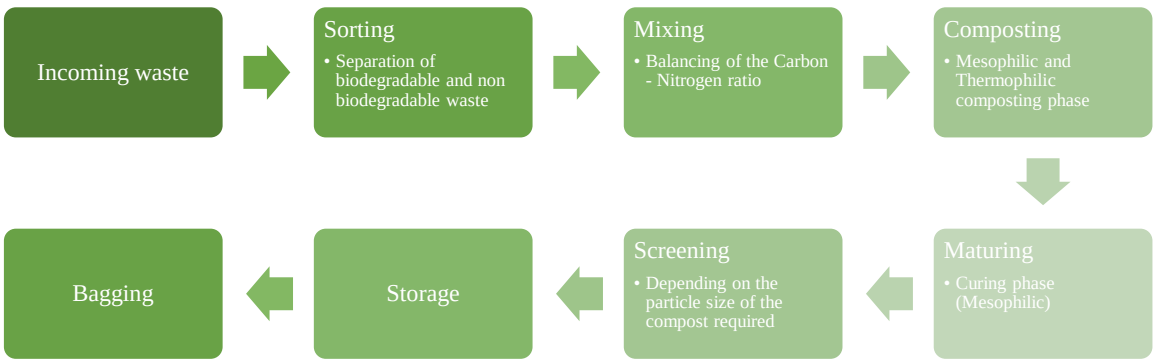

Figure 13: The composting process

2.4.4.2 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. Other types of wastes are sorted within the IWMC. Hazardous waste and residues are kept in their respective compartments, as well as recyclables.

Table 12: Domestic Waste Categories

Incoming Domestic Waste			
Suitable for composting	**Not suitable for composting**		
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
Composting Process	**Storage**		

2.4.4.3 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.

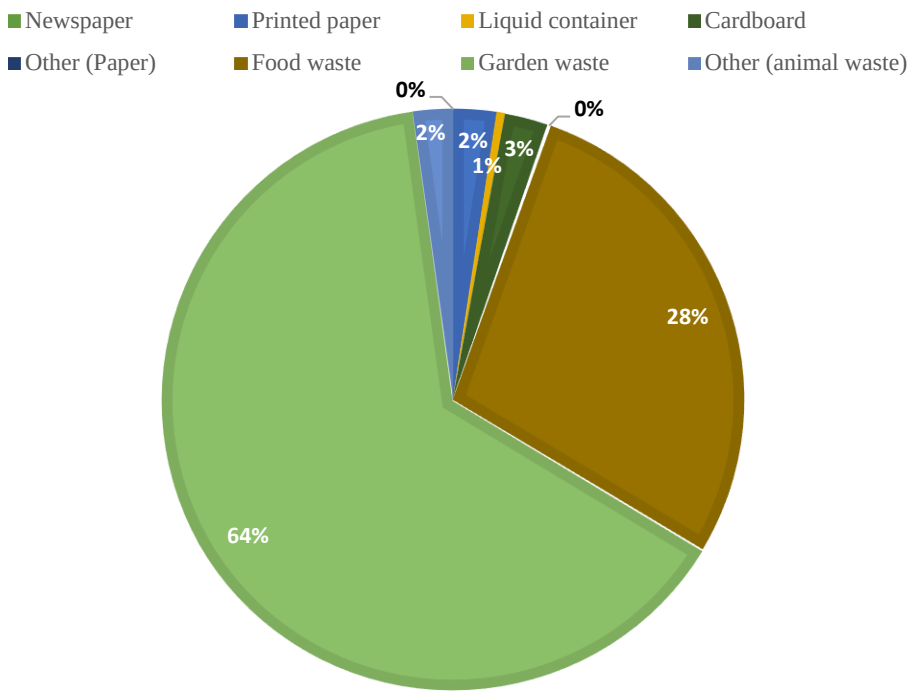

Figure 14: Composition of compostable waste for Zone 1

Table 13: 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 in the islands in Zone 1 is in favour of providing a high Carbon content compared to Nitrogen.

2.4.4.4 Composting and Maturing

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

Table 14: 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 14**, the composting process can prolong to several months.

2.4.4.5 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. This slab is 15m long by 5m wide. The bottom of the slab and ground beams in this area have an HDPE membrane between the reinforced concrete and the ground.

In addition to this, the expansion joints of the compost slabs are filled with silicone and polythene joint filler foam. This ensures that the leachate does not leak into the ground. The compost slab is also designed with a 1◦ slope from both sides, towards the centre, where the ground beam is fitted with a 100mm PVC pipe cut in half with 1% slope towards the leachate collection tank. The leachate is then collected in the dedicated leachate collection tank at the end of the compost slab.

2.4.5 Volume Reduction

The incoming waste is sorted, and either used for composting, or stored in their respective compartments. 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.

2.4.6 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 70 – 75% of waste generated within the island to be transported to the a central waste management facility). The projected capacity for 1 month's waste for the island of Noomaraa is shown below.

Table 15: Projected waste management capacity for the waste generated in Sh. Noomaraa in 1 month

Waste Type	Details	Amount	Unit
Organics	Composting capacity in IWMC. Assuming 1m height windrow with a width of 2m	39	m3
	Organic waste generated per month	20.01	m3
Paper waste	Storage capacity (2.5m by 3.15m compartment assuming height of pile 1.5m	7.875	m3
	Waste generated bulk density after volume reduction 0.65 tons/m3	1.369	m3
Glass	Storage capacity (2.5m by 3.15m compartment assuming height of pile 1.5m	7.875	m3
	Waste generated bulk density after volume reduction 0.65 tons/m3	0.394	m3
Plastics	Storage capacity (2.5m by 3.15m compartment assuming height of pile 1.5m	7.875	m3
	Waste generated bulk density after volume reduction 0.65 tons/m3	1.774	m3
Metals	Storage capacity (2.5m by 3.15m compartment assuming height of pile 1.5m	7.875	m3
	Waste generated bulk density after volume reduction 0.65 tons/m3	0.360	m3

Organic wastes make up the bulk of the waste stream in the island, taking 72.2% of the total waste generated in Noomaraa. 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 39 m^3. The calculated volume for the organic waste generated in a month in Noomaraa is 20.01 m^3 assuming waste is generated from the current population. Therefore; it is be expected that, less than 1.5 month's organic wastes produced in Sh Noomaraa 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 16: 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	29.66 m3	Local Suppliers
		Reinforcement		
		Reinforcement T10	1.231 tons	Local Suppliers
		Reinforcement R6	0.19 tons	Local Suppliers
		Reinforcement T12	0.09 tons	Local Suppliers
		Formwork	135.66 m2	Local Suppliers
		Masonry Works (200mm bricks)	205.8 m	Local Suppliers
		Structural Steel		
		50mm and 38mm GI Pipe for perimeter fence	77.4 m	Imported / purchased where available locally
		75mm GI pipe (flood light fixing poles and roof fixing)	18 Nos.	
		38mm GI bearer pipes	46.2 m	
		38mm GI purlin pipes	95 m	
		38mm GI pipes between columns	35.2 m	
		75mm GI pipe to support machine room door	3.5 m	
		Paint		
		Primer and 2 paint coats (Grey Color)	345.96 m2	Local suppliers
		Electrical Components		
		3 Phase power sockets	4 Nos.	Local suppliers
		Single phase power sockets	3 Nos.	
		100 mm ceiling mount lights	1 Nos.	

		Wall mount exhaust fan	2 Nos.	
		500W flood light	2 Nos.	
		25 mm2 4 core power supply cable	290 m	
		Well water pump	1 Nos.	
		Metal doors for		
		Equipment room	1 Nos.	Local suppliers
		Hazardous waste area	1 Nos.	
		Waste yard entrance	1 Nos.	
		Plumbing		
		25mm PVC intake pipe		Local suppliers
		1/2 inch PVC pipe from pump to all distribution points	40.9m	
		Roofing		
		Storage area roof sheets	85.5 m2	Local suppliers
		Flashing sheets	28 m	
		Lysaght gutter	19 m	
		50x50 PVC coated mesh fence	77.4 m2	Local suppliers
		HDPE membrane	209.54 m2	Imported / purchased where available locally
		Timber top cover	1 nos.	Local suppliers
		PVC pipe for leachate tank drain	15 m	Local suppliers
		600 x 900 5mm plastic sheet signboard	1 Nos.	Local suppliers
Operation	Equipment and Materials	Chainsaw	1	Imported / purchased where available locally
		Wheelbarrow	4	
		Heavy Duty Gumboots	5	
		Heavy Duty Hand Safety Gloves	5	
		Long Handled Flathead Steel Rake	3	
		Long Handled Cultivator	3	
		Garden Hoe	3	
		19” Round Point Shovel	3	
		48” Square Point Shovel	3	
		19” D-Handle Square Point Shovel	2	
		20L Bucket	3	
		40L Bucket	2	

		Polypropylene Surgical Mask Box (50pcs)	5	
		Weighing Bench Scale	1	
		Wheelie Bins	40	
		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 0.6 ton of waste per day	Waste collected by vehicle from the waste bins within the island
	Fuel	Diesel	5000-15000 L/month	Local suppliers
	Food supplies	Food waste	1500 calorie/day/person	Local suppliers
	Water	Fresh water	200-1000l/day	Groundwater

Table 17: Project outputs

Stage	Output	Source / Type	Amount	Means of managing
Construction	Soil	Excavation for substructure	11.78 m3	To be used back in the levelling and backfilling of site.
	Construction Waste	Construction works		Transfer all waste to nearest Waste management facility
	Yard waste from site clearance	Yard waste While a great emphasis is placed on relocating, trees some trees and branches may have to be removed and preferably used as timber or discarded as yard waste.	Approximately 5 tons	See **Section 2.3.12** for details
	Hazardous waste	Construction and clearing of vegetation		See **Section 2.3.12** for details
	Municipal waste	Workers	346.5 kg	See **Section 2.3.12** for details
	Dust	Excavation	Moderate amount of dust	
		Cement mixing	Moderate amount of dust	
	Green House Gases	Machinery		
		Concreting works	100.1kg of CO2 indirect emissions (DEFRA/DECC, 2012)	
		Reinforcement	5311.1kg of CO2 indirect emissions (Ma et.al, 2016)	
		PVC Pipes	164.81kg of CO2 indirect emissions (DEFRA/DECC, 2012)	
Operation	Compost	Open windrow composting	15.6 m^3 of compost per full batch	Sold as fertilizer
	Crushed Glass	Glass crusher	0.25 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	0.23 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	1.15 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

Sh Noomaraa has a land area of 50.1 ha. The island's community of 462 people has a settlement footprint of 12 ha. This is 24% of the island's total land area. 1.9 ha from the southern side of the island is used for farming. The Island Council informed that each household is given a farm land by the council. Approximately 21 ha of the island is covered with natural vegetation. Significant patches of wetland can be found on the western side and north-eastern side of the island. These areas are highly vegetated.

Figure 15: Terrestrial vegetation of Sh. Noomaraa. A: Pomegranate plant B: vegetation at proposed site C: Banyan tree D: Vegetation at proposed site

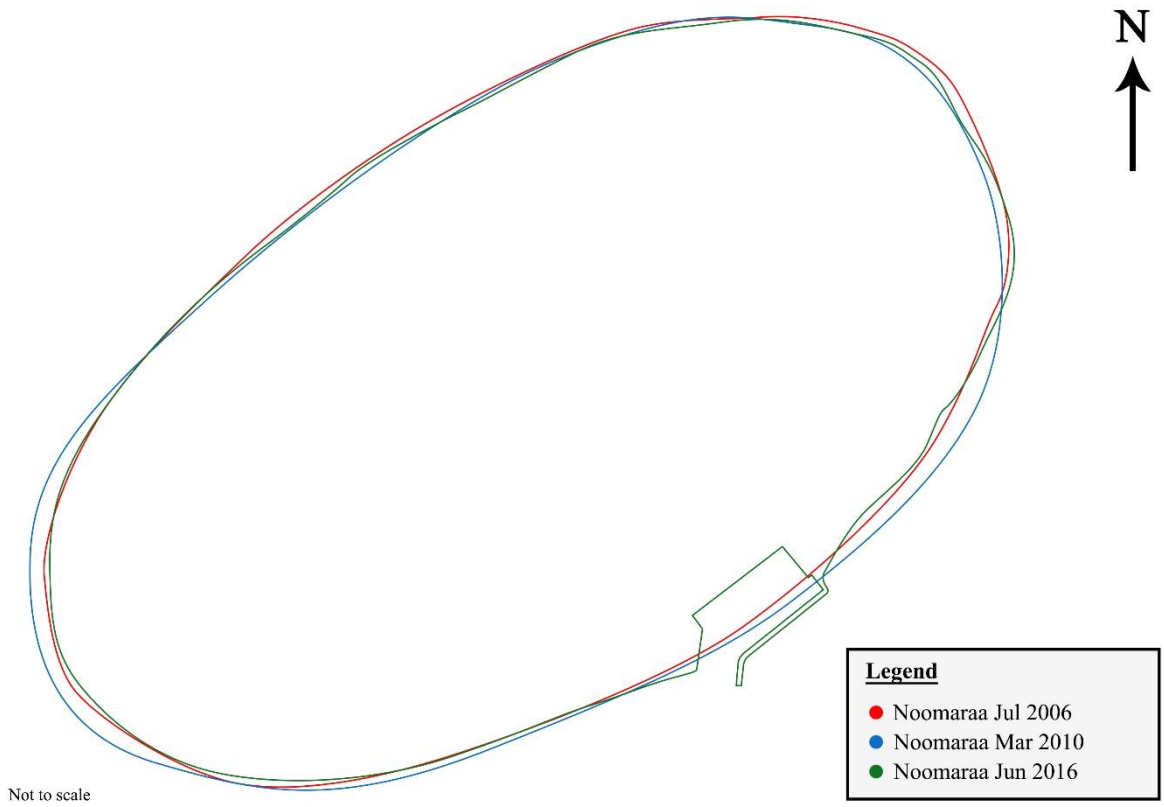

Figure 16: Changes to the coastal region of Noomaraa from 2006 to 2016

Island morphology for Noomaraa was obtained using satellite images 2010 through 2016. Major changes were not observed to the shoreline.

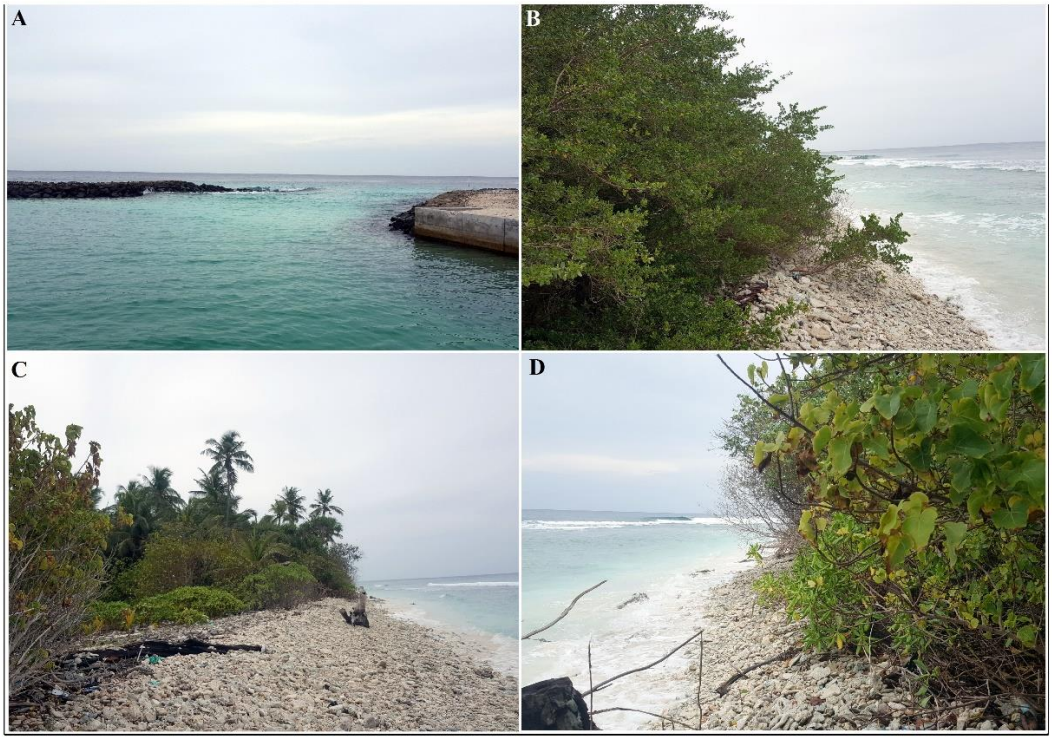

Figure 17: Coastal areas of Noomaraa. A&B: Northern coastal area and C&D show the southern coast

3.2 PROJECT SITE

The proposed Island Waste Management Centre (IWMC) is located at the south eastern side of the island. The site requires vegetation clearance. 26 trees including 6 coconut palms and 21 other trees. Trees observed in the area include Pandanus (Kashikeyo), *Guettarda speciose* (uni), *Cocos nucifera* (Dhivehi ruh). Furthermore, some vegetation undergrowth require clearance. The site is accessible via a main road to the east of the plot. The road has a width of 5 meters and can be utilised by vehicles. The site is 95 m to the east of the island's harbour.

Figure 18: A, B, & C: Vegetation at the proposed site, D: Access road west of the proposed plot.

3.3 Wetlands

Approximately 2.7% of the island's vegetated areas are wetlands. It should be noted that the exact boundaries of the island's wetlands have not been surveyed during the visit, and approximate areas have been determined with the use of satellite imagery and approximate boundaries provided by the Island Council. There are 4 significant patches of wetland throughout the island. The largest wetland was located on the northern side of the island. This patch has an area of approximately 8224 m^2 and is highly vegetated, common plant species at the area include Coconut palms (*Cocos nucifera*), Country almond (*Terminalia cattapa*) and Sea hibiscus (*Hibiscus tiliaceus*). There is also a significant population of Small-leafed orange mangrove *(Bruguiera cylindrica)* and Mangrove apple (*Sonneratia caseolaris)* plants in this area.

Figure 19: A, B, C & D vegetation at wetlands of Sh. Noomaraa (Photo: Sh Noomaraa Council)

3.3.1 Site zoning recommendations by EPA

The EPA has provided recommendations for the optimum zoning of the IWMC site. The distances include, the site being at least 15 m from the coastal vegetation belt, at least 30 m from the nearest freshwater well, at least 40 m from the nearest recreational area and at least 30 m from the wetlands area as well as the residential 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 recommendations are provided below:

Table 18: Comparison between the proposed site location and EPA recommended distances

Location	Distance from site (m)	EPA Recommended Distance (m)
Coastal vegetation	37	15
Freshwater well	180	30
Recreational area	88	40
Wetlands	41	30
Residential area	280	30

As seen on **Table 18**, The proposed plot is located 37 m from the shoreline and 280 m from the nearest residential areas. The site is 41 m away from the closest wetland area, therefore it fulfils the EPA recommended buffers. The closest freshwater wells are located in the football field, which are approximately 88 m west of the IWMC site. The site meets all the recommendations of the EPA,

3.4 STAKEHOLDER CONSULTATIONS

Stakeholder consultations were held for the project with the Proponent MEE, enforcing agency EPA and the Island Council of the project island. Meetings with MEE and EPA were held both before and after the survey trips in light of findings regarding some project islands. The initial meetings were mainly regarding the EIA project islands and scoping, although, due to the similar scope of works, the meetings included discussion of the project as a whole. Highlights of the meetings which apply to the EMP islands are presented below. Consultation attendances are provided in **Annex 3.**

3.4.1 Meeting with Proponent

- The Proponent was consulted at the start of the assignment to discuss project scope and after field surveys to discuss findings of the initial field surveys.
- Proponent informed that MEE will be responsible for the construction of IWMC, while land clearance shall be undertaken by the respective Island Councils.

3.4.2 Meeting with EPA

- It was highlighted that waste management will not involve burning waste at the island level. Waste from islands will be transferred to the regional waste management centre. Only organic waste will be managed at the island level to make compost. All necessary equipment required to manage waste at in the IWMC will be provided as part of the project.
- EPA highlighted, relocation of trees within the island or outside of the island is preferred and requested the consultant to explore or identify options for which trees can be relocated as opposed to being removed for timber.
- EPA informed that buffer distances recommended by EPA in the zoning form shall be kept in order to mitigate impacts.

3.4.3 Meeting with Island Council

- The Council mentioned that waste management is the most pressing issue at Sh. Noomaraa.
- They explained the difficulties and challenges cause by widespread terrestrial pollution at the island. There are 3 sites at the island which the locals use regularly to burn waste. The Council is now trying to limit burning waste throughout the island to these three areas. The Council pointed out that periphery of the island's residential zones, certain forested areas and coastal areas are the most polluted.
- Burning yard waste and dumping bio degradable organic waste at the beachside are common practices among the locals. Sanitary waste is dumped at the beaches regularly as well. The Council mentioned that waste management has been given the highest priority when the Council's official 5-year work plan was developed.
- The Council explained that getting rid of waste accumulated at different areas of the island is a major issue. Locals sometimes organize small scale cleaning projects to clean public areas of the island.
- There are 3 sensitive areas at the island according to the Council
- The Council stated reasons why the proposed site to develop IWMC was selected
    - Residential areas are not planned to be developed on the eastern side of the island, the Council plans to further expand residential developments to the western side of the island, where the current approved site is present
    - The closest planned development to the proposed site is a site allocated for the FENAKA power plant
    - A 30m buffer can be obtained between the site and the nearest wetland.

3.4.4 Meeting with Ministry of Housing and Infrastructure

Consultation meeting was held on August 10, 2017 to discuss the proposed site of Sh. Noomaraa. Meeting highlights are summarized below:

- MHI stated that there was currently no approved Land Use Plan for the island.
- MHI mentioned that there was no issue with the proposed site, as long as the buffer distances were available.

4 ALTERNATIVES

This section explores alternatives for the proposed project. The options explored include:

1. No project option;

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

Under the current scenario waste is not managed at the island (See **Section 1.6**). Currently Sh. Noomaraa has 3 areas that are used for dumping and burning waste regularly. However, public disposing of waste in various locations of the island, including the beaches and the periphery of the residential areas is a common practice. These practices have resulted in the spread of diseases in the island. Wide spread terrestrial pollution at the island is directly linked to the uncontrolled mosquito population. The practice of burning waste at various locations of the island leads to respiratory issues from the inhalation of smoke. The no development option would result in continuation of the aforementioned practices in the island, thus exacerbating the various negative impacts. Hence the no development option of the project is rejected as the existing situation results in more environmentally and socially negative impacts. **Table 19** below shows comparison of no development option with the development option at Sh. Noomaraa.

Table 19: Comparison of the no development option with development option

Option	Environmental	Social	Economic
No Project Alternative	Island largely remains in its current form. The island environment may continue to slowly deteriorate due to pollution as a result of waste disposal. It is likely that disposal of waste into sensitive areas will remain largely uncontrolled without being regulated. A lot of 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. However, all negative impacts of the project detailed in **Section 5** can be avoided with the no project alternative.	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 rapid urbanisation.	No significant improvement to the local and regional economy. New job opportunities will not be created Income opportunities missed. Increase in illegal waste disposal.
Project Alternative	Sh Noomaraa		
	The project involves removal of trees and undergrowth from the island. Vegetation clearance will be required for the plot. It will generate waste and GHG and bring irreversible change to existing landscape. This would have negative impacts on the soil and biological environment of the island. However almost all the foreseeable impacts of the project can be mitigated and kept at an acceptable level and the project will not	Increased direct and indirect employment opportunities for the locals as 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 hence pollution of the island will be stopped or controlled.	Enhanced opportunity for locals to start and diversify tourism related services, since a safe and clean island would facilitate and benefit any local tourism venture. Direct contribution to government revenue through taxes and duties. Creation of job opportunities and skilled labour in the region. Development and expansion of agriculture

	result in a loss of a sensitive or critical habitat or species. The project will control and prevent further pollution of the environment, and facilitate utilisation of land area more effectively.	During the operational phase of the project, smell dust and smoke will be emitted from the IWMC.	and fisheries market in in the island. Agriculture is widely practiced in the island. Price and profit from agricultural produce will become more competitive due to availability of compost. Potential to attract foreign currency by selling compost etc. which would develop the national economy. More settlers will be attracted to the island, which would promote the development of local public services and infrastructure.

Hence based on the evaluation the ***no development option*** is ***rejected*** as the existing situation results in more environmentally and socially negative impacts

5 ASSESSING THE LIKELY IMPACTS AND MITIGATION MEASURES

5.1 METHODOLOGY, NATURE AND IDENTIFICATION OF IMPACTS

Various impacts arising from the project such as direct, indirect and cumulative impacts have been identified. The methodology was based on:

a) Scoping meeting with stakeholders;
b) Observations made during the visit of the project island and site
c) Literature review of similar local and other EMPs; and
d) Findings from other similar projects in Maldives and experience of the Consultant.

Impacts on the environment were identified based on their location/attribute, magnitude and duration of the impact. Impacts were assessed based on their significance and categorized as negligible, minor moderate and adverse. A Leopold Matrix was used for this purpose, for both the construction and operation phase.

The Leopold Matrix was developed by Leopold et al. (1971). It is a quantified Matrix which consists of 100 project actions and 88 environmental characteristics, elements and conditions. Relevant environmental characteristics and project actions were used for the impact identification. First of all, all of the relevant activities of the project that may have an impact on the environment was identified and written on the top of the matrix. These were divided for both the implementation and operational phase of the project. The environmental characteristics that may be affected by the project is written at the left side of the matrix.

A slash is placed at the intersection with each item on the side of the matrix if an impact is possible. The upper left corner of each box where an impact is possible, a number from 1 to 10 is written as the *magnitude* of the possible impact. The number 1 represents the least possible impact and the number 10 represents the highest magnitude of the possible impact. No 0's are used in the Leopold Matrix. A + sign is placed before the number if the possible impact is a positive impact. No sign is placed before possible negative impacts. In the bottom right corner of the box, a number from 1 to 10 is written as the *importance* of the possible impact. 1 being the least important and 10 being of the greatest importance. In giving scores, the magnitude and importance of the activities were judged for their short term and long term impacts. The impacts with greater long term impacts were given higher scores compared to the impacts with more short term impacts.

5.2 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 Site Clearance and Earthworks	C5 Construction	C6 Waste Generation	C7 Resource Consumption (Water, Electricity)	Total (Impact Area)
Physical Components	Seawater	-2					-3		-5
		1					4		5
	Ground water	-3			-5	-3	-4	-5	-20
		1			3	4	4	5	17
	Air	-3	-3	-2	-6	-3	-5	-3	-25
		2	3	2	4	3	4	3	21
	Noise	-2		-1	-5	-5	-2		-15
		1		2	3	6	2		14
	Coastal Zone							-1	-1
								1	1
Biological Components	Flora	-2	-1		-6	-2	-5	-3	-19
		2	3		4	2	5	2	18
	Endangered species/protected areas		-2		-3				-5
			2		5				7
	Coral Reef						-1		-1
							1		1
	Fauna		-2		-4	-4	-4		-14
			2		4	3	3		12
Socio-Cultural Component	Aesthetics	-2	-3		-5	-5			-15
		2	3		3	5			13
	Accidents	-1	-7	-2	-5	-5	-2	-1	-23
		1	5	1	7	4	2	1	21
	Landscape				-5	-7			-12
					6	7			13
	Health/Well being	-1	-5	-1	-4	-5	-6		-22
		1	5	2	3	3	6		20
	Local economy	4	4	1	4	7		-2	18
		1	4	2	6	5		2	20
Total (Construction Activity/Risk)		-12	-19	-5	-44	-32	-32	-15	
		12	27	9	48	42	31	14	

5.2.1 Impacts and Mitigation from Construction Phase

5.2.1.1 C1 Worker Influx and Settlement

An estimated 10-15 workers will be required for this project. The influx of workers can have a negative impact to the environment such as damage to vegetation, sensitive areas, and fauna of the island. This can be both intentional and unintentional.

For the duration of the project, the workers related waste output is detailed in **Section 2.3.12**. For this project, worker related impacts can be reduced through the following mitigation measures. 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. Other impacts include the increased use of resources by the workers in the island. This can be mitigated by choosing local developers operating on the island.

In addition to this, when a new group of foreign workers arrive on the island conflicts can arise with the resident population in the instances where local culture is overlooked or not respected.

Mitigation for impacts on flora and fauna

- The developer is required to keep the workforce as minimum as possible, and to not bring in any surplus workers for the project;
- House rules shall be formulated by the developer and workers shall be oriented on the rules and conduct during the project works;
- Workers shall be given instructions on the sensitive and protected areas of the island;
- 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

- Encourage choosing of local workers to reduce increased demand of resources.

Mitigation for sociocultural impacts

- Hire local workers where possible;
- Orient foreign workers on communication, personal hygiene and sanitation in addition to the prevention of STDs and other infectious diseases; and
- Ensure all foreign workers have their legal permits.

5.2.1.2 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 . Reduction of the transportation distance from the source to the project island is proposed. As the resource sourcing hierarchy in **Figure 20** shows, the greatest importance shall be placed on sourcing

any available materials from within the island, with the next option being from within the north region, from islands such as HDh. Kulhudhuffushi. 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 developer procure the material from a neighbouring country.

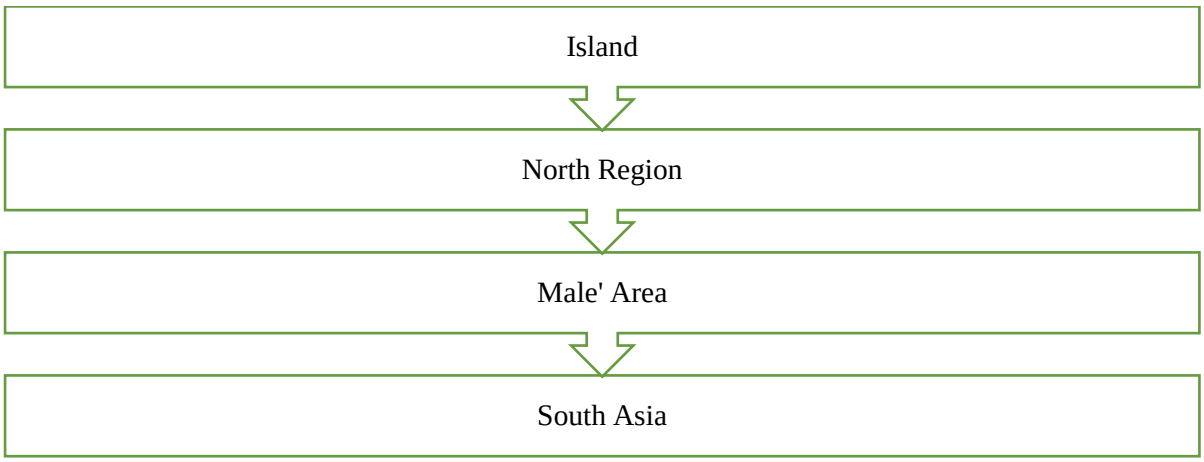

Figure 20: Material sourcing hierarchy proposed for the project

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 developer 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 CO2 emissions result. Therefore for this project, an estimated 100.1 kg of CO2 emissions are expected for the concrete casted. 3136 kg of indirect CO2 emissions (Defra / DECC, 2012) occur per tonne of PVC pipe produced. For this project, the amount of indirect CO2 emissions are estimated at 164.8 kg. The greatest indirect CO2 emissions are estimated from the usage of reinforcing steel. 1.5 tonnes of reinforcing steel are estimated to be used for this project, which can cause a release of indirect CO2 emissions of 5311 kg (Ma et al, 2016). Due to the small scale of the construction, the estimated indirect CO2 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 21: 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.

Although, for the purpose of land clearance and uprooting of trees, a hydraulic excavator of 20 tonnes will be used (in cases where trees can be removed for replanting). The movement of the excavator through the roads of the island can incur damage to the roads as stated above. It should be noted that the movement of the excavator will not occur frequently through the public roads.

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 20**. 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 developer 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;
- The developer shall use serviced vehicles and plant equipment for the project;
- The developer shall only use the needed amount of vehicles and plant for project; and
- The 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 developer 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 developer.
- 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

- The vehicle drivers shall be licensed and competent;
- The loads being transferred shall be fully secured; and
- The transportation shall be done during day time.

Mitigation for marine and terrestrial pollution

- The developer shall clean any littering on the terrestrial or marine environment caused during transportation;
- The developer shall enforce strict policy against littering and appropriate penalties; and
- Spill kits shall be made available in cases of spillage of hazardous wastes, and hazardous waste storage shall be provided.

5.2.1.3 C3 Site Demarcation & Fencing

Site demarcation and preparation involves, surveying all the trees within the footprint of the plot and identifying trees that needs to be removed or relocated as described in **Section 2.3.3**. Vegetation surveys shall be done in detail (**Section 2.3.3)**. This activity is considered to have minor environmental impacts as it is largely noninvasive.

However, improper or inaccurate demarcation and labelling could result in removal of untargeted trees which could result in having to remove more number of trees than that are required. Incorrect labelling of the trees may lead to increased waste generation and reduced number of trees that can be salvaged. In areas with thick undergrowth may cause bodily harm if proper protective clothing is not used. Trimming undergrowth to access vegetated areas and use of spray paint during demarcation could have a slight negative impact on the biological environment and health of workers.

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 and labelling of trees;
- accurate and reliable equipment shall be used to minimize errors;
- ensuring proper labelling according to how they will be used following uprooting. Example labelling method proposed is described in **Section 2.3.4.1;**

- hazardous waste used during site demarcation and fencing such as empty spray paint containers shall not be discarded haphazardly. These will have to be managed as per the **Section 2.3.12**.
- wearing, clothes/helmets to protect against thorns and freefalling coconuts and wearing protective clothing;
- carrying out the works during the day time; and
- ensure mosquito repellants are available for the workers;

5.2.1.4 C4 Site Clearing and Earthworks

Trees will be removed using an excavator, which will be used to gently uproot the tree from its base (See **Section 2.3.4** for details of tree removal method). Two scenarios have been proposed in the report for the management of trees the baseline scenario where all trees are removed and the preferred scenario where majority of trees are relocated. Since scope of land clearance falls under the island council, preferred method of removing trees is to procure a bidder who buys and relocates trees (See **Section 2.3.4.1** for details). This method is proposed to address challenges of budget and resource availability for the island council.

Land clearance will also involve removal of undergrowth which will be stockpiled and burned. Trees that require removal shall be labeled and identified during the site demarcation.

It is estimated that 31 trees will be removed from the island in order to clear the IWMC plot under the baseline scenario where no actions are taken to mitigate or salvage trees falling onto the direct footprint area of IWMC plot.

The environmental impacts to the island resulting from the removal of trees can include, damage and death of trees. Loss of trees can directly affect the nests and nesting birds on such trees and destroy habitats for invertebrates that live on trees. Tree removal can alter the visual landscape of the island. Trees provide numerous eco-system services. They help reduce, storm water runoff, wind penetration and air pollution. Trees, prevent and reduce soil erosion which is one of the major issues currently faced by Maldivian islands. Trees maintain groundwater quality, and keeps the land fertile. Removal of trees, could increase surface salinity of groundwater. They are a habitat for animals and act as a food source. They enrich soil nutrient, facilitating growth of different types of trees. Maldivian soils are generally weak in nutrient. The typical concentration of total nitrogen in soil samples tested in Maldivian islands hovered at 1140 mg/kg (ALS Scandanavia AB, 2015)[1]. Nitrogen content decreased rapidly, at the bottom soil layer where, concentration hovered at 209 mg/kg. Hence removal of trees would reduce the thickness of organic topsoil. Addition of fill material which usually consists of coralline sand and rubble to cover root bulb cavities and use of fill material to level the road would further deplete the organic top soil and interfere with the natural bioturbation of the soil. Since the root systems of coconut palm trees are embedded deep into the ground, removal of the root system may expose the groundwater below, which will be sensitive to pollution (Meerow & Broschat, 2003).

Forests and tree plantation crops are particularly important as carbon reservoirs because trees hold much more carbon per unit area than other types of vegetation (Lasco et al., 2002; Lamade & Bouillet, 2005). Coconut, being a perennial tree crop with 50-60 years of economic lifespan, has a potential to act as a carbon sink (Jayasekara & Jayasekara, 1995); (Ranasinghe & Silva, Photosynthetic assimilation, carbohydrates in vegetative organs and carbon removal in nut-producing and sap-producing coconut palms, 2007) and their potential to sequester carbon and the net carbon exchange rates were found to be in the range of 0.4 –1.9 Mg C ha^{-1} $month^{-1}$ (Ranasinghe & Thimothias, Estimation of carbon sequestration potential in coconut plantations under different agro-ecological regions and land suitability classes, 2012). In this regard, removing mature trees imply reducing the potential of the island's vegetation to act as a carbon sink.

[1] Source: Soil chemical analysis for R.Vandhoo, Lab report: T1633252

Palm trees hold cultural and economic value. Coconut palm tree is a national symbol which is integrated to the national identity. All parts of the coconut palm tree are utilised in the Maldives. They provide wood for construction, leaves for shelter and fruits as food and fibre for rope making.

The method proposed to remove trees has inherent risks which may result in accidents. If trees are not removed with precaution they may potentially damage adjacent plants/equipment/people. Secondary impacts of the activity include air pollution and propensity for accidents as a large excavator will be used to remove trees. Health implication are also prominent as there is a risk of falling trees/coconuts and accidents due to electric saws which will be used to separate the crown and root.

Due to the significantly important services provided by the trees, removal of trees is considered to have a negative impact on environmental receptors. Land clearance is singled out have the greatest negative impact on environmental receptors due to the project.

The project will however not result in a loss of protected species or have an effect on threatened or rare plant species. Since most of the native and migratory birds in the Maldives are protected removal of trees may affect bird nests and juveniles that may be associated with a tree that are required for felling. Although removal of trees and associated activities are considered to have the highest degree of negative impacts of all the activities that are planned under the proposed project, most of these can be avoided and reduced to an acceptable level through appropriate mitigation measures proposed in the report. Since the most significant impact of the project is expected from the removal of trees, all necessary measures shall be in place to minimise the number of trees that are removed and to salvage as many trees as possible by making arrangements to relocate them.

Mitigation Measures:

Measures to Reduce Number of Trees Targeted for Removal

- During the initial set out survey, mark the limits of the plot as accurately as possible to avoid damaging or removing trees not intersecting with the plot.

Measures to Salvage as Many Trees as Possible

- A thorough tree survey shall be carried out to ensure only those trees that are absolutely required for uprooting is removed from the island;
- each tree falling on the footprint shall be labelled as per the code given in **Section 2.3.3** and recorded;
- once the trees have been identified and marked as requiring removal, all trees suitable for re-location shall be identified. Relocation of trees shall be prioritised as illustrated in **Figure 22.**

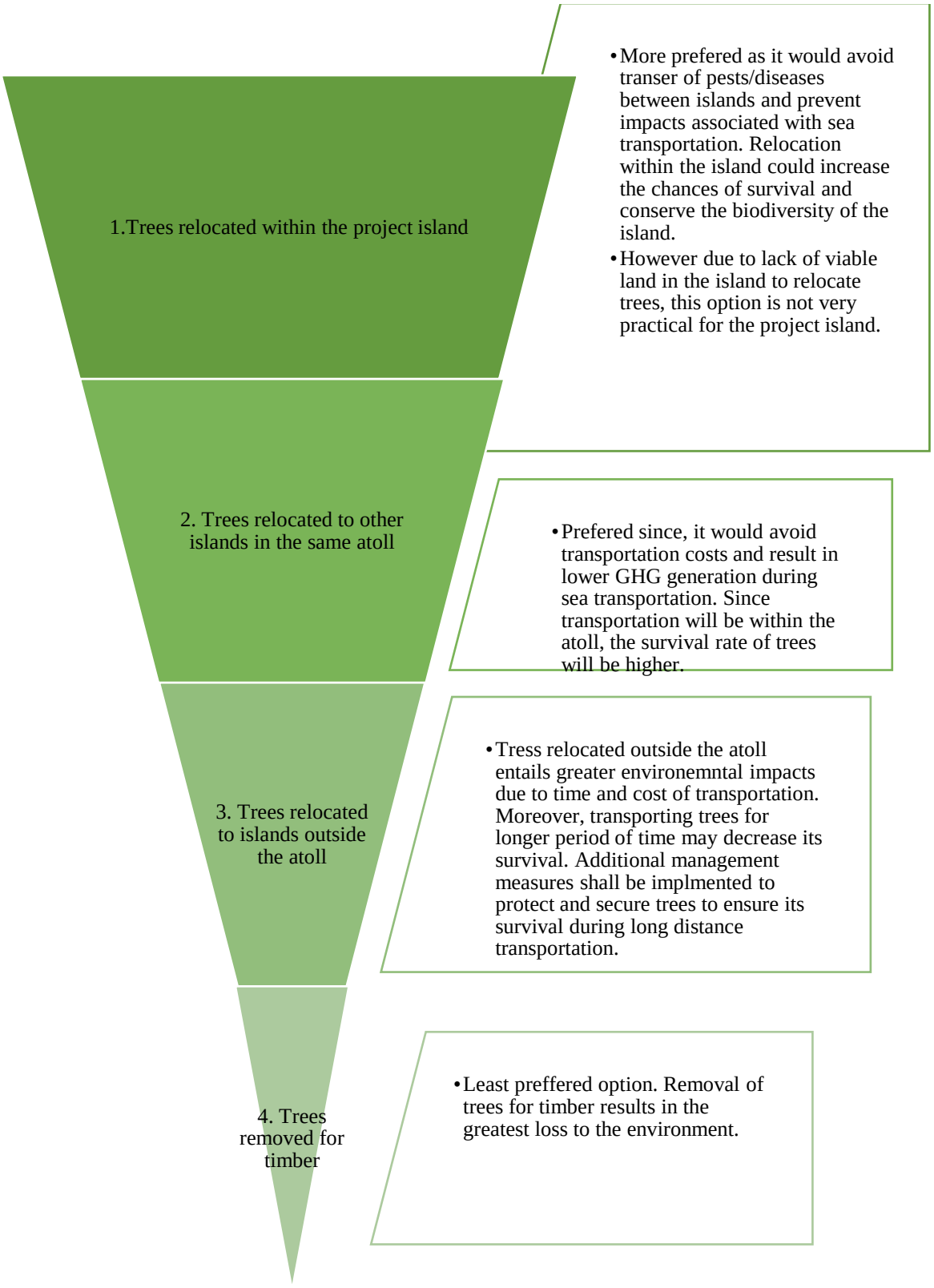

Figure 22: Preferred steps of relocation and removal of trees

- Since relocation of trees is expensive and costly, the report recommends to procure potential buyers who will undertake removal of trees by themselves as described in this report (See **Section 2.3.4.1** All measures proposed in **Section 2.3.4.1** shall be followed by the buyers and council to mitigate and prevent impacts associated with land clearance and most importantly to

successfully complete land clearance. MEE shall provide assistance and support to the island councils as described in the report;

- establish a good coordination arrangement with the potential buyers of trees identified for relocation, to minimise the transfer time and to enhance tree survival;
- strict supervision shall be in place during the tree removal works to ensure only the intended trees are removed;
- method prescribed for removing the tree in **Section 2.3.4** shall be followed;
- method prescribed for replanting trees in **Figure 8** shall be followed; and
- all records of trees removed and their end use shall be kept and monitored.

Measures to Minimise Social Impacts

- Social impacts shall be mitigated by following the steps illustrated in **Figure 23.**

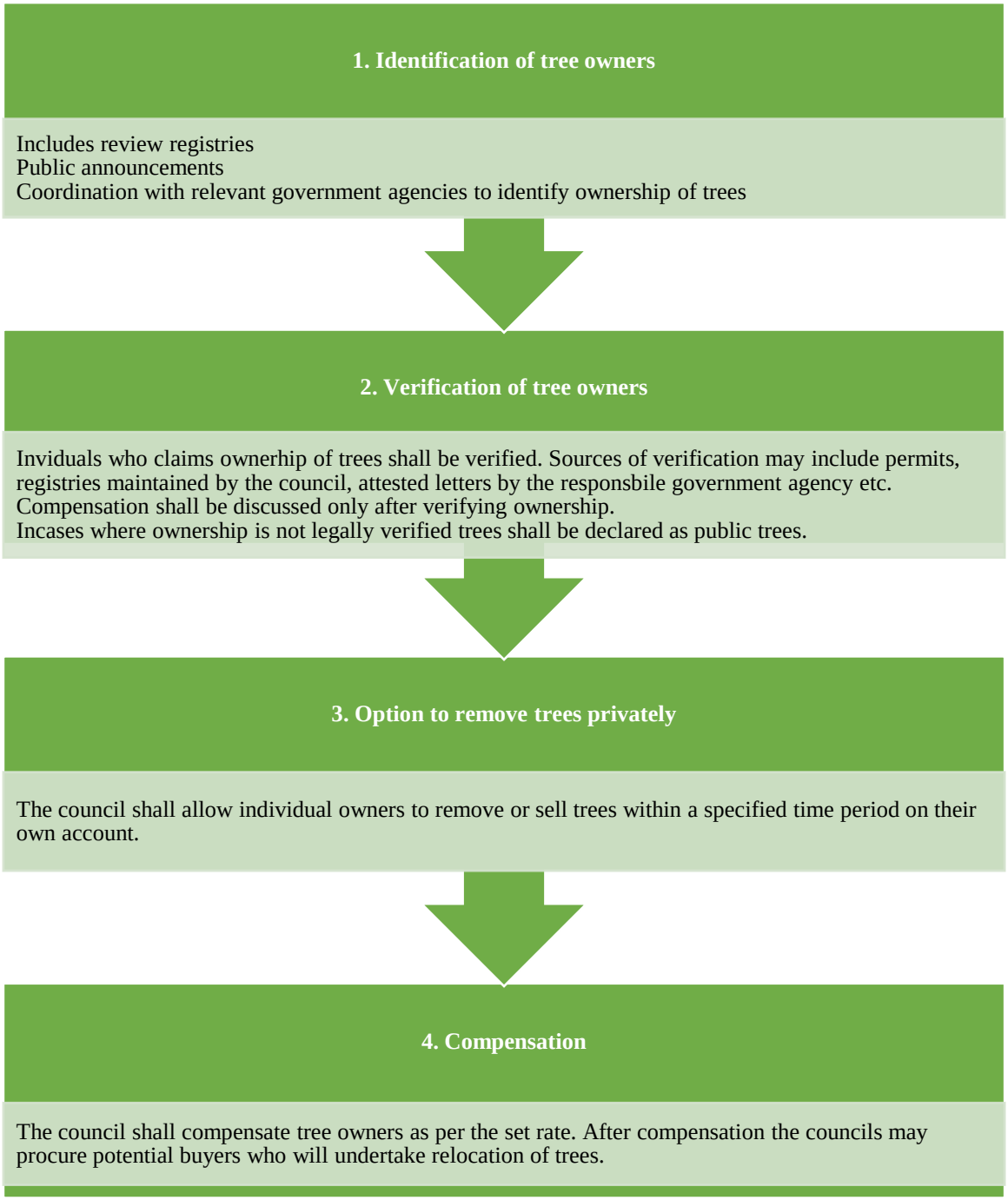

Figure 23: Social impact mitigation measures

Measures to Minimise Impacts to the Soil and Groundwater

- Fill the root bulb cavity as soon as possible to prevent spills and contamination of groundwater (As described in **Section 2.3.4**);
- plastics, non-biodegradable wastes shall not be used in backfilling of the hole created by uprooting of trees;
- when removing trees it is important to follow steps described in **Section 2.3.4** to minimise impacts on soil and groundwater;

- Ensure that root bulb cavities are filled with sand or root bulbs if trees are removed for timber The sand shall be responsibly sourced by respective buyers of the trees. Sand shall not be mined from the lagoon or the island; and
- After removal of trees the ground shall be levelled and compacted.

Minimising Impacts to Untargeted Species

- In cases where bird nests are strongly believed to have existed on a tree that is targeted for removal, efforts shall be made to remove the nests carefully and relocate them to safer tree before the tree is knocked down.

Minimising Impacts of Vehicular Emission during Site Clearance

- Vehicles should be serviced and maintained regularly to avoid delays and emission of harmful gases;
- machines should be switched off when not in use; and
- idle time shall be decreased; fuel minimization should be practiced by reducing use of electricity during day time.

Measures to Minimise Accidents and Injuries to Workers

- Work shall be carried out only during fair weather. Work shall be terminated and employees moved to a place of safety when environmental conditions such as but not limited to high winds, heavy rain, and darkness that may endanger employees in the performance of their jobs;
- hard hats, eye protection, hearing protection, and foot protection shall be used by the workers during work times. Equipment operators should wear seat belts. Wear high visibility clothing as well;
- overhead hazards can cause injuries and therefore all workers should practice "heads up" to avoid possible hazards;
- inspect all machineries and equipment before use. Establish a regular, preventative maintenance program on all equipment; and
- all safety measures given **Section 5.2** shall be applied during construction phase.

Measures to Minimise Aesthetic Impacts

- Limiting the number of trees removed to bare minimum by carefully surveying the project area.
- re-planting as many trees as possible by relocation as recommended in the report.

Measures to Minimise Impacts of Carbon Balance

By designing the project as described in **Section 2.3.4** almost all of the coconut trees removed can be relocated, which could potentially neutralise the net loss of carbon balance. Hence the most logical mitigation strategy would be to compensate for trees removed and relocate trees. For trees that cannot not be re-planted it is recommended to plant six new trees in the island. MEE shall commission and facilitate planting coconut palm trees as stated in the report.

5.2.1.5 C5 Construction

Material Storage

This includes, storing all the vehicles, machineries, and tools required for the land clearance and IWMC construction. Due to the nature of the project, a lot of construction materials are not required. Apart from the vehicles and tools, fuel and water will be required for storage. Fuel will be stored on the cleared land in tanks. Vehicles will be stored inside the fenced plot area. Tools and equipment will be stored in the tool shed within the fenced land plot. The project does not require land clearance or construction of extra building for material storage, hence the impacts arising from this activity is considered to be

minimal. However, there is a risk of accidents, such as fires, oil spills and trespassing. These could be easily mitigated by implementing appropriate measures.

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, due to the distance provided between the residential areas and the project site.

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 21: 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 66 dBA at the nearest residential area. This is expected to further decrease taking into consideration the vegetation surrounding the proposed site.

Noise during construction is determined to be a short term negative impact. Due to the distance of the project site and the surrounding vegetation, 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.

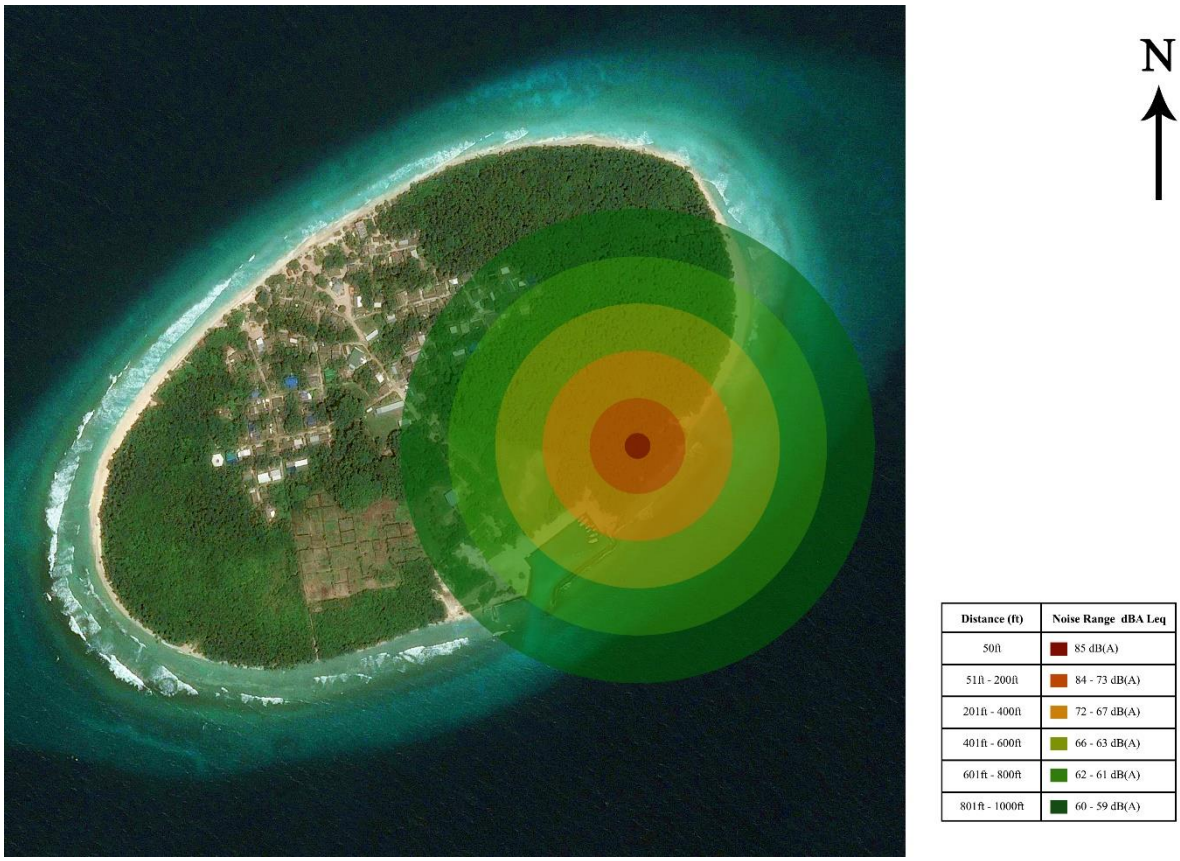

Figure 24: Noise range map for Sh. Noomaraa

Impact on vegetation

The impact and measures on vegetation have been discussed in **Section 5.2.1.4.** No other structures, temporary, or permanent are proposed to be built for this project (such as workers' camp).

Accidents and injuries

Accidents and risks (hazards) are important elements that need to be properly assessed, identified and analysed for what could happen if a hazard or accident occurs during and post development of the project. There could be many risks (hazards) and accidents to consider associated with many possible scenarios that could unfold depending on time, magnitude and the location it occurs. Hazards during construction 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 trenches and seriously injuring themselves.
- Being struck by moving equipment and vehicles.

Mitigation for material storage impacts

- 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 Liquid Petroleum Gas (LPG) bottles and cleaning solvents and chemicals will be closed off from public access. Fire extinguishers and instruction in case of fire will be located in all the public, industrial and staff accommodation areas;
- portable extinguishers placed to be readily available when someone finds a fire;
- closed off non-public storage areas will be provided for inflammable goods (fuel drums, portable fuel containers, LP gas bottles, cleaning solvents etc.) with NO SMOKING, NO NAKED LIGHTS, HIGHLY FLAMMABLE sign boards in both English and Dhivehi languages;
- 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.

Mitigation for terrestrial pollution

- Set up a temporary waste disposal area within the project site;
- Regularly collect litter and dispose at the temporary waste disposal area;
- Hazardous waste shall be placed in enclosed containers;
- Vehicle maintenance shall be carried out on paved areas; and
- After the construction works are completed, transfer all collected waste to nearest waste management facility

Mitigation for noise and vibration impacts

- Provide workers with noise cancelling headphones.
- Use quieted equipment where possible, such as mufflers on engines;
- Use of well serviced vehicles and plant; and
- Switching off equipment and vehicles when not in use.

Mitigation for impact on vegetation

- Setting out survey shall be done by the developer and the site limits shall be demarcated prior to any construction or clearing works;
- Fence off the site in order to avoid the removal of any vegetation out of bounds of the project site; and
- Allocate temporary stockpile area within the site, which is free from vegetation

Mitigation for accidents and injuries

- The developer shall be required to develop occupational safety management plan, and safety guidelines shall be displayed in the work site at all times;
- Occupational safety training should be given to all workers present on site;
- Workers should be provided Personal Protective Equipment and the use of PPE shall be enforced;
- Site visitors 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
- Securing any loads on vehicles during transportation.

5.2.1.6 C6 Waste Generation

Solid waste generated during land clearance and IWMC construction work would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite. Waste burned onsite would generate smoke, possibly impacting negatively on ambient air quality and human health. On the other hand, if all site clearance waste is to be transported this would also result in requiring burning fossil fuels and would require significant finance. 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 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 and solvents. 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 2.3.12** of the report;
- open defecation whether it's on land or on the beach shall be prohibited;
- waste other than sewage shall not be flushed down the toilet;
- 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.

5.2.1.7 C7 Resource Use

During the construction phase, machineries and vehicles used will consume fuel. Notable impacts of this activity include, increased air pollution, risk of spillage, impacts to health/wellbeing and accidents. The primary pollutants generated due to power production from diesel based generator system include Nitrogen oxides (NO_X), Sulphur dioxide (SO_2), Carbon monoxide (CO), Hydrocarbons/ Polycyclic

Aromatic Hydrocarbons (HC/PAH), Particles (PA) and Carbon dioxide (CO_2) in the form of emission although the exact amount is difficult to quantify.

The visible pollution generated by burning diesel contains elemental carbon as soot. The typical odour comes from polycyclic aromatic hydrocarbons, which also are cancer causing components.

Due to the scale of these activities, the machineries won't be used for long periods of time. This would significantly reduce the impact of electricity generation. IWMC construction stage as well as land clearance stage will not use heavy vehicles and equipment extensively.

Water used during construction will be sourced by the developer from available groundwater wells. Water used for drinking and cooking will be purchased from local shops or collected from existing rainwater tanks or from the groundwater well in the island. Water and electricity consumption for the project is considered to be minor.

Mitigation

- Initiate rainwater collection and storage as early as possible into the project construction;
- turn off the tap while washing your hands;
- use salt water to wash dishes and only use rainwater to rinse them;
- water conservation devices shall be used;
- use well maintained, energy efficient equipment. The emission of carbon dioxide is directly related to the amount of fuel used. High efficiency is therefore important to reduce the amount of released carbon dioxide and consequently to reduce the global greenhouse effect;
- reduce idle time of machineries and vehicles. Switch them off after use;
- utilize day time hours for the construction when plenty of light is available; and
- FENAKA power supply will be used for electricity generating purposes.

Table 22: Impact identification matrix for operational phase

	Envisaged impact factors	O1 Waste collection and transportation	O2 Waste sorting, separating, storing and compost making	O3 Waste Generation	O4 Resource consumption (water/electricity)	Total (Impact Area)
Physical Components	Seawater	4				4
		4				4
	Ground water	5	-2	-1		0
		3	2	5		12
	Air	-3	-2	-2	-3	-13
		5	3	2	4	16
	Noise	-3	-1			-4
		4	2			6
	Coastal Zone					0
						0
Biological Components	Flora	6	7	-1	-3	4
		2	6	1	4	18
	Fauna	5	5	-1	-3	3
		5	5	1	4	19
Socio-Cultural Component	Aesthetics	6	8			9
		6	6			17
	Accidents	-4	-4		-4	-18
		4	4		5	19
	Landscape	5	6	-1		5
		6	5	2		18
	Health/Well being	5	-5	-2	-6	-10
		6	5	2	8	23
	Cultural heritage					0
						0
	Local economy	-3	8	-2	-1	5
		9	2	4	1	19
Total (operational Phase Activity/Risk)		23	20	-10	-20	
		54	40	17	26	

5.2.2 Impacts and Mitigation from Operational Phase

5.2.2.1 O1 Waste Collection and Transportation

As stated in this report, currently Sh. Noomaraa has 3 areas that are used for dumping and burning waste regularly. However, public disposing of waste in various locations of the island, including the beaches and the periphery of the residential areas is a common practice. These practices have resulted in the spread of diseases in the island. Wide spread terrestrial pollution at the island is directly linked to the uncontrolled mosquito population. The practice of burning waste at various locations of the island leads to respiratory issues from the inhalation of smoke. The successful implementation of the IWMC and the Waste Management Plan will lead to the reduction of the littering and burning of waste throughout the island. This will lead to the improved health and psychological well-being of the residents and visitors of Noomaraa. It has been identified as a long term positive impact on the residents and visitors of Noomaraa.

A vehicle is expected to be used to collect and transport the waste within the island daily, at a set schedule. This is identified as a minor impact in terms of noise, due to the fact that multiple vehicles are not used, and no receptor will be exposed to the noise for long durations of time.

Waste Collection and Transportation is identified to have a positive impact on the island.

Measures to ensure and enhance the positive impacts

- The Island Council shall formulate a Waste Management Plan and obtain the approval of the EPA;
- Until a WMP is formulated and approved, the intermediary waste management steps prescribed in **Section 1.7.1** shall be followed;
- The Island Council shall formulate and gazette the Waste Management Regulation and Waste Management Guidelines for the island;
- The aforementioned regulation and guidelines shall state the penalties on persons that do not act according to the regulation and guidelines (i.e. littering, burning and dumping of wastes elsewhere), and Island Council shall enforce the penalties as prescribed;
- The Proponent and Island Council shall follow the management plan provided with the EMP 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;
- The Proponent shall review the waste management operations within the island regularly and update the National Waste Database;
- The operations shall be awarded to a developer with the capacity to run the IWMC;
- The 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;
- Polluter pays principle established in order to reduce the waste generation within the island;
- The Proponent shall provide resources in terms of budgetary allocations, required equipment, and technical expertise to ensure the operation of the IWMC; and
- The 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; and

- The status of the vehicle shall conform to the Waste Management Regulations 2013/R-58 and provide cover to the waste being transported in order to avoid littering.

Mitigation for accidents and injuries

- The vehicle should be driven by licensed drivers; and
- A strict schedule shall be stated in the WMP and followed in order to reduce the transportation frequency thus reducing the probability of accidents.

Mitigation for air quality impacts

- Spray the roads with water during the dry season to suppress dust;
- 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 Waste Management Plan;

5.2.2.2 O2 Waste Management Activities

Waste sorting, separating storing and composting make up the largest portion of the IWM concept. On top of reducing the volume of waste, these activities, convert waste to re-sable and value added products. 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. Hazardous chemicals that get into the soil (contaminants) can harm plants when they take up the contamination through their roots. If humans eat plants and animals that have been in contact with such polluted soils, there can be negative impact on their health.

All these impacts can be mitigated and prevented by the proposed IWM concept. 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. More so considering that IWMC is equipped to handle only about 20-30% of organic waste generated in the island. 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 550m 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 23: 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 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. The composting capacity of the IWMC is expected to be two windrows of approximately 39 m^3, each batch to take around 4 – 6 months to mature. 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 Section.

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. 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 from composting

The main gas by product from the composting is CO2. In anaerobic conditions, methane is released into the atmosphere, which has a higher greenhouse warming potential compared to CO2. 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 CO2 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 24: Odours generated from the composting process (Source: Goldstein (2002)

Compound	Description of smell	Detection limit for a particular odour panel ($\mu g/m^3$)
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 280 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 24** can be used for this purpose too. The map shows that the noise reduces to a maximum level of 66 dBA near the residential areas. This calculation does not take into account the dampening effects of the surrounding vegetation. 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 developer 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 280 m is available between the IWMC and the nearest residential area, which can act as a buffer zone, it is expected that bio aerosol concentrations will reduce to background level at the stated distance;
- The site is located in such a way that winds from both monsoons blows the airborne particles from the IWMC away from the residential zone;
- Ponding will be minimized at the site by grading of the ground;
- Handling of compost will be minimized;
- Compost turning will be done based on temperatures and not on schedules;
- Add moisture to the compost to minimize dust;
- Add a geofabric cover over the compost windrow to minimize release of bio aerosols;
- Workers will follow the workplace safety mechanisms and guidelines set by the developer 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.

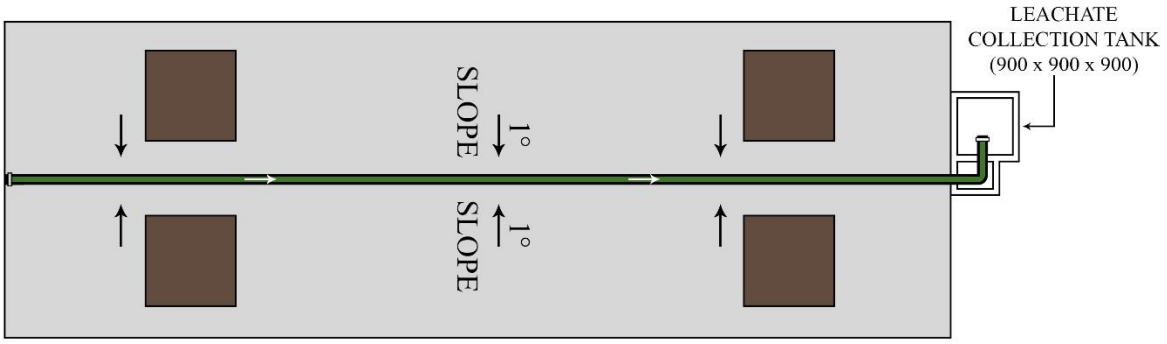

Figure 25: Compost slab design and leachate collection system (Plan view)

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 (see **Figure 25**). 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.

- There is a valve placed at the inlet pipe which can be closed in instances where the leachate tank may overflow from heavy rainfall onto the compost slab;
- The 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;
- A 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 26: 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 less than 1.5 month's organic waste produced in the island. As the composting process may take between 4 – 6 months (Halliburton, 2002), the remaining months' organic wastes can accumulate unmanaged and without any means of storage.

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, without any cover. As per the area of the IWMC, there is a capacity to arrange up to 25 nos. 660 L wheelie bins 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.

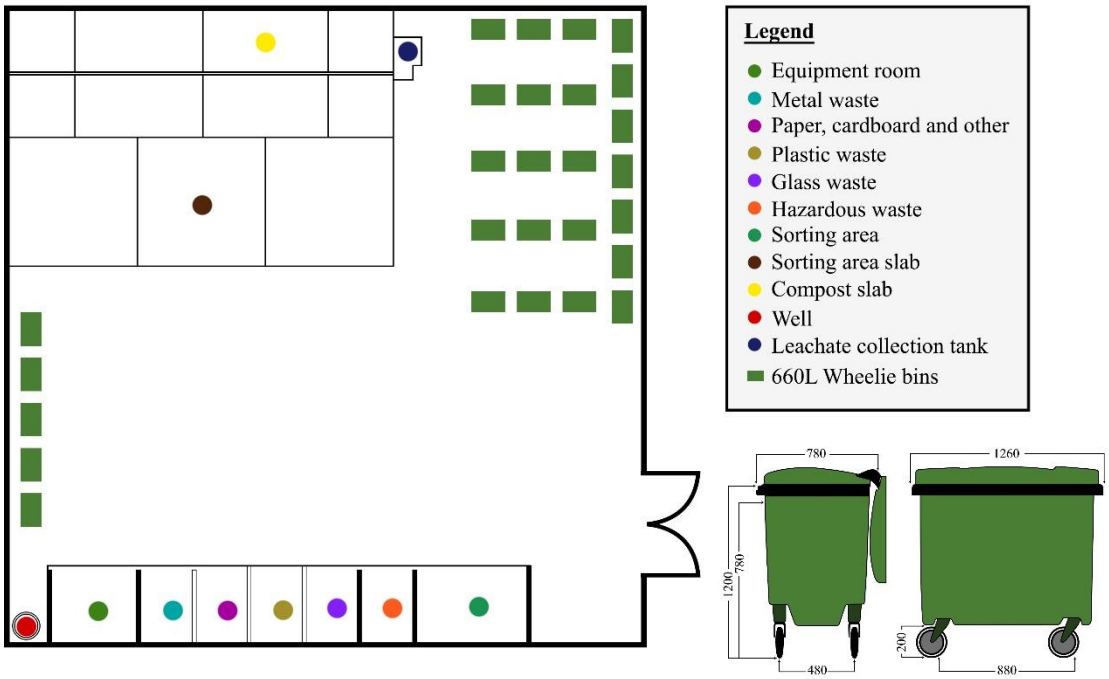

Figure 27: Proposed wheelie bin arrangement to provide for temporary storage of unmanaged organics

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. 660L wheelie 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 a 2.8 m high 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;
- 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 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; and
- Workers shall be trained to use the firefighting equipment and able to manage fire outbreaks.
- 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.

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 and instructions to employees on how to operate any machinery;
- Instruct employees on safe systems of work;
- 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 28: 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 25: 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

5.2.2.3 O3 Waste Generation

Waste generated during the operational phase of the IWMC will be relatively low. These will include waste oil/batteries for waste management equipment. 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.

Mitigation Measures

- Closed containers shall be provided to manage hazardous wastes;
- Spill kits shall be provided to manage oil spills; and
- Prohibit eating/cooking in the IWMC.

5.2.2.4 O4 Resource Consumption

Water will mainly be required for washing equipment, work ware, hands etc. and to water the compost pile. Water required for moistening compost piles 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 empties, therefore resulting in lower transportation costs. Compactors and crushers 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

- 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 26: Impacts and proposed mitigation measures for the construction and operational phase of the project

No	Potential Risk/Impact	Receptor	Nature	Reversibility	Significance	Mitigation	Cost
	Description	**Description**	**Positive**	**Reversible**	**Major Negative**	**Description**	**USD**
					Major Positive		
			Negative		**Moderate**		
				Irreversible	**Minor**		
CONSTRUCTION PHASE (C)							
C1	Impacts from worker influx and settlement (flora and fauna, resource use and sociocultural impacts)	People of Noomaraa, and terrestrial and marine environment	negative	Reversible	**Minor**	• **See Section 5.2.1.1**	Included in the construction costs.
C2	Impacts from transportation of materials. (climate impacts, and impacts on roads)	Residents of Noomaraa, terrestrial and marine environment, global environment	negative	Reversible	**Minor**	• **See Section 5.2.1.2**	Included in the construction costs.
C3	Impacts from site demarcation and fencing (Impacts on flora and fauna)	Local flora and fauna	Negative	reversible	**Minor**	• **See Section 05.2.1.3**	Included in the construction costs.
C4	Impacts from site clearing and earthworks (terrestrial pollution, vegetation removal)	Vegetation of the site and surrounding areas	Negative	Reversible	**Major**	• **See Section 5.2.1.4**	Included in the construction costs.
C5	Impacts from construction works (vegetation impacts, noise and vibration,	Workers and residents of Noomaraa	Negative	Reversible	**Moderate**	• **See Section 05.2.1.5**	Included in the construction costs

	accidents and injuries, pollution from material storage)						
C6	Terrestrial pollution from construction waste generation	Residents of Noomaraa, ecosystem	Negative	Reversible	**Moderate**	• **See Section 5.2.1.6**	Included in the construction costs
C7	Impacts from resource use	Residents of Noomaraa, ecosystem	Negative	Reversible	**Minor**	• **See Section 5.2.1.7**	Included in the construction costs
OPERATIONAL PHASE							
O1	Waste collection and transportation (Climate impacts, air quality, amenity impacts)	Residents and visitors to Noomaraa	Positive	Reversible	**Minor**	• **See Section 05.2.2.1**	Cost borne by IWMC occupier
O2	Waste management activities (Public health, noise, groundwater, fire, accidents, odour impacts)	Mostly IWMC workers, residents and visitors to Noomaraa,	Positive	Reversible	**Minor**	• **See Section 5.2.2.2**	Cost borne by IWMC occupier
O3	Waste generation (terrestrial pollution, groundwater contamination)	Residents and visitors to Noomaraa	Negative	Reversible	**Minor**	• **See Section 5.2.2.3**	Cost borne by IWMC occupier
O4	Resource consumption (water and electricity)	Residents and visitors to Noomaraa	Negative	Reversible	**Minor**	• **See Section 5.2.2.4**	Cost borne by IWMC occupier

6 IMPLEMENTING THE ENVIRONMENTAL MANAGEMENT PLAN

6.1 SCOPE

The 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 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.

a) Environmental Management Planning and establishment of key performance indicators: The EMP 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 EMP;
c) Monitoring and corrective action: The implementation of EMP measures will be monitored during operational stage and will be reported. Any inconsistencies between the EMP and its on-site implementation will be identified and addressed through corrective actions; and
d) Auditing, reviews and enhancement: The EMP will be reviewed. Improvements to the EMP 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. The scope of land clearance falls within the responsibility of the Island Council. 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.

6.3.2 The Contractor

Contractors to construct the IWMC and clear land will be procured by MEE and Island Council respectively. The contractor will undertake the project in accordance with the EMP 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.

6.3.3 Environmental Consultant

The environmental consultant would prepare the EMP 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 EMP during any stages of the project, the consultant would do the modification and would conduct the environmental monitoring according to the monitoring framework. The environmental consultants are also responsible for auditing the management/monitoring plan to identify gaps, limitation in management and propose remedial measures to ensure the project is sustainable.

6.3.4 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.

6.3.5 Island Council

During the construction phase, the Island Council is responsible in land clearance works. In addition, the Island Council will be responsible for the following:

- Formulation and implementation of the Waste Management Plan (WMP) for a period of 5 years. Sh. Noomaraa currently does not have a WMP at the time of visit;
- Formulation and gazetting of Waste Management Regulations for the island;
- Formulation and gazetting of Waste Management Guidelines for the island;
- Plays a role in the site selection in collaboration with other responsible parties; 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.

6.3.6 IWMC Occupier

The IWMC occupier will be responsible in running the operations in accordance with the guidelines set by this EMP and the approved WMP of Noomaraa 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 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 EMP. 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 5.2.2.2**, 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 27:Details of environmental 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 EMP. 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
Documenting non-conformances and corrective actions	Construction Operation	Non-conformances to the environmental regulations, permits and the EMP is monitored and documented. Corrective measures are taken and follow ups are done. IWMC operations reports and public grievances are compiled by the island council and reported to the Proponent within the prescribed frequencies as stated in **Table 31**	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

6.6 ENVIRONMENTAL MONITORING PLAN

Table 28: 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[2]
Minimize vegetation removal	Tree survey & set out survey	Vegetation falling within the footprint of plot. Set out survey shall be carried out as described in **Section 2.3.4.1**	At project site (land)	Vegetation and set out survey.	Once	Contractor	Survey report. The report shall contain the exact number of trees identified to be relocated and removed as timber should be identified. The survey report shall provide a justification for removal of a tree as timber.	45,000	C

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

Ensuring that the project activities does not affect the quality of the groundwater	Establish baseline just before the construction works begin and continue monitoring as stated. Establish a groundwater monitoring stations and geo-reference it. Preferably close to the IWMC.	Groundwater quality for electrical. conductivity, salinity, temperature, DO, BOD_5, Nitrates, phosphates, Turbidity, pH, hydrocarbon, total coliform and faecal coliform	**Project site**	Potable water quality testing equipment and/ or by sending samples to the lab	Baseline data before work begins. During Operational Phase. Bi annually	Proponent and environmental consultant	Water quality report	12,000 per monitoring trip	O

Ensure waste generated at work site is audited and managed responsibly	Management of waste generated as described in **Section 2.3.12** 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

Ensuring survival of relocated and re-planted trees.	It is important to ensure the survival of relocated trees after investing heavily in its relocation.	The parameters for monitoring include: 1. Nitrogen Deficiency 2. Phosphorous Deficiency 3. Boron Deficiency 4. Manganese Deficiency 5. Water Deficiency 6. Pests and Diseases	**Re-planted and relocated island**	Based on visual assessments and chemical tests	Monitoring shall be undertaken for a period of 4 years, annually.	Environmental consultant	Monitoring reports which shall include diagnosis, remedial measures and observations after remediation.	Approximately MVR 100,000.00	O

Monitoring Health and safety of workers and the public	Accidents during construction of IWMC, land clearance, 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) land clearance 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

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 EMP with their responsible organisation and person, planning, methodology, timing and other relevant aspects.
An independent registered environmental consultant shall be hired and contacted to undertake and audit the monitoring program prescribed in this report. Following each monitoring visit the consultant 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 28 highlights the monitoring plan in which responsibilities of main stakeholders has been assigned. In order to track and compile the findings of these measures an independent environmental consultant shall be tasked to audit the projects EMP. This is to

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

Monitoring frequency for various individual components **Table 28** shall be followed by all responsible parties. **Table 29** gives indicative timeline for the monitoring visits by third party consultant.

Table 29: Monitoring visit schedule

Visit	Indicative timeline	Indicative parameters to monitor	Reporting	Cost (MVR)/per report/island.
Visit 1	During land clearance	Setting out survey, work method, waste management monitoring and monitor health and safety of workers. Review reports by contractors and Proponent.	Submit monitoring summary report 1 to Proponent (Island Council) within 2 weeks	10,000.00
Visit 2	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	10,000.00

Visit 3	One year after relocation/replantation of trees. Annually for four years.	Monitor relocated and replanted trees according to **Table 28**	Submit summary report 3 (1-4.) Proponent within 2 weeks	30,000.00
Visit 4	Two months into operation of the IWMC. Biannually for four years	Monitor water quality and noise. Monitor IWMC. This includes review of reports dated in **Table 31** or determine condition of IWMC. Monitor compost condition as described in **Table 31**and **Table 28.**	Submit summary report 4 (1-4.) Proponent within 2 weeks	25,000.00

As indicated, during the course of the Project implementation summary reports following each trip is expected to be submitted by the Project's environmental consultant. 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 consultant 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 environmental consultant 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 28** below will be used in reporting environmental monitoring to be carried out as given in the monitoring plan.

Table 30: 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. Management of trees removed
These include monitoring trees removed, its fate and validation of number of trees removed.
c. Survival of relocated plants
These include monitoring for pests and diseases as described.
d. 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 31: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	
Compost output report	Details of amount of input waste materials	Bi-Annually
	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	

Island Council (Municipal Unit, Waste Management Committee)

Components	Details	Frequency
Public grievances	Log of public grievances regarding	Bi-Annually
	Fee structure	
	Waste Management operations	
	Noise and odor complaints	
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	

7 RECOMMENDATIONS AND CONCLUSION

The construction and development of the IWMC at Sh. Noomaraa 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.

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:

- To include this EMP as part of the contractor's contract and ensure the measures and recommendations brought forth are followed;
- Follow the procurement procedures described in the report;
- Implement the work method and mitigation plan as prescribed in the report to the fullest;
- To conduct supervision and monitoring of the project works by the Proponent;
- To conduct supervision and reporting of the project works by an independent consultant;
- To conduct stringent evaluation of contractor's capacity to undertake and complete the project;
- Ensure necessary clauses regarding the workers safety are fully implemented;
- 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 EMP has looked into the key factors that need to be considered during construction and operational stage. The study has identified the following unavoidable terrestrial impacts due to proposed development works:

- Almost an irreversible change to the overall terrestrial environment as a result of the placement of the IWMC footprint;
- Loss of mature vegetation from the project site (with no mitigation); and
- Generation of yard waste as a result of site clearing (with no mitigation).

The study also found that through the implementation of the proposed practical and cost effective mitigation measures almost all significant impacts can be brought to an acceptable level. This EMP will guide the Proponent in implementing the project with conformity to EIA regulation 2012.

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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

Sh. Noomaraa had no WMP formulated at the time of visit.

ANNEX 8: IWMC SITE SELECTION FORMS AND EPA DS