PROJECT SYNOPSIS

Name of the Project: Development of Sea Cucumber Facility at L. Gan
Project Proponent: S.S Farming Private Limited
Project Value: Approximately MVR 8 Million
Expected Duration: 12 months
EIA Consultant: Ahmed Saleem
EIA Date: February 2017

WEIGHTS AND MEASURES CONVERSIONS

1 metric tonne = 2,204 pounds (lbs.)
1 kilogramme (kg) = 2.2 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
CO₂-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
GHG Green House Gas
GoM Government of Maldives
HIES household income and expenditure survey
Hs Peak Height
MAS Marine Analysis Station
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
NBSAP National Biodiversity Strategy and Action Plan
MNSSD Maldives National Strategy for Sustainable Development
NAPA National Adaptation Programme of Action
MCCPF Maldives Climate Change Policy Framework
NEAP3 National Environmental Action Plan
SNAP Strategic National Action Plan
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<tr>
<td>MCCPF</td>
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DECLARATION OF THE CONSULTANT AND PROPONET

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

Ahmed Saleem (EIA 03/13)
Signature:

Proponent
The Proponent’s declaration and commitment to undertake the mitigation and monitoring is given in Annex 2.
EIA for Sea Cucumber Culture in L Gan, Maldives

30,000

526,350

Holothuria scabra

MEECO
EIA for Sea Cucumber Culture in L Gan, Maldives

100,000
12

D. Measurement

0.005
30,000
526,350
0.005

MEECO
EIA for Sea Cucumber Culture in L Gan, Maldives

(Compiled by)

Holothurin

for Sea Cucumber Culture in L Gan, Maldives

MEECO

| xv |
NON-TECHNICAL SUMMARY

This environmental impact assessment (EIA) report highlights the findings of the EIA carried out for the proposed sea cucumber Project in L. Gan, Maldives. Since aquaculture projects are listed under Schedule D of the EIA regulations warranting to conduct an environmental impact assessment prior to the undertaking of the project, the EIA was prepared as a fulfilment of this mandatory requirement under the EIA Regulations 2012 of the Maldives and to obtain environmental clearance from the Environmental Protection Agency of the Maldives.

The report was prepared according to a Terms of Reference (TOR) agreed between the EPA and the project proponent. All issues identified in the ToR have been carefully considered in the relevant chapters of this report.

EIA was conducted by consultants from the consultancy firm – MEECO.

The Proponent of the project is S.S. Farming Pvt. Ltd. which is owned and operated as a local investment and as such registered with the Ministry of Trade of the Republic of Maldives in 2015.

The proposed investment for the project is MVR 8 million which will go towards developing all relevant facilities necessary for breeding, rearing of juveniles, growing and processing of sea cucumber to produce bêche de mer for the international market.

This assessment confirms that the project has been planned and executed to adhere with the relevant laws, regulations, guidelines and is in accordance with government policies and development plans.

The project has been planned to be undertaken in L. Gan which is the largest and longest natural island in the Maldives. An area measuring 30,000 ft² from land and 526,350 ft² from the lagoon on the southeast coastal area of the island has been allocated and leased to the developer for the project. The intended species for aquaculture is Holothuria scabra which is the only sea cucumber species that is commercially cultured in the Maldives. This species is widely cultured in several Asia Pacific countries and is known to be among the most popular in aquaculture industry. It is now believed that the threatened status of H. scabra in the wild was mainly due to the over exploitation of the species to cater for the high demand created. Hence the only alternative available to maintain the market need is to culture and grow the species to a marketable size. H. scabra is not believed to be native to the Maldives although since its first introduction into the Maldives it is now believed that it has naturalised and well adapted to the local environment.

Key project activities involved in the proposed sea cucumber Project are site clearance, construction of hatchery units, larval rearing units, wastewater collection and treatment system, sea water intake, wastewater discharge pumping station, grow out cages, processing (gutting, cooking and drying) and packing of processed sea cucumber. The facility will have the initial capacity to produce 100,000 H. scabra seeds and up to 12 tons of processed bêche de mer per year.

Assessment of the baseline conditions of the site revealed that the proposed site for the project possesses conditions that are very suitable for the aquaculture of sea cucumbers. Although due to the isolated nature of the site and due lack of any proper waste management in place on the island waste littering had taken place at the site to a noticeable degree. As a consequence, the DO levels
in certain near shore locations were found to be well below the required level requiring site rehabilitation as a priority activity before the actual project related works commence. The assessment also found no unique feature associated with the location nor does it contain any rare or endangered or protected species. There was no indication that the project activities affecting the way of life of the community in a negative manner as a result of the project.

Stakeholder consultation constituted an important aspect of this study. All relevant stakeholders including representatives of the community were consulted and their views considered in the preparing the report. The community and the stakeholders consulted were in support of the project and highlighted the socio – economic benefits that the project would bring to the people of L. Gan.

The impacts assessment identified land clearance for development of the land based facilities, operation of the hatchery and nursery, stocking of sea cucumbers in the grow out area and processing of sea cucumbers as the activities that would have most significant impacts on the environment.

In the worst case scenario, the project would result in habitat alteration covering an area of 30,000 ft$^2$ on land which is just 0.1 % in relation to the landmass area of the island. Land clearance for buildings would result in loss of mature trees and coconut palms. Mitigations measures to avoid or reduce the number of trees requiring removal will be explored and for those trees which requires absolute removal will be compensated for by planting two trees for each coconut tree removed. Wastewater from hatchery including those produced from producing feed for the larvae are expected to contain pollutants that may in the long run affect the environmental quality of the lagoon as a result wastewater from hatchery has been proposed to be treated and discharged out of the reef.

Stocking of sea cucumbers in grow out area in the lagoon has been found to be an activity that can potentially affect the habitat including changes to the microflora composition and physical characteristics of the bottom substrate. As a result, measures such as controlling stocking density and instead of repeated use of the same area allowing areas that that have been used for grow out to fellow has been recommended. In addition, use of artificial feed in the lagoon has been recommended to be avoided.

Sea cucumber gutting and cleaning will generate waste that would contain high level of holothurin which is a known toxic compound for fish and other marine organisms, such wastes if dumped into the marine environment can be deleterious to fish and other organisms and therefore have been proposed to be avoided. Hence burying it in the ground has been recommended as a mitigation measure. Similarly, wastewater generated from boiling sea cumbers will also contain holothurin. Therefore, wastewater produced from processing of the sea cucumbers has been recommended to be diluted and treated and dumped through the discharge pipe outside the reef slope. Smoking and boiling of sea cucumbers will require significant volume of fuel wood which can lead to deforestation and habitat degradation. Therefore, in order to avoid such impacts alternative fuel has been recommended for boiling sea cumbers while coconut husk, driftwood, and firewood obtained from trees cut down for other projects legally has been suggested to be utilised for smoking of sea cumbers.

The assessment found no evidence of any significant negative impact on the society and culture as a result of the project, whereas, in terms of employment generated, technology transfer, alternative
livelihood opportunities expected from project will have significant positive socio–economic impacts.

The study also explored in detail the alternatives available for project related activities in terms of locations, technologies and processes. Through this exercise best practical environmental option has been determined and proposed in the report as an effective way to minimise environmental impacts and enhance positive impact of the project.

A detailed environmental monitoring program has been proposed in the report with a view to recognise the actual impacts of the project, to ensure environmental compliance and to assist the proponent to take necessary mitigation measures in the event of unexpected impacts. The proponent has shown full commitment to undertake the proposed monitoring plan.

In conclusion, the EIA revealed that the project will not result in loss of critical habitat or species or degradation of a habitat that has high ecological value nor does it involve forced re-settlement of inhabitants, loss of historical or cultural heritage and intervention into regular way of life of the people and that the predicted impacts are expected to be mitigated and residual impacts could be kept within generally acceptable levels. It has also been determined that the project is being undertaken in state-owned land with no encroachment into private land involved. Based on the findings, the EIA concludes that the project should be allowed to proceed with the proposed mitigation and enhancement measures during the construction and operational phases of the project as the benefits of the project far outweigh its imposition on the environment and the people.
1. INTRODUCTION

1.1 PROJECT BACKGROUND

A local company registered in Maldives named S.S Farming Pvt. Ltd has intended to develop sea cucumber (sand fish) farming at a designated location on eastern side of Gan close to Maandhoo area in Gan. Laamu (L) Atoll, Maldives. The project will be fully financed by the project owner S.S Farming Pvt. Ltd (hereinafter referred to as the proponent) with a total estimated investment of MVR 8.0 million. This report highlights the findings of the Environmental Impact Assessment (EIA) carried out for the aquaculture of sea-cucumber project at L. Gan Island, the Maldives (hereinafter referred to as the project).

The land area 30,000 ft² (land) and 526,350 ft² (lagoon) required for the project has been leased to S.S Farming Pvt. Ltd by L. Gan Council for a period of 15 years. The lease process has been undertaken in consultation with Ministry of Housing and Infrastructure.

The client has proposed to culture Holothuria scabra (sandfish) under the proposed project by using flow through cell aquaculture system. It is expected to produce 100,000 of sandfish seeds per production cycle for grow-out that in turn is expected to produce 8-9 tons of cultured sandfish from grow-out culture units per year. H. scabra is the only commercially cultured sea cucumber species in Maldives.

This EIA report has been prepared to obtain the required environmental clearance for the proposed project in accordance with the EIA Regulation No. 2012/R-27 enforced by Environmental Protection Agency (EPA). This report evaluates and analyses the existing environment, existing arrangement for implementing the project, its anticipated impact to environment and appropriate mitigation measures for all adverse impacts.

The findings in this report are based on information collected from literature, qualitative/quantitative assessments of the project consultations with stakeholders, professional judgements. For detailed site investigation a field visit was conducted during September 2016.

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 EIA report 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. Hence the term Environmental Impact Assessment (EIA) shall be taken synonymous to Environmental and Social Impact Assessment (ESIA). The term mariculture has been used in the report in synonymous to aquaculture.
Proponent in the document implies the project owner which is the S.S Farming Pvt. Ltd and the Island shall be interpreted as the project island of L. Gan. The term Project means ‘Sea Cucumber Farming in L.Gan’ and the developer shall be interpreted as the company undertaking development works of the Project.

1.3 THE PURPOSE OF THE EIA

The Environment Protection and Preservation Act (Law No 4/93) of the Maldives states that all development projects carried out in the Maldives will require carrying out an Environmental Impact Assessment prior to its undertaking. The details of the EIA procedure is stipulated in the Environmental Impact Assessment Regulations, 2012 (Reg No: 2012/R-27) and its Amendment 1, Amendment 2 and Amendment 3. Since aquaculture projects are listed under Schedule D of the EIA Regulations (2012) the EPA required the proposed project to undertake an EIA prior to its commencement. Hence this EIA is prepared to fulfil this legal requirement under the Environment Protection and Preservation Act (Law 4/93). Furthermore, the Ministry of Fisheries and Agriculture to issue the aquaculture licence for the project has also requested the proponent to clear the EIA process in order to proceed with issuing the said licence.

More specifically, this EIA focuses on the management of potential environmental and social impacts and risks of the proposed sea cucumber farming in L Gan.

Three major objectives of the EIA are to:

- Identify and assess potential impacts or consequences of the project on the natural and human environment in the project area;
- Propose measures to avoid or mitigate or control potential adverse impacts and risks and to enhance beneficial impacts; and
- Develop an environmental monitoring plan (EMP), where the proponent should adhere to during construction and operations of the said project; and
- Enhancing sustainability of the project and to promote environmentally sound decision making.
1.4 THE EIA IMPLEMENTATION PROCESS

The EIA implementation process is explained in detail in the EIA Regulations. The process is summarised below in Figure 1.

**Figure 1: EIA implementation process**
1.5 EIA APPROACH & METHODOLOGY

1.5.1 EIA Approach

The approach adapted for this EIA report is primarily aimed at capturing and presenting information needed to meeting the legal requirements of both Environmental Protection and Preservation Act (4/93) and the Environmental Impact Assessment Regulations of the Maldives.

The approach used in this EIA study involved systematically understanding and evaluating the project components through identifying the impacts (both positive and negative) on the biophysical and socio-environment followed by determination of practical and sound mitigation measures and proposing an appropriate monitoring mechanism to evaluate the effectiveness of the proposed mitigation measures.

Two most important aspects in impact prediction involved understanding in detail all aspects related to the proposed project including, setting, design, development, operation, decommissioning and the characteristics of the natural and social environment of the project location. Once these have been achieved, it was followed by prediction of potential impacts and evaluation of the impact characteristics to determine their significance using generally accepted methodologies. For the identified negative impacts, regardless of the significance level, practical cost effective mitigation measures have been proposed to avoid, or further minimise the negative effects.

1.5.2 Scoping and Terms of Reference

Scoping and finalising the Terms of Reference (ToR) was one of the very first steps in the initiation of the EIA process. The ToR initially drafted by the EIA team based on judgement and experience of other development schemes of similar nature in the Maldives was submitted EPA. Followed by submission of draft ToR the scoping meeting was held on 28th April 2016 at EPA attended by project consultant, project client and relevant key stakeholders. Stakeholders present at the meeting discussed the ToR and suggestions were made to the ToR. These suggestions were then incorporated into the revised ToR and submitted to EPA.

Following the review of the revised ToR, EPA gave no-objection to carry out the EIA and the revised document was endorsed on 2 May 2016 as the final ToR and given 6 months duration to complete the EIA report. However, due to delays faced by the client in commencing the project within the given duration in the TOR, a 3 months extension of TOR has been obtained by EPA All issues identified in the ToR have been carefully considered in the relevant chapters of this report. The final ToR for the EIA is provided in the Annex 1.
1.5.3 EIA Methodology

To effectively determine and evaluate the impacts the right mix of expertise in relevant disciplines was chosen. This was followed by a number of critical steps such as, defining the spatial boundary of the study area, identifying specific areas for detailed study to understand the sensitivities of the baseline environment. It also included, a number of specific stages in the preparation of the EIA characterisation of baseline environment, determining project sequence, activities and methodology, alternatives evaluation and review of relevant laws policies.

1.5.3.1 Identifying Impacts and Analysis

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

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

A modified Leopold Matrix (Leopold, et al., 1971) was applied in evaluating the impacts identified. The steps involved are briefly summarised below:

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

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

Importance

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

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

**Magnitude**

Magnitude of the impact was expressed in terms of relative severity, such as major, moderate or minor/negligible. In determining severity other aspects of impact magnitude, notably whether or not an impact is reversible and the likely rate of recovery are also considered.

Hence, the following equation was used to determine the impact significance (UNEP, 2002).

\[ \text{Impact characteristics (magnitude)} \times \text{Importance (value)} = \text{Impact significance} \]

The scores obtained for the magnitude of each of the impacts (both positive and negative) were categorised as given in Table 1.

**Table 1: Categorization of the significance**

<table>
<thead>
<tr>
<th>Total magnitude score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 40</td>
<td>Major positive</td>
</tr>
<tr>
<td>20 to 39</td>
<td>Moderate positive</td>
</tr>
<tr>
<td>1 to 19</td>
<td>Minor positive</td>
</tr>
<tr>
<td>0</td>
<td>Negligible</td>
</tr>
<tr>
<td>-1 to – 19</td>
<td>Minor negative</td>
</tr>
<tr>
<td>-20 to – 39</td>
<td>Moderate negative</td>
</tr>
<tr>
<td>&lt; - 40</td>
<td>Major negative</td>
</tr>
</tbody>
</table>

Significance categories of negative impacts given in table 1 is defined as explained in Table 2.
Table 2: Impact characterization matrix

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

1.5.3.2 Social Assessment

The aim of the social assessment (SA) is to study the potential social and community benefits of proposed project in L Gan. In recognition of with this, the report includes aspects related to social inclusion and labour impacts. The specific objectives of the social assessment are to:

1. Identifying the stakeholders of the project;
2. Identifying appropriate mechanisms for providing information about the project to all stakeholders;
3. Investigating the impacts to the stakeholders from the implementation of the project;
4. Understanding the current social, cultural, socio-economic and poverty conditions of the island;
5. Understanding the impacts of the project on the social and socio-economic profile of the island with particular reference of the following:
   a. Impacts of the design, development and decommissioning of the farm
   b. Impacts on demographic developments (migration);
   c. Impact on coastal fishing and tourism related activities and navigation;
   d. Impacts on agricultural development;
   e. Impacts on island employment, income and economy diversification;
   f. Impacts of workers on the local population;
   g. Impacts on cultural sites and heritage;
   h. Impacts of increased demands on natural resources and services especially water supply, land availability, waste management, energy supply, harbour capacity;
6. Formulating mitigation and enhancement measures to optimise the benefits for the communities and limit the adverse effects; and
7. Monitoring of socio-economic impacts during implementation of the project.
1.5.3.3 Cumulative Impacts

Cumulative impacts which may be defined as impacts that result from incremental changes caused by other past, present or reasonably foreseeable activities together with the project are generally considered in EIA studies. The environment where the proposed aquaculture project will be situated is relatively undeveloped and no projects have been planned for the immediate future in the close vicinity of the project site. Hence the proposed approach for assessing cumulative impacts was to consider those that had already been completed in close proximity of the project site.

1.5.4 Impact Mitigation

Impact mitigation in the report refers to measures that are necessary to avoid, eliminate or reduce the negative effects of the project on the environment and enhance positive effects. The ToR for the EIA requires practical and appropriate mitigation measures for significant impacts identified to be proposed. For each identified significant negative impact in proposing mitigation measures the priority was given to avoidance of a predicted impact by taking measures such as bringing changes to the design and/or work methodology. In cases where avoidance of an impact was not possible practical and cost effective measures have been proposed to reduce the impacts and enhancing positive impacts. Practical experience and lessons learnt by the EIA team from projects of similar nature played a key role in proposing mitigation measures. Hence in interpreting the impacts and mitigation the document as a whole shall be taken into account rather than a particular section of the report. The proponent as part of this report has submitted a letter of commitment stating that all the mitigation measures proposed in the report will be implemented during all phases of the project. Hence the project will be implemented with full commitment of the proponent to undertake the mitigation measures to ensure environmental sustainability of the project.

It should also be noted that in addition to predicting impact of the project on the environment, the EIA regulations also requires determining impacts of the environment on the project components for ensuring sustainability of the project. This aspect was well taken into account in the project formulation.

1.5.5 Gaps in Baseline Information

Availability of quality baseline data is an important element for any EIA study. However certain baseline information had not been considered in the evaluation partly due to capacity constraints. For instance, lagoon sediment analysis and microflora assessment of the lagoon benthic environment is seen as an important aspect of the study. However, no facilities are available in the country to undertake such an assessment. Long term oceanographic information of the grow out area would have been very useful but was not possible due to the short period of time available to complete the assessment. Hence it becomes necessary to make assumptions or use information from research carried out in other countries to fill the gap. Lack of long term past data specific to the project environment resulted certain degree of uncertainties in evaluating baseline conditions and predicting future environmental changes.

Limited understanding of the baseline conditions as studying existing environment was limited to a short period of time. Ideally, a site should be visited multiple times during the two monsoons to
ensure to properly capture the environmental conditions at the site. However, this is rarely possible due to time and resource constraints and therefore, the data captured is representative of the conditions at the time of the surveys. The marine flora and fauna described in the report are those observed at the sampling locations and therefore is assumed to be representative of the site. This represents a sufficiently conservative and cautious approach which takes account of the study limitations.

1.5.6 Gaps in Understanding Impacts

Although *H. scabra* as a commercially important species has been extensively studied by the scientific community there is very little scientific literature available specific to the Maldives on this species. As explained in the report, *H. scabra* was an imported species for aquaculture and it is not believed to be native to the Maldives. As a broadcast spawner in the natural environment, there exist the likelihood of *H. scabra* breeding with related local species. This aspect has not been studied and the impact of genetic shift in the local population is not understood. Aquaculture of *H. scabra* in the Maldives is still limited to a few projects and not much information is available on the actual impacts of sea cucumber farming on other aspects of the environment at local level in particular the effect on non – target species. Studies done in other countries have shown the importance of aquaculture aspects such as disease and effect on benthic environment. Local information on these aspects are not available making understanding of such impacts difficult. Furthermore, specified criteria necessary for impact evaluation such as environmental standards and thresholds are yet to develop in order to strengthen the EIA process in the country. In order to address these gaps, where impact magnitude cannot be predicted with certainty available scientific literature and lessons learnt from similar projects were used. In cases where a greater degree of uncertainty is believed to exist a precautionary approach had been adopted in which likely maximum impact was considered.

1.5.7 Review of Similar Reports

EIA reports of similar sea cucumber farming works in Maldives were reviewed for this EIA. Major findings from the EIAs show that the proposed *Holothuria scabra* is a naturalised species well adapted in the local condition that is not identified as a known threat to the wild stock.

The potential significant negative impacts identified from sea cucumber farming in the reviewed EIA’s are similar in nature. The most prominent of these are vegetation clearance for site setting, enclose of sea cucumber grow out site in the lagoon and discharge of wastewater into marine environment. These EIA’s reviewed shows sea bed contamination and likely disease transmission are some of the concerns of such projects that however can be minimized or eliminated through regular monitoring.

The main positive impacts identified by the EIAs are job opportunities and income that generates from such projects increase the revenue of the client and benefits to the island economies. Also, it helps to restore degrading environments of the proposed farming sites. Some of the EIA’s reviewed are as follows

This EIA was conducted for the project proposed by Ali Ahroosh Ibrahim of M. Meadows, Malé to develop sea cucumber aquaculture farm in Boduhaikondi, R Atoll. The scope of the project involves the setup of sea cucumber facility with lagoon based sea pens or open cages for grow out in the lagoon (3,100 m²) and 2,563 m² on land at Boduhaikondi, Raa Atoll.

Key environmental impacts both during development at operational were identified as follows

**Developmental**
- loss of vegetation due to site preparation for setting;
- loss of bottom sediment from dredging for channel and jetty development;
- elevation of environmental pollution from wastewater generated from workforce; and waste generated

**Operational**
- Contamination of sea bed due to excess food and nutrient loading;
- impact of likely disease transmission;
- impact of cages; and
- loss of visual amenity of the site.


This EIA was prepared for the project proposed by Adil Mohamed for developing a sea cucumber aquaculture farm in Maroshi, Shaviyani Atoll. The scope of the project involves the setup of sea cucumber facility in an area of 40,000 sq.ft in Sh. Maroshi leased to the project developer.

Key environmental impacts both during development at operational were identified as follows

**Developmental**
- Loss of vegetation due to site preparation for setting; and
- Elevation of environmental pollution from waste.

**Operational**
- Contamination of sea bed due to excess food and nutrient loading
- Impact of likely disease transmission;
- Pollution from solid waste; and
- Loss of benthic life forms.

1.6 THE EIA TEAM

This EIA report was prepared by a multi-speciality team of local experts. The team consisted Mr. Ahmed Saleem, Mr. Mohamed Musthafa and Ali Hammad 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 3.
Table 3: The EIA Team

<table>
<thead>
<tr>
<th>Name</th>
<th>Qualification</th>
<th>Designation/Field of Expertise</th>
<th>Contributing Area</th>
</tr>
</thead>
</table>
| Mr. Ahmed Saleem      | MSc. Ecology & Environment            | Lead EIA Consultant                                 | • Overall administration of the EIA  
                                                                                        • Contributed to the various chapters  
                                                                                        • Report review                      |
| Mr. Mohamed Musthafa  | M.Tech (Environmental Management)    | EIA Consultant (Environment, Water and Sewerage)   | • Deputy Team Leader  
                                                                                        • Report writing and compile  
                                                                                        • Data analysis                      |
| Mr. Ali Hammad        | BSc. Environmental Management        | EIA Consultant                                     | • Data collection  
                                                                                        • Water sampling  
                                                                                        • Stakeholder consultations  
                                                                                        • Contributed to the various chapters of the report |
| Mr. Dinal Shalika     | Surveyor                             |                                                    | • Marine survey  
                                                                                        • Preparation of maps and charts     |

1.7 PROJECT SETTING

The proposed project is planned to be carried out in the island of Gan in L Atoll, Maldives. The proposed project is located on the eastern side at the southernmost point of the island. The site has not been in use for any specific purpose in the past. L. Gan is the longest and biggest natural island in the Maldives with an area of 583 ha (vegetated area). In comparison to the relatively large land area the population is small with a population density of just 7/ha (Census 2014). The island has a small enclosed natural water body measuring 27.7 ha. The industrial island of Maandhoo where fish processing is established is connected to L. Gan and is situated very close to the site given for the proposed project. Similarly, Kadhdhoo airport which is also connected by land to Gan lies just about a kilometre from the project site. Although the project area is located in an inhabited island the closest area where resident population is found was located approximately 2 km away. Hence, in effect the project area is isolated and situated close to an industrial area.

For the nature of commercial activity, the site given seemed to be quite fitting due to availability of adequate space and lack of any conflicting resource use in the area and the natural setting of the site. Despite these advantages site assessment revealed that much of the land area and the coast was used in the past for illegal dumping of mixed waste. Clean environment is a pre–requisite for a successful sea cucumber farm and therefore site rehabilitation has to the first priority of the project. Being close to an industrial area, away from the population and its isolated nature created conditions for people to irresponsibly dump waste in the location. As a result, the land area allocated to develop the hatchery, the coastal area and lagoon area was found to be polluted.
Irresponsible waste dumping as created an environment suitable for pests such as flies and mosquitoes to breed. Disposal of organic waste into the coastal lagoon area has affected its physical and chemical properties. DO is vital for living organisms and depletion of DO due to waste will have a negative impact on the natural life forms, hence this area of the lagoon, without restoration will be unsuitable for any commercial activity in particular for aquaculture purposes. The area had lost its pristine qualities and is considered environmentally degraded. Thus the project setting is such that, the project activities will have to be targeted towards improving the environmental qualities of the site making it a suitable environment for a grow out area and suitable for workers as well.

Once rehabilitated the project setting is such that it is considered to be very suitable for the proposed activities. In terms of environmental characteristics of the project site, the proposed grow out area and hatchery was situated in a bay protected from strong winds and waves. The area was relatively shallow and extremely calm due to the significantly large reef flat and shielding provided by the curved shaped of the area. The bottom of the lagoon was composed of dark silt/clay formed as a result of decomposing organic matter. Initial observations by experts identified high detritus content in the bottom layer which was ideal for sea cucumber farming. The lagoon was shallow and had the ideal depth for setting up the grow out area. These natural features of the area made the lagoon very calm and nutrient rich, which meant that the area was easily accessible and ideal for culturing sea cucumber. These natural environmental features of the area will prevent significant negative impacts of aquaculture activities such a nutrient loading. Bing sited close to other industries, isolated from the resident population, lack of unique aesthetic qualities, shallow, calm ample lagoon space availability make the project setting ideal for the proposed aquaculture venture.

1.8 PROJECT JUSTIFICATION

Economic development and sustainable livelihood policies of the government encourages private sector to venture into commercial business activities that can be carried out in a sustainable manner in the Maldives. Thus this sea cucumber culture project has been initiated in line with this key policy of the government. Maldives being a maritime archipelago, it possesses abundant shallow water lagoons with seagrass beds that are very suitable for aquaculture of sea cucumbers. Furthermore, the coral reef systems of the Maldives considered as the 7th largest reef ecosystem in the world contributing 5% of the world’s total coral cover area (MEE, 2016). Hence, Maldives is considered as one of the highly potential mariculture sites in the region. At a more local level, Gan is sited in a huge reef system covering an area of 45 km² stretching to some 29 km providing ample suitable environment for carrying out marine based sustainable commercial ventures. Even though this being the case until recently only a very few initiatives have been undertaken to benefit from the vast productive coastal areas available in the country. At the global level, the contribution of the Maldives in sea cucumber production remains very low with mere 1.1%. According to available data during the period 1994 – 2005 Maldives produced an average of 160.2 tonnes of sea cucumbers. During the period the peak was reached during 1997 with 318 tonnes produced during the year (see Figure 2)

According to the research carried out during the period 1996 – 1999, and experience gained from projects of similar nature over the last decade, it is now established that sea cucumber can be successfully cultured at commercial level in the Maldives.
Proven results from the research indicate that approximately 26% of the total fertilized eggs survived to reach the adult stage successfully. With the successful hatchery programs carried out in the Maldives, grow out areas have been established and bêche-de-mer production has been successfully carried out in the country since early 1990s and the interest by the private sector to venture into this industry is growing as the techniques used to produce breed bêche-de-mer in controlled environments gained confidence with greater success rate. Thus, there is a tremendous potential for establishing mariculture farms to diversify the economy and to boost country’s foreign currency earnings via export markets at the same time creating additional local employment opportunities in the islands. In countries such as Madagascar, the Philippines, Vietnam, and Fiji where sea cucumber fisheries have provided alternative livelihood for coastal communities (Hair, et al., 2012). *H. scabra* accounts for the majority of bêche-de-mer export from India, Sri Lanka and Madagascar (Conrad, 1990)

Depletion of the natural stock of one of the most valuable species – *H. scabra* had been the main factor that investors got motivated to venture into aquaculture of this species. Due to the shortage in supply the price of this species had significantly increased in the world market from approximately US$ 25/Kg in 1990 to US$ 65/Kg in early 2000.

In the Maldives the reef fishery has concentrated mainly on groupers, sea cucumber and aquarium fish. However, the research on reef fisheries in Maldives shows these have been over-fished and overfishing have become a threat to conservation of biological diversity (MHE, 2010). Similar to worldwide trend commercial sea cucumber species has been recorded to be declining in Maldives, indicating the need to promote aquaculture of sea cucumber to sustain this fishery. Although the sea cucumber fishery that began in Maldives in 1985, were initially harvested by hand pick and snorkelling today high priced sea cucumber species are fished by scuba diving.

The early targeted nine species named *white teetfish, elephant’s trunkfish, killofish, surfredfish, pricklyredfish, turtleshell, lollyfish, greenfish and amberfish* become over exploited and the export
declined. The most valuable of these species, *Prickly redfish*, was rapidly overfished followed by other medium value species (FNR CBD, 2002). Due to the serious decline in commercial sea cucumber species in the Maldives there was a ban on the use of SCUBA in the Maldives to protect the stocks of *H. fuscogilva* and *T. ananas* (Reichenbach, 1999). With such serious decline the only option now left is to farm them in order to keep the sea cucumber fisheries alive.

In the case of the Maldives, sea cucumber export data and revenue generated also clearly show the potential of aquaculture fishery in the Maldives. The Maldives Custom Service (MCS) statistics shows MRV 45,395,542.17 worth of sea cucumber of weight 954,800.46 Kg was exported between 2011 and 2015. As per the MCS records 97% of the sea cucumbers treated in dry form were exported to Sri Lanka, Hong Kong and Singapore. The decline in production and export of sea cucumber to international market in the last five years during the period 2011 – 2015 indicate the potential for investments in sea cucumber farming. The current high demand for dried sea cucumber product is likely to continue and increase in many Southeast Asian countries (FAO, 2003). Sustainable mariculture has thus been identified to be the most suitable way to cater for the growing demand and relieve pressure on the wild stocks.

Hence, the perceived socio-economic benefits, availability of the *H. scabra* broodstock, adequate local experience in the area, increasing demand for bêche-de-mer globally, availability of suitable environment for establishing the grow out area, the hatchery and well understood nature of techniques involved make the project justifiable from an economic and environmental perspective.

According to the land lease agreement signed by L. Gan Council and the project proponent, the proponent must pay 20% of the revenue that generates from sea cucumber fanning to the island council which will be a vital income for the council for its island development plans. Also, the client agrees to help in the development of community sea cucumber farming once the facility becomes operational and attains a sustainable flow of operations. The community farming component of the project will come into effect during the second phase of the project. Once this phase has been reached, the relevant environmental clearance will be obtained and the community farming component will be planned and executed together with the island council and relevant authorities.

The proposed project site in L Gan leased to S.S Farming Pvt. Ltd for sea cucumber culture found to be polluted with mixed solid waste disposed from nearby industrial sites. The proposed sea cucumber project will also aid in removing waste accumulated both on land and submerged in the lagoon, in effect restoring the lagoon area and coastal vegetation area through removal of harmful industrial solid waste that has accumulated in the project area. In general removal of waste from the project area will be ecologically and environmentally beneficial.
2. DESCRIPTION OF THE PROJECT

2.1 PROJECT PROPONENT

The project is proposed by a local company registered under the name of S. S Farming Pvt. Ltd (hereinafter referred to as the Proponent).

The contact details of the proponent representative is given below;

Shaffaaf Naseer
General Manager
S.S Farming Pvt. Ltd
Company Registration No: C-0325/2015
Contact Number: 9940202

2.2 PROJECT OVERVIEW

The proposed aquaculture project is owned, financed and operated by S.S Farming pvt. Ltd. The company shareholders are widely involved in various types of business activities in the Maldives namely; tourism industry and cafe and restaurant business. The required land for this project has been leased to the company from the secretariat of the Laamu Gan Island Council (see Annex 6). Under the project, sea cucumber seeds will be produced from captive broodstock which would be conditioned in a hatchery facility. The company focuses to conduct at least 4 breeding cycles per year and each breeding cycle would have capacity to produce around 100,000 sand fish seeds for grow out culture.

A proposal for undertaking the proposed project was submitted to the Ministry of Fisheries and Agriculture and a conditional approval was granted (see Annex 6), one of the condition being undertaking and getting approval for the EIA carried out for the project.

The project land (including lagoon space) was approved by the Island Council of L. Gan via their agreement number (AGR)399-EDS/PRIV/2016/1 dated 14/8/2016 on lease basis (see Annex 6).

2.3 PROJECT LOCATION & SITE

As described earlier in this report the project will be undertaken in L. Gan Island located at latitude 1° 52' 56" N and longitude 73° 31' 50" E. The island is located approximately 250 km from the Maldives’ capital city of Male’. Gan is the largest natural island in the Maldives which is divided into three administrative areas Thundi on the northeast part, Mathimaradhoo on the east part and Mukurimagu on the southern part of the island. The project site is on the south-eastern coast of the island at latitude 1°52'46.62"N and longitude 73°31'47.76"E (Figure 3). Mukurimagu is the closest settlement region of the island although the site is separated by some 1.7 km from Mukurimagu. Hence the project site is isolated with no development on or adjacent to it. The total area of the project site covers 556,350 ft² of which 30,000 ft² is from land and 526,350 ft² is from the adjoining lagoon. The plot of land is densely vegetated while much of the lagoon space was comprised of seagrass bed. The coastal area showed no sign of erosion while the lagoon is sheltered and calm condition is expected to prevail (see Figure 4).
Figure 3: Project location
Figure 4: Project site features (A) thickly vegetated land (B) stable coastline with a gentle slope (C) shallow calm lagoon (D) extensive seagrass beds in the lagoon

2.4 PROJECT OBJECTIVES

The primary object of the project is the commercial aquaculture of bêche-de-mer in an environmentally sound manner and hence the proponent intends to develop all the necessary facilities at the project site to culture, grow and process sea cucumbers to produce high quality bêche-de-mer products for the export market.

The specific objectives of the proposed project are to:

a. To develop and operate a sustainable a sea cucumber farm that is commercially viable and environmentally sound;
b. to producing reliable and constant stream of sandfish seed for export and cater local demand;
c. To supply cultured and processed sandfish for export market demand;
d. To transfer sandfish culture technology and knowledge to local communities;
e. To increase income and diversify revenue sources; and
f. Improve the living conditions of within the atoll in general and L. Gan community in particular through creation of income earning opportunities by transferring of sea cucumber farming technology, knowledge and resources.

2.5 MAIN FEATURES OF THE PROJECT

The project involves mariculture farming of sea cucumbers at a designated location in L Gan. The project at the start will obtain broodstock from a local supplier and grow the juveniles in pens set up in the shallow lagoon to a marketable size. However, if adequate number of juvenile sea cucumbers could be obtained from a local source, the project intends to start grow out activities at the same time as the breeding takes place in its hatchery. Hence, to kick start project activities two options have been considered.

**Option One**: buying around 1000 (one thousand) juveniles from Sh. Nalandhoo aquaculture farm or from an approved project implemented in the Maldives and grow them in sea pens from which future broodstock will be selected. If this turn out to be viable, grow out activities can begin while inland facilities are being constructed. This would be the preferred option for the project proponent.

**Option Two**: purchasing approximately 100 mature animals from L. Mabaidhoo and L. Dhanbidhoo local community sea pens.

The key features in this process is briefly outlined in Figure 5.

The project intends to develop all facilities that are necessary for breeding, growing and processing sea cucumbers for the export market.
2.6 SPECIES CULTURED

*Holothuria scabra* Jaeger, 1833, commonly called as the sandfish is the only tropical species that are currently mass produced in hatcheries (Toral-Granda, et al., 2008). Similarly, it is also the only species that is farmed in the Maldives at commercial level. Hence, *H. scabra* is the intended species to be cultured under the proposed project. This species has been the subject of the number of studies since 1833 (Hamel, et al., 2001), largely because of its popularity as a commercial species and due to the strong desire to commercially farm this species as the natural populations dwindled due to the over exploitation. As this species is estimated to have experienced at least a 50% decline over the past 30 – 50 years IUCN has classified the species as endangered in its natural habitat (Anon., 2017).

The taxonomy of the intended species for culture is as follows:

Phylum: Echinodermata,
Class: Holothuridae (with tube feet),
Family: Holothuriidae (with circular body and single gonad),
Genus: Holothuria
Species: *H. scabra*

*Figure 6: H. scabra or the sandfish proposed to be farmed at the project site (A) Live appearance photo by: S.W. Purcell (B) Processed appearance (photo by: S.W. Purcell) adapted from (Purcell, et al., 2012)*

The species has particular advantages to culture and grow as a commercial species as summarised below:

- It is extensively studied and a large volume of literature is available on various aspects of this species including, its biology, diseases, farming and processing;
- It has high value on the Asian market;
- It is the only tropical holothurian species that can currently be mass produced in hatcheries; and
- It is among the few holothurian species that yield first grade bêche-de-mer among 20 or so sea cucumber species that are commercially fished (Hamel, et al., 2001).
2.6.1 Physical Characteristics

*H. scabra* possesses dorsal body surface which is relatively smooth and has small papillae with black dots; colour varies from grey to black with dark distinct lateral wrinkles, with five dark lateral bands (Conrad, 1990). The sandfish is greyish-black on the upper side with dark-coloured wrinkles but paler on the underside. In the Indian Ocean, it is usually dark grey with white, beige or yellow transverse stripes (Purcell, et al., 2012). The ventral surface of the body is flattened and is generally whitish in colour. The mouth is on the ventral surface at the anterior end of the body. It is oval in shape and has 20 short peltate tentacle, anus is located dorsally at the posterior end of the body. Anus is terminal with no teeth. When processed *H. scabra* appears cylindrical with bluntly curved ends. Coloration ranges from dark tan to near black and ventral surface usually amber-brown. The dorsal surface retains the deep transverse wrinkles. Dried specimens has a measured length of 10–15 cm for top grade sizes (Purcell, et al., 2012).

2.6.2 Biology

*H. scabra* have the same general anatomy as other sea cucumbers. The gonads (ovaries or testes) lie in one tuft and open dorsally at the anterior end of the body through a single gonopore (i.e. genital orifice). The digestive system is composed of a mouth, oesophagus, stomach, intestine, cloaca and anus. Respiratory trees, which sandfish use to obtain oxygen, lie in the posterior of the body and open to the cloaca. Sandfish move with the help of tube feet densely distributed on the ventral face, and through muscular action of the body wall. Their natural spawning is believed to be related to the lunar cycle as they tend to aggregate increasingly towards the full moon and spawning taking place in the following day (Mercier, et al., 2000).

2.6.3 Geographic Range, Habitat & Ecology

*H. scabra* has a wide distribution throughout the tropical Indo-Pacific in sheltered near shore environments (depths less than 4 m) (Mercier, et al., 2000). *H. scabra* do not occur in the reef slopes and the outer lagoon (Conrad, 1990). Naturally found adult sandfish is known to prefer inshore sandy substrate areas at depths 1 – 3 m whereas smaller sandfish prefer shallower waters (30 – 120 cm). They are known to avoid fine silt or shells and coral pebbles and sediments with high organic content (>30%). They are sensitive salinity changes and tend to burrow when salinity decreased. Increasing water temperatures reduces their normal burrowing behaviour. Smaller sandfish seem to prefer shallow waters close to the coast while distributional data suggest that larger individuals migrate out to deeper water. One view is that larvae settle in shallow water and as they grow, migrate out to deeper water to spawn (Hamel, et al., 2001). Newly settled juveniles are mostly found on seagrass leaves in natural environment. Studies have also found that juveniles with mean length around 65 mm released on sand moved less and grow faster than juveniles released in seagrass beds (Mercier, et al., 2000). It is believed that juveniles remained approximately 4 weeks on seagrass leaves before moving onto underlying sand when reaching approximately 10 mm in length. Upon leaving the nursery seagrass shoots, juveniles move away from them during their normal foraging activities and settle on muddy and/or sandy patches of intermediate richness where their growth is optimum. (Mercier, et al., 2000). Sandfish exhibit a regular burying cycle and moves in and out of sub surface sediments and the water temperature is known have a significant effect on the burying and feeding behaviour of *H. scabra*. Prolonged
periods of burying has been observed when sea cucumber is stressed due to changes in temperature, strong currents, predation, desiccation or changes in salinity. More adult sandfish are known to spend more time buried during the day with decreasing water temperature and hence affecting their feeding time (Wolkenhauer, 2008).

2.6.4 Growth, Feeding and Habitat Preference

Experimental evidence suggests that of newly-settled juveniles of *H. scabra* the critical period is when they are <5 mm in size during which high mortality occurred (Battaglene, et al., 1999). Experiment also showed that juveniles as small as 3 mm could be transferred to sand although it is better to delay transfer to sand until the juveniles reached a size of 20 mm and 1 g in which case the survival rate was found to be higher. Cultured juveniles are known to feed on sand particles and when they reach up to 50 mm in length diatoms and epiphytic algae become important sources of food. Juveniles and adults of sea cucumbers feed on detritus or decaying organic matter. However, under captive or culture conditions they can feed on dry seaweeds and artificial feeds (Al Rashdi, et al., 2012).

Studies have shown that sea cucumbers selected sediments with the highest content of microalgae (Uthicke, 1999). Research has also indicated that unless the juveniles are in high densities adding feed does not enhance their growth. Absolute daily growth rates for juveniles ranges from a mean of 0.2 to 0.8 mm day\(^{-1}\), with an overall average of 0.5 mm day\(^{-1}\) which is equivalent to a weight range of 0.1 to 0.4 g day\(^{-1}\), and an average of 0.2 g day\(^{-1}\) (Battaglene, et al., 1999). Sea cucumbers prefers medium grain sized particles, then the fine sand and finally coarse size, even if the sediment with the medium gain size is not the richest in organic matter ingests (Plotieau, et al., 2013) suggesting their preference for muddy substratum over sandy bottom (Baskar, 1994) with grain size class < 250 \(\mu\)m in the natural environment. Medium sized grains is believed to contain a good load of nutrients, easy to ingest and to burrow into (Plotieau, et al., 2013). Adult sea cucumber (>250 mm) while sizes smaller this (10 – 250 mm) preferred mud and muddy sand (Mercier, et al., 2000). Gut content analysis of *H. scabra* was found to contain mud, sand, shell debris, molluscan shells, bivalves and algae (Baskar, 1994). Organic content found in the ingested mud and sand is then extracted as the particles pass through their stomach (Basker, 1994) and intestine (Tokuchica, 1915). Sea cucumbers grow to a size between 150 – 1000 g with a mean weight of 480 g with their drained weight varying from 150 – 850 g and gutted average weight being 270 g (Conrad, 1990). They can reach a length of 370 mm with an average length of 230 mm (Basker, 1994). For commercial purposes *H. scabra* must be at least 350 g in weigh and 22 cm long to fetch a good market price (Plotieau, et al., 2013).

2.6.5 Sex, Reproduction and Maturity

In the natural populations of sea cucumbers sex ratios have been found to be 1:1 (Conand, 1990) although by looking at the external physical features, it is not possible to distinguish males from the females. Their sex can only be determined by biopsy or dissection of animal to obtain a gonad sample (Al Rashdi, et al., 2012). The maturity Sea cucumbers can reproduce both sexually and asexually, although most species have defined sexes. Sandfish can be sexually mature at a size as small as approximately 140 g by drained weight (Conand, 2009). During its growth five maturity stages have been observed as given in Table 4. During sexual reproduction the external
fertilization of eggs and the subsequent fertilization by sperm within the water column. The fertilized eggs will hatch and the larvae will live a planktonic or free floating existence, swimming along with the aid of tiny cilia for mobility, eating and growing until they have reached the metamorphosis stage (Al Rashdi, et al., 2012).

**Table 4: Maturity stages in Holothuria (Metriotyta) scabra (Jaeger) (Basker, 1994)**

<table>
<thead>
<tr>
<th>Maturity stages</th>
<th>Macroscopic feature</th>
<th>Microscopic feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undetermined sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Immature</td>
<td>Single tuft of tubules, tubules short</td>
</tr>
<tr>
<td>II</td>
<td>Maturing</td>
<td>Gonadal tubules elongated partly, yellow in colour</td>
</tr>
<tr>
<td>III</td>
<td>Early mature</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Gonadal tubules yellowish red, branched with round saccules.</td>
</tr>
<tr>
<td>IV</td>
<td>Late mature</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Tubules pale red, elongated with swollen round saccules, having 2-3 ancillary branches.</td>
</tr>
<tr>
<td>V</td>
<td>Spent</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>Gonadal tubules shorter and wider, pale red in colour.</td>
</tr>
</tbody>
</table>
Although not much information is available on the growth and weight progression of *H. scabra* in the natural environment. According to available information it can be determined that a mean growth of 0.5 cm per month which is equivalent to 0.5 g of fresh weight implying the growth *H. scabra* is between 10 and 25 cm (Conand, 2009).

### 2.7 OVERALL AQUACULTURE PROCESS

Although initially juveniles of *H. scabra* will be bought from Sh. Nalandhoo for growing at the project site, the proponent intends to breed *H. scabra* using broodstock maintained at the hatchery at a later stage. The methods that are already practiced in the Maldives and elsewhere will be used for breeding to grow and process. A general description of the method that will be used is given below.

The normal procedure for the aquaculture of sea cucumber is that individuals are induced-spawned, generally at times of the year in synchrony with their natural spawning cycles. Thermal stimulation was found to be the most successful spawning method (Ivy & Giraspy, 2006). Induced spawning by slight raise in temperature has been shown for *H. scabra* (Pitt, 2001). The fertilization is external and takes place in the water column. The oocytes are fertilized quickly as they make contact with the spermatozoa. Fertilization takes place rapidly and the fertilized egg develops into larva within 24 hours. After the oocytes and sperm are released in the water, the sea cucumber is removed from the tank. The eggs will be washed several times with UV-treated seawater to remove excess sperm and accumulated dirt during spawning. Excess spermatozoa can reduce the rate of fertilization and cause the development of deformed embryos.

Sea cucumbers have planktonic larvae which takes about 14-20 days to settle. Larval stages are most critical in terms of determining the success of a breeding episode. Generally speaking, heavy mortality rates incur during the entire larval phase slowing decreasing mortality rates as the larvae undergo phase changes. Food in right concentration in the right environmental conditions is essential for maintaining acceptable levels of mortality rates. Experiments have shown that growth the *H. scabra* larvae are readily affected by the concentration of *Isochrysis galbana* (see below, (Morgan, 2001).

Although fertilization is normally successful with millions of larvae to start with, even a 30-50 % daily mortality rate (which is not uncommon in nature) would mean very few survive past the 15th day when they are ready to settle. For example, if there were 1,000,000 larvae to start and with 30 % daily mortality rate (i.e., instantaneous rate) only 2,480 individuals will survive at the end of the 20th day. Thus extreme care and proper husbandry techniques will be implemented to enhance success rate.

Food for the larval stage is the live algae that will be cultured at the facility when the project begins handing its own broodstock. *Chlorella* and *Isochrysis* (both phytoplankton) species will be cultured indoors (at the laboratory using artificial light) and outdoors using sunlight. Generally, larvae are fed by algae in the first few days, followed by *Chaetoceros sp* marine planktonic diatoms and *Navicula sp* marine benthic diatoms. The initial start-up algal stock would be obtained from Marine Research Centre. During later stages it is also common to feed larvae with *Artemia*
(brine shrimp cultured from dehydrated cysts). All these species are used in the Maldives in aquaculture and the lineage is maintained by continuous production.

Once past the larval stage they metamorphose and settle at the bottom of the tanks. This stage is reached by around 15-20 days. They switch food from planktonic feed to detritus or to their ‘normal’ diet. Sufficient food and a hard substratum; the two most important conditions for pentactula to settle, are provided. If these two conditions are not satisfied the pentactula continue to swim in the tank for long periods. In order to achieve increased survival rate, a settling density at the optimum level between 200 and 500 juveniles/m² is maintained as higher densities and insufficient food will adversely affect growth and survival. Juveniles reach 20 mm in length after two months and 40 mm after four months.

The natural diet of bêche-de-mer is believed to consist of largely benthic algae and bacterial associated with organic detritus which they extract by ingesting and excreting large quantities of substrate. At this stage a ready-made food prepared at the facility is used. The food is simply ground rice mixed with the mud (or clay).

After 45 days in the hatchery tanks they will be taken to the grow-out area in the lagoon. Feeding is not essential during this time. However, usually rice-clay-mud mixture pallets may be added to water for boosting their growth rates. Harvesting will be done after 10-18 months.

These processes and facilities planned under the project are further explained in the following sub sections.
Figure 7: Schematic diagram of sea-cucumber aquaculture and processing
2.8 HATCHERY FACILITY DESIGN COMPONENTS AND PROCESSES

The design components of the proposed sea cucumber *H. scabra* farming considered in the facility are given in Table 5 and illustrate in Figure 8. All the units would have separate entry to avoid contamination from one unit to other. Moreover, the hatchery design and culture technique are also geared towards low cost and simplicity to ensure for the profit and return on investment. Hence, this project would have three types of culture tanks, which are fiberglass, canvas and HDPE geo-membrane. Fiberglass tanks used for egg incubation larval rearing and broodstock conditioning, canvas tanks would be use for live feed culture and HDPE geo-membrane would be used in nursery phase1 and nursery phase 2.

*Table 5: Key components of sea cucumber hatchery*

<table>
<thead>
<tr>
<th>S.N</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Broodstock conditioning unit</td>
</tr>
<tr>
<td>b</td>
<td>Larval rearing units</td>
</tr>
<tr>
<td>c</td>
<td>Live feed culture unit</td>
</tr>
<tr>
<td>d</td>
<td>Laboratory and office</td>
</tr>
<tr>
<td>e</td>
<td>Nursery units</td>
</tr>
<tr>
<td>f</td>
<td>Water intake and air supply</td>
</tr>
<tr>
<td>g</td>
<td>Air blower house</td>
</tr>
<tr>
<td>h</td>
<td>Pump house</td>
</tr>
</tbody>
</table>

*Figure 8: Key elements in the hatchery*

The proposed concept plan of the facility is illustrated in Figure 9 and shows all the units within the hatchery facility.
Figure 9: Proposed plan of the hatchery and associated facilities
2.8.1 Broodstock Unit

The key elements in the design of hatchery are power source, water inlet, nursery tanks, larva rearing unit and effluent discharge as shown in Figure 8. All these units in the hatchery are designed with separate entry to avoid cross contamination from one unit to another.

The hatchery will have three types of culture tank - Fiberglass, Canvas and HDPE geo-membrane. Fiberglass tanks will be used for egg incubation larval rearing and brood stock conditioning, canvas tanks will be used for live feed culture and HDPE geo-membrane would be used in nursery tanks.

2.8.1.1 Conditioning the Broodstock

As described healthy juveniles of \textit{H. scabra} would be obtained from island of Nalandhoo in Shaviyani Atoll or from another government approved sea cucumber farm. These sandfish seeds would be cultured in the lagoon until them reaches to mature size. The \textit{H. scabra} is a species that could be easily mature and spawn under captive condition. Healthy brooders would be chosen for spawning Aanimals weighing 250 – 500 g with no bodily damage or lesions due to collection procedures, have smooth and shiny skin with transparent mucous layer, and have not eviscerated should be selected (Al Rashdi, et al.; 2012). The broodstock will be conditioned them in 4 m³ tanks in hatchery at the density of 10 animals /m³. These tanks are filled with 10-15 cm layer of sand feeds provide daily at rate of 50 g/m². Brooders would be adapted in tank condition within 3-6 months after stock ing them.

2.8.1.2 Spawning

The spawning would be conducted in the broodstock condition and spawning unit in the hatchery. Prior to conduct spawning, special attention would be given to clean and disinfect the spawning tank with chlorine. After that tank would be filled with 1 micron filtered and UV sterilized seawater to a height of 30 – 40 cm. Aerate the tank water moderately to maintain uniform temperature and sustain the eggs in water column. Around 30 – 45 conditioned brooders would be gently cleaned and transfer them in to flat bottom tank with a volume of 1.5 m³. All sediments and faeces will be removed from the tank bottom by syphoning until spawning starts. Temperature shock treatment would be the method applied for spawning. In order to do this water temperature would be raised for 3–5 °C for 1 hour, by adding warmed seawater into the spawning tank or by using aquarium heaters. Newly spawned eggs are white, spherical and visible to the naked eye. Sandfish eggs range between 80 to 200 μm.

2.8.1.3 Egg Collection and Incubation

After spawning is complete, breeders will be removed from the tank, eggs would be siphoned out gently from the water column by using 50 – 80-micron mesh placed in a bowl. The eggs will be washed several times with UV- treated seawater to remove excess sperm and accumulated dirt during spawning. Then the eggs would be transferred to container for estimation before placing the eggs for incubation in larval rearing tank a stocking density of 0.5-1 per ml. Incubation tanks would be filled with 1 micron filtered and UV sterilized seawater. Hatching occurs at 36 hrs after fertilization at water temperature of 25-29 °C (Al Rashdi, et al., 2012). Important water quality parameters during larval rearing of \textit{H. scabra} is given Table 6. Newly-hatched larvae will be
maintained in the same tank where they were hatched. Larvae will be stocked at density of 1000/l of water volume in 1000-L plastic containers filled with 800 l of UV filtered seawater.

**Table 6: water quality parameters during larval rearing of H. scabra (Source: Al Rashdi, et al., 2012)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salinity, ppt</td>
<td>32-36</td>
</tr>
<tr>
<td>Temperature, °C</td>
<td>26-30</td>
</tr>
<tr>
<td>Rearing water</td>
<td>UV-filtered</td>
</tr>
<tr>
<td>Illumination, lux</td>
<td>400</td>
</tr>
<tr>
<td>Dissolved oxygen, ppm</td>
<td>6-9</td>
</tr>
<tr>
<td>pH</td>
<td>0.07-0.4</td>
</tr>
<tr>
<td>Ammonia, ppm</td>
<td>0.07-0.4</td>
</tr>
</tbody>
</table>

**2.8.2 Egg Incubation and Larval Rearing Unit**

Egg incubation tanks are placed in indoor area and where the egg incubation unit is always maintained clean and bio secured to avoid stress and contamination. It is an enclosed area with walls, roof and doors. This facility also has close control over the ambient environmental conditions from outside. For the purpose of egg incubation and larval rearing 24 fiberglass tanks would be used at a volume of 1.5 m³. The proposed project egg incubation and larval rearing facility are shown in **Figure 10**.

![Figure 10: Proposed egg incubation unit](image-url)
2.8.2.1 Feeding Management in Early Larval Culture

Growth and health of the larvae are primarily dependent upon an adequate supply of nutrient, both in terms of quantity and quality, irrespective of the culture system in which they are grown. There are various food sources used for sandfish larval rearing. However, the use of mixed algae is best for sea cucumber larvae (Al Rashdi, et al., 2012). The early larval rearing requires around 1-30 days during this stage the survival rates would be lower. First food for sand fish larvae would be a mixture of microalgae and it would be supplied to the rearing tank at the density of 20000 to 40000 cells/ml. Moreover, from day 8 to 12 suitable settlements would be installed in larvae rearing tanks. These settlement substrates are sprayed with combination of algal paste.

2.8.2.2 Juveniles Culture Nursery-1 and Nursery-2

The early juveniles would be harvested from larval rearing tanks after 30 days culture from larval rearing tanks. The juveniles sizes ranging from 10–20 mm would be removed from and transfer to a bare tank nursery – 1. Nursery – 1 would be consists of detaching, counting and grading the individuals overtime. The juveniles would be stocked around 500–700 juveniles per m². After one-month culture period in nursery-1 small juveniles are graded and transferred to nursery – 2 where the tanks floors covered with thin layer of fine sand. Dry algae or algae paste (Navicula sp) mixed with blended seaweed and shrimp starter food is usually given twice daily not more than 1 g/m². The juveniles would be stocked at a density of 300–200 juveniles per m².
2.8.3 Larval Rearing

Egg incubation tanks are placed in indoor area and where the egg incubation unit is always maintained clean and bio secured to avoid stress and contamination. It is an enclosed area with walls, roof and doors. This facility also has close control over the ambient environmental conditions from outside. For the purpose of egg incubation and larval rearing 24 fiberglass tanks will be used with a volume of 1.5 m³ each. The larvae will be checked every day for changes in shape, size, life cycle stage, and for the presence of bacteria.

2.8.4 Live Feed Culture Unit

As a separate activity live feed culture will be routinely carried out as part of the aquaculture process. Live feeds (algae) will be produced in a fully air-condition laboratory at the facility. A constant temperature of 18 – 20 °C is required for feed production. Live feed is required to rear the larvae – the most critical stage in the life cycle of the cultured species. Species of microalgae are cultured using light. In the laboratory they are maintained in controlled conditions so that lineage of culture line is maintained without any contamination. Outdoors they are cultured in large quantities for feeding the larvae.

For feeding larvae and juveniles Chlorella sp, Isochrysis sp, (both single cell phytoplankton) Chaetoceros sp (marine planktonic diatoms) and Navicula sp (marine benthic diatoms) will be used. stock culture of these species will be maintained indoors at the laboratory using artificial light and outdoors using sunlight.

The sea water medium is 1-μm mesh filtered and UV treated, and enriched with chemical fertilizers at the rate of 2 to 3 ml per l of water. Chaetoceros, Isochrysis and Navicula sp are all cultured in the laboratory or in outdoor tanks (water temperature: 29 – 30 °C) and fertilized with Guillard’s F/2 medium (Trademark: Proline). Feeding of auricularia larvae starts on Day-2 or two days after hatching (Al Rashdi, et al., 2012).

Feeding of the larvae and juveniles are the most important component in the aquaculture process. Feeding is critical for the larvae. The general principles are that water flow rate (rate of water renewal) and the concentration of food should be maintained at specific levels for different stages to ensure good survival rates. Feeding rate will be generally judged by colour change since it will be difficult to count or otherwise estimate residual algal cell densities. The Table 2 below gives some guidelines which are used at hatchery. From auricularia, larvae transform into doliolaria which is non-feeding. It proceeds the stage when the larvae settle in the tank bottom or on any substrates provided and begin their benthic life as pentactula larvae. This stage is reached 3 – 4 weeks after fertilisation when juveniles reach approximately 0.5 mm. At this stage larval feeding is slowly removed and the diet changed to a mixture of phytoplankton and Sargassum particles. The feed particles are added at a concentration of 1 ml/100 l tank volume.
Table 7: General feeding rates for larvae of H. scabra (Source: Al Rashdi, et al., 2012)

<table>
<thead>
<tr>
<th>Days after spawning</th>
<th>Feeding rate (cells/ml)</th>
<th>Water management</th>
<th>Stage</th>
<th>Other feeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No feeding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – 7</td>
<td>20,000</td>
<td>100% change every 2 days</td>
<td>Early auricularia</td>
<td>-</td>
</tr>
<tr>
<td>8 – 15</td>
<td>40,000 cells/ml</td>
<td>100% change daily</td>
<td>Mid to late auricularia</td>
<td>-</td>
</tr>
<tr>
<td>18 – 20</td>
<td>Non-feeding stage</td>
<td>100% change daily</td>
<td>Doliolaria</td>
<td>-</td>
</tr>
<tr>
<td>22 – 29</td>
<td>Benthic diatoms &amp; Sargassum extract</td>
<td>Flow through</td>
<td>Pentactula</td>
<td>-</td>
</tr>
<tr>
<td>30 – 40</td>
<td>Benthic diatoms &amp; Sargassum extract</td>
<td>Flow through</td>
<td>Juveniles</td>
<td>mixed algae: Chaetoceros, Phaeodactylum, Nannochloropsis, Isochrysis</td>
</tr>
</tbody>
</table>

2.8.5 Air Supply

In order to maintain proper aeration in the hatchery tanks adequate supply of oxygen will be made available through two 5 – 6 kW air blowers. These air blowers will provide aeration to all tanks of the hatchery facility continuously, including live feed production unit. In case of technical failures and drop in oxygen supply, there will be a standby air blower for immediate use.

2.8.6 Feed for Juveniles

After about 45 days the juveniles will be moved out from the hatcheries to grow-out area. Here feeding is generally natural. They ingest the loose surface layer taking out the microalgae and diatoms within them. In the Maldives food pallets are added to the lagoon for enhancing detritus layer which consists of ground rice and clay materials obtained locally as binding agent. In preparing the food material, rice is initially boiled followed by sun drying. Dried rice is then grounded and mixed with the clay. This feed material will be sprinkled into the lagoon almost on daily basis (Saleem, 2005). The proposed project however has no plans to add feed materials rather from juvenile stage to maturity sea cucumbers will be left to grow with their natural diet.

2.8.7 Chemical Use

The project absolutely requires use of certain chemicals as disinfectants and as nutrients for continuous production of healthy live feed for the sea cucumber larvae. The culture tanks will be fertilized with urea and ammonium sulphate at concentrations of 1 ppm. Important cell culturing chemicals include potassium, urea, ammonium chloride, manganese magnesium, sodium silicate
and silver nitrate. All these chemicals are used in very low concentrations of about 1 ppm. Further, chlorine is used to clean the hatchery tanks on a weekly basis for cleaning and disinfection.

Efforts directed at early detection of disease of aquatic organisms in the aquaculture setting would assist in eliminating the need to use these chemicals and reduce the risk to the aquatic environment.

Since chemical use will be relatively small and at low doses short term impacts associated with chemical use is not expected to be significant. This reflects the importance of an on-site water quality monitoring program.

### 2.8.8 Water Intake and Discharge

The seawater required for the hatchery will be drawn from an intake well located in the lagoon 20 m away from shore as depicted in Figure 11. From the water is pumped and is passed through sand micron cartridge filtration to remove colloidal suspension and sediments and will be stored in tanks from which seawater will be pumped to pass through UV for sterilisation before being pumped to the hatchery. The sea water will be stored in a 20 m$^3$ holding tank for supplying to various hatchery units. From the hatchery wastewater will be discharged into the sea. The schematic representation of the water circulation process is shown in Figure 12.

High quality seawater in a sea cucumber hatchery is an important prerequisite. Researches carried out in this field shows that numerous physical and chemical factors (e.g. temperature, pH, salinity, ammonia, dissolved oxygen, heavy-metal concentration, turbidity, etc.) will influence the success of a culture (FAO, 2004).

![Figure 11: Seawater Intake Well (not to scale)](image-url)
Figure 12: Seawater circulation at the hatchery\(^1\)

\(^1\) Based on a seawater circulation system already in place in a similar project in the Maldives.
2.8.9 Seawater Management

Fresh seawater is an important element in the commercial aquaculture of sea-cucumber. Hence proper management of seawater is critical for the good outcome of the project. As such measures will be put in place for regular monitoring of key parameters (pH, salinity, oxygen concentration, temperature) at intake before distribution to the hatchery tank systems. The water will be taken from a well placed in shallow reef flat (see Figure 11) where mixing is good by wave action. They are drawn by pumps in PVC pipes passed down a series of filters before been stored in tanks. In the tank systems, particularly the larval rearing stage water quality is checked at regular intervals. Water quality will be maintained by increasing rate of water renewal in the tanks. In addition to the usual parameters the concentration of the micro algae will be carefully regulated to provide optimum feeding conditions for the larvae.

The overflows from the hatchery with effluent discharged into the wastewater treatment system. Elsewhere in the Maldives, hatchery overflow is released back into the lagoon to slightly enrich the grow-out waters. The water from hatchery contains fertilisers which will enrich the sediments in the lagoon which the growing sea-cucumbers ingest. However, in addition to fertilisers, water from hatchery will also contain, animal faeces, excess food, dead animals, hydrogen sulphide and ammonia (James, 2004). Continuous discharge of such harmful substances even in low concentration into a relatively quiescent water body such as that found in the projects grow out area may have a cumulative effect. Therefore, as a precaution it is best to treat this water and discharge it thorough the outfall reaching beyond the house-reef.

During water changes a sieve (80 mm mesh size) is used to prevent loss of eggs and/or larvae. While the water is being changed, water is constantly and slowly stirred lightly around the tank to prevent damage to the larvae during the water change as without stirring the larvae would be forced into the sieve causing mechanical injury.

In coming water is required to have certain chemical physical characteristics to ensure its suitability for the hatchery. Thus regular water quality monitoring is critical at the facility. The following paragraphs highlight the most important water quality factors in the aquaculture of sea cucumber.

Temperature

At L. Gan, the average temperature of the seawater was 30.75 °C. The optimum temperature for rearing of the larvae is reported to be 28 – 32 °C (Asha & Muthiah, 2005) even though sea cucumbers can adapt a range between 10 and 26 °C (FAO, 2004).

Dissolved oxygen

Dissolved oxygen (DO) levels vary with water temperature. The higher the temperature the lower the DO level. Constant aeration is provided to the larval tanks throughout the day to make sure the oxygen level did not decrease. The DO should be maintained at >5 mg/litre (FAO, 2004). DO level in the lagoon was found to be 6 mg/l.

pH
Measured seawater pH at the project site was 8.5 which is within the normal pH range for seawater (7.5 – 8.5). Tests have shown that the larvae adapt to a fairly wide range of pH. However, when the pH rises above 9.0 or drops below 6.0, the movements of the larvae weaken and the growth cease. The optimal pH for hatchery is 7.8 (Asha & Muthiah, 2005) but it can range from 7.5 to 8.2. (FAO, 2004).

**Salinity**

Salinity is an important factor that affects development of embryo and larvae. Salinity of normal seawater at L. Gan lagoon was found to be 35 ppt. The lethal critical salinity is 12.9 g/l, whereas the ideal salinity for larval development was found to be 35 ppt (Asha & Muthiah, 2005). Extreme salinity levels adversely affect the normal development of embryos and larvae, resulting in a large number of deformed larvae and death (FAO, 2004).

**Ammoniacal nitrogen**  

The ammoniacal nitrogen (NH$_3$-N) content of seawater is very low. The main sources in breeding tanks are the metabolites of the larvae, excess food and decomposing organisms. Accumulation of ammonia in concentrations above 500 mg/m$^3$ can be harmful for the larvae. The larvae can develop normally with ammoniacal nitrogen in the range of 70 to 430 mg/m$^3$ of water.

**2.8.10 Wastewater Treatment and Discharge**

The wastewater generated in the hatchery, washing areas and processing area are passed to wastewater treatment unit as shown in **Figure 13** before pumped into sea via sea outfall. The average discharge volume is expected to be at 4.3 l/s hence a submersible discharge pump of capacity 13 kW will be used at the main discharge pumping station.

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2 A measure for the amount of ammonia, a toxic pollutant often found in waste products, such as sewage, liquid manure and other liquid organic waste products.
Figure 13: Wastewater Treatment Process
The water treated and discharge will maintain good standard in order to ensure that the project waste water dumped into sea does not deteriorate the quality of the reef and marine environment (Table 8). Hence the effluent quality would be well within the recommendations of the EPA.

**Table 8: Effluent treatment and discharge standard**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Units</th>
<th>Effluent parameters range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Temperature</td>
<td>ºC</td>
<td>27-30</td>
</tr>
<tr>
<td>DO</td>
<td>Mg/l</td>
<td>&gt;5.0</td>
</tr>
<tr>
<td>Salinity</td>
<td>ppt</td>
<td>30-36</td>
</tr>
<tr>
<td>Nitrite</td>
<td>mg/l</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>Nitrate</td>
<td>mg/l</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/l</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>mg/l</td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Chlorine</td>
<td>mg/l</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Hydrogen sulphide</td>
<td>mg/l</td>
<td>&lt;0.002</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>6.7-8.6</td>
</tr>
<tr>
<td>BOD5</td>
<td>ppt</td>
<td>&lt;0.5</td>
</tr>
</tbody>
</table>

**2.8.11 Sea Outfall**

A sea outfall of length 700m will be laid from the main discharge pump station to sea 10m away from the house reef. The outfall will be anchored using concrete anchor blocks as shown in Figure 14. As the lagoon is calm year round the anchoring is expected to be stable throughout the year, except on the reef top where wave action is high. The layout of sea outfall is shown in Figure 15.

The materials required for the construction of the sea outfall pipelines include HDPE pipes, anchor blocks, anchor bolts, uPVC straps as well as T-head diffusers. Pipe sections are fused together, and anchor blocks are placed at intervals. uPVC straps and stainless steel rods are used to fix the pipe to the anchor blocks. The pipe is laid along the profile of the seabed with a minimum gradient of 0.5%. uPVC straps along with anchor bolts are used to secure the pipes to the reef face. A diffuser is placed at the end of the sea outfall pipeline. A 250 mm minimum cover is provided from the pipe to the edge of the reef. The contractor is to assess the outfall site and its natural profile in order to produce a methodology to install and fix the sea outfall pipeline. The outfall pipe will be laid by certified divers, with the help of survey and engineering expertise to obtain the required gradient and positioning of the outfall pipe.
Figure 14: Proposed Sea Outfall

Figure 15: Wastewater collection and discharge outfall
2.8.12 Stocking Density and Method

Juveniles when they become suitable for release in the wild be released into the nursery. *H. scabra* juveniles requiring transfer from hatcheries will be placed in plastic buckets containing seawater and transported in pull carts to the adjoining lagoon where nursery has been set up. Stocking density is one of the most important aspect to be considered for a successful sea cucumber farm. The proposed project proper stocking density would be applied accordingly depending on life stage of the animal. The initial grow-out stocking density of cultured sandfish seed would be less than 50 individuals per m$^2$. Once the animal reaches to 50 – 100 g the stocking density could be reduced to > 5 individuals per m$^2$ Overstocking and crowding of sea cucumbers can lead to diseases and slow down their growth according to research. It has been demonstrated that a critical biomass value of 692 g m$^2$ is crucial to avoid negative effect on the growth of sea cucumbers. Below this critical mass sea cucumbers cease to grow (Lavitra, et al., 2010).

2.8.13 Grow Out Areas

Approximately 35 days after settling, at a length of around 5 – 7 mm, sandfish juveniles will be moved from settlement tanks to a nursery system as explained above. Nursery areas are sea pens that will be set up in the lagoon. All sea pens planned for the project will be constructed basically similar to that is being used in L. Dhanbidhoo aquaculture project as shown in Figure 16. Juveniles will be placed in the sea pens (nursery cages) at a stocking density described above. There will be two types of nursery cages distinguished as hapa nursery cages (fine mesh nets) and bag net cages placed in the lagoon. The juveniles going into a particular type cage depends on the size of the animals as given in Table 9. It is planned to have 24 hapa cages and 24 bag net cages in the beginning for juveniles. Hapa nets are routinely used in grow out for juveniles and have produced high survival and growth rates. Juveniles are known to feed on algal fouling that grows on hapa mesh (Mills, et al., 2008). Supplementary feeding is not expected when juveniles are transferred to sea pens.

Table 9: Net pens types used for grow out

<table>
<thead>
<tr>
<th>Weight range of sea cucumbers</th>
<th>Net pens</th>
<th>Net mesh</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 – 1 g</td>
<td>Hapa 1 m$^2$, 1 m deep</td>
<td>660 – 670 µm</td>
</tr>
<tr>
<td>1 – 2 g</td>
<td>Bag net 1 – 4 m$^2$, 1 m deep</td>
<td>1 mm</td>
</tr>
</tbody>
</table>

These cages will measure 5 m × 5 m and will be constructed in the grow-out lagoon area using plastic mesh nets, GI Pipes and PVC Pipes.
Once the animal reaches 50 g they will be transferred to grow-out phase 2 cages and stocking density would be 10 – 14 individuals per m². These cages will measure 14 m × 14 m and will be constructed the same materials with a mesh size of 4 mm. Total final stage cages 100 sea pens.

A conceptual drawing of the proposed sea pen structure is depicted in Figure 17.

In all cases stocking density will be carefully controlled as the higher stocking density could affect their growth, survival and feed conversion ratio.

2.8.13.1 Cage management

To maintain good water quality is essential for culture animal to sustain in good health condition and also it helps to maintain uniform growth. Therefore, this project would have special consideration to study the lagoon area to know the water current before locating the cages. Moreover, clogged nets replaced regularly to access water flow and also to prevention of parasite
diseases. The clogged nets would be dried under the sun to destroy the pathogens wash the nets with fresh water then store it for future use. Regular cleaning and maintenance of cage nets will be implemented at the project.

2.8.14 Harvesting and Handling

The sea cucumbers reach a marketable size they will be collected by hand. The harvested sea cucumbers will be kept in cold seawater until cooking takes place. Generally typical grow out time from a 2 – 5 g juvenile to 350 – 400 g saleable product is around 12 months (Mills, et al., 2008).

2.8.15 Final Processing

In order to fetch premium market price, the sea cucumbers will have to processed properly which implies the transformation of live sea cucumbers into a product form that can be exported or sold for consumption. In order to maintain the premium quality, the final product will be clean, unbroken and in an appealing form to fetch the best price for the dried bêche-de-mer. Export of poor quality bêche-de-mer represents uneconomic utilization of the resource (FAO, 1992). Although there is no ideal method for processing, the steps that is described here are based on the guidance provided by the FAO on processing sea-cucumber and the expertise gained from local project in the Maldives. These major steps include:

- Blanche first and squeezing out guts
- Cutting across mouth and making a small slit on underside of the animal
- Cleaning
- Cook sea cucumbers in hot seawater (60ºC to 80ºC), stir sea cucumbers every 5 minutes;
- Take out after they have cooked for the desired time and cool for 2-3 hrs;
- Salting for a week;
- Smoke the sea cucumbers in a smoker;
- Removal of spicules from body wall;
- Soak in seawater or bury in sand for overnight;
- Clean
- Re – boiling
- Dry it second time; and
- Vacuum packaging for export.

These potential steps have also been depicted in Figure 7 above. The steps may slightly differ in actual practice and over time with better experience and knowledge improvements could be brought to the way sea cucumber is processed. Not all final products may be smoked dried. The final drying may be tailored on the export market preference. Nevertheless, boiling and smoking will be part of the process and will require fuel energy. In some island countries, demand for fuel wood for sea cucumber processing has resulted deforestation and habitat destruction (Eriksson, 2012). Learning from the experiences from elsewhere it is intended to opt fuel by the following ways; boiling of sea cucumbers will be done with cooking gas supplied from Male’ and smoking will be done mainly by burning dried coconut husks which will be obtained from L. Gan and from nearby islands. Coconut husks are generally discarded as waste products. Large plantations of
coconut trees in Gan can be a good source of coconut husks. Drift wood and imported firewood may also be used. However, the project would not undertake any form of logging for the sake of obtaining fuel wood.

**2.8.16 Product Storage Unit**

Harvested and treated sea cucumbers will be vacuum packed and stored in product storage unit. The produce will be kept dry and above the ground to avoid mould from moisture. The storage space will be regularly checked for the presence of rodents and pest infestations.

**2.9 FRESHWATER USE**

About 2.5 tonnes of fresh water has been estimated to be required on a daily basis for various purposes at the facility such as salinity adjustment, equipment cleaning and domestic use. Most of this will come from rainwater tanks installed in the compounds of the project site (Figure 18). When the facilities are fully complete the total roof area will be 30,000 ft². Taking into account the average rainfall, it was determined approximately 1,457,820 gallons of rainwater can be collected per year. This means on average 15,119 litres (15.1 tonnes) of rainwater can be available for operational purposes on a monthly basis with adequate storage capacity in place. The technology intended to apply for collection and safe use of rainwater is flexible and quite simple. The running costs will be low, the construction, operation, and maintenance are also not labor-intensive (see Figure 19).

Rainwater storage maintenance practices will include;

- Periodic cleaning and checking of the cisterns;
- Regular cleaning of the roof catchments to remove dust, leaves and bird droppings so as to maintain the quality of the water produced; and
- Gutters and down pipes will be periodically inspected and cleaned carefully.
Part of the water use will be met by using groundwater mostly for toilet flushing.

Being a large island, L. Gan is believed to have good groundwater reservoir and physical and chemical tests carried out for the groundwater showed that it is suitable for certain uses. However, the proponent is aware that overuse of island’s groundwater can be damaging to the fragile water lens and therefore it has to be used wisely and responsibly. Groundwater lens thickness of the project site was calculated using the algebraic method described by (Bailey & Khalil, 2014).
Equation and Table 10 below shows the formula and input data used for the calculations and results.

\[
Z_{Lim} = y_0 + (Z_{HP} - y_0)(1 - e^{-dw})
\]

\[
Z_{Lim} = 12.75 \text{ m}
\]

Table 10: Input data for water lens calculation and results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>(y_0)</td>
<td>-16.07</td>
</tr>
<tr>
<td>d</td>
<td>0.0075</td>
</tr>
<tr>
<td>K</td>
<td>200 m/day</td>
</tr>
<tr>
<td>(Z_{HP})</td>
<td>15 m</td>
</tr>
<tr>
<td>w</td>
<td>350 m</td>
</tr>
<tr>
<td>Project area</td>
<td>2,787 m(^2)</td>
</tr>
<tr>
<td>Area of L.Gan</td>
<td>5,657,000 m(^2)</td>
</tr>
<tr>
<td>Available volume of water</td>
<td>35.5 ML</td>
</tr>
<tr>
<td>Available amount of water (tons)(^3)</td>
<td>97 tons/day</td>
</tr>
<tr>
<td>Sustainable yield (tons)(^3)</td>
<td>3.2 tons</td>
</tr>
<tr>
<td>Percentage of water lens impacted</td>
<td>0.003%</td>
</tr>
</tbody>
</table>

The calculation were based on the limiting thickness defined by (Bailey & Khalil, 2014) as a consequence of Thurber discontinuity as a result of hydrologically distinct Holocene and Pleistocene aquifer. The calculations were done assuming that the water lens was fully recharged, and available water was limited to the footprint of the project area, hence the percentage of water lens impacted is a slight underestimation, which is sufficient for the impact assessment. Nevertheless, the calculations show that with the proposed limited water use by the project will not have a significant impact on the island’s groundwater lens. The results showed that the sustainable yield of groundwater was 3.2 tons from the project area, which meets the freshwater requirements of the facility with no significant impacts.

2.10 POWER GENERATION

The project proponent plans to source power from existing power grid in L.Gan operated by FENAKA. Consultation has already been made with FENAKA regarding the use of island’s mains for sourcing power. However, due to the limitation of the existing mains network it is not foreseen that electricity from the mains can be supplied to the project area when the project commences work. Hence the proponent will be installing onsite gensets for the power production and when islands mains network reaches the project area, the onsite system will act as a redundancy power system. For the entire operation the energy requirement is expected to be approximately 30 kW. Two diesel generator sets of size 20kW and 24 kW will be installed as backup power to be operated one at a time until power connection to the grid is made.

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\(^3\) Based on 10 staffs as per safe yield of 300 L/day per person, determined by Bailey & Khalil, 2014
The power system will be designed and installed to comply with the Maldives Energy Authority’s (MEA) Guideline for Power Systems Approval and Guideline for Approval of Standby Power Generation and Electricity Regulations of the Maldives. In this regard following directions will be taken into account in the detailed design of the power system.

- Generator house will be located away from the accommodation units (at least 200ft from the living areas);
- the generator house will be soundproofed;
- sound level at 1 meter from the generator will not be higher than 70 dB (A);
- stack height will be such that it will meet the regulatory requirements with the objective of avoiding any disturbance by exhaust emission from the generator;
- temperature immediately outside the wall where the generator is located will not be more than 10 degrees Celsius higher than the ambient temperature; and
- cooling air released from the generator will not be faster than 5 meter per second.

Following the construction of the power system it will be registered at the Maldives Energy Authority (MEA).

### 2.10.1 Fuel Handling and Storage

Since all the energy required for the aquaculture work will be mainly generated by diesel generators the site is required to have an oil storage system. The fuel required for the operation is expected to be 200 liters x 4 barrels which will be stored in a fuel tank with proper bund to contain the fuel stored in the storage in a situation of any accidental spill. This fuel used for the operation will be sourced from fuel suppliers. The fuel storage tank with metal key box to prevent contact with the ground will be kept isolated connected by hose pipe and a small pump supplying fuel to the generator set. Fuel tank will be kept protected from rain by placing a small roof above the tank. The arrangement for storing the fuel is depicted in (Figure 20) Fuel will be handled and stored with maximum precautionary measures. Fuel storage tanks will be constructed in such a way it will not be in contact with the ground and protected from rain and any spillage will be contained. The bund wall around the fuel storage tanks will ensure fuel storage handling and safety regulations are enforced.
Figure 20: Proposed fuel storage for standby genset (Source: http://www.eurodieseltank.com/products/storage-diesel-tanks/storage-diesel-tank-5000-litersdetail).

2.10.1.1 Fire Safety

National Fire Code (NFC) will be strictly followed while handling, transporting and storing fuel. Closed-off, non-public storage areas will be provided for inflammable goods such as fuel drums, portable fuel containers Liquid Petroleum Gas (LPG) bottles and cleaning solvents and chemicals. Fire extinguishers and instruction in case of fire will be located in all the public, industrial and staff accommodation areas. Fire safety standard set by the National Security Service (NSS) and NFC will be met, and the overall, safety management plans at the project site will meet the NFC requirements.

The following specific aspects will be covered in the facility to prevent fire incidents:

- Installation of smoke detectors at appropriate locations;
- Standpipe hose connections will be in place;
- Emergency lights installed in important locations;
- Portable extinguishers placed to be readily available when someone finds a fire;
• Placing at least one portable firefighting pumps or pressurized fire hydrants at suitable location;
• All staff shall be trained with basic firefighting skills before beginning operations at the facility;
• 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; and
• Cooking gas used in kitchen will be kept in a separate shed outside the kitchen area.

2.11 WASTE MANAGEMENT

Various types of wastes are anticipated from the project including solid wastes, yard wastes, human wastes as well as waste stemming from the aquaculture related activities. It is important to note that waste shall be disposed of at the closest waste management centre that has the capability to handle construction, operational and hazardous waste that may be generated. At the time of EIA, there is no proper waste management facilities in L.Gan. Hence the closest waste management centre at Thilafushi shall be utilised during the project, until a waste management facility is established closer to the project area.

2.11.1 Solid Wastes and Human Waste Management

The proponent is cognizant of the fact that unsuitable management of waste generated can deteriorate the health of the environment, can negatively affect the project progress and hence efforts will have to be made to sustainably manage solid waste and other wastes generated at the project site. The issue of waste management will be challenged by the fact that L. Gan has no proper facilities or a system to manage its own waste. Haphazard waste littering and disposal of waste in public areas throughout the island has been observed to a major environmental problem faced to the island. The project’s waste during all stages will be managed in a responsible manner that is least impactful to the environment. It will give most priority to reduce waste at the first place and where waste generation is inevitable it will sort the waste so that wastes can be reused and recycled. The management will ensure that wastes requiring disposal is minimized to best extent possible. Waste management would be divided into two major phases. Initially it would not be possible to determine the nature of the waste and their composition in the waste stream. Hence responsible approach will be adapted at the early stages of the project. During the implementation phase a proper waste audit will be conducted and the project’s waste management plan will be developed.

2.11.1.1 Site Preparations and Construction Phase

During the site preparations, the existing waste dumps will be cleaned. Illegal dumping of waste in the surrounding areas have resulted in much accumulation of various types of wastes. All waste that have been accumulated in the premises will be removed and piled. These will be packed in appropriate containers and shipped to Thilafushi. A large volume of yard waste and vegetation waste are also expected to be generated during site preparation, However, when it comes to transport of a large volume of green wastes to Thilafushi costs as well as fuel burnt for transportation does not justify it. Therefore, all green wastes produced during site preparation will
be collected at a designated area within the project site and allowed to dry in the sun and will be burned to reduce the volume. Tree branches will be stockpiled and dried and stored for later use. The ash will be buried within the site. All chemical wastes will be collected and sealed for transportation to Thilafushi. Similarly, plastics, metal, glass wastes will be stored at the waste management area later removal and transportation to Thilafushi. Excess soil generated will be piled and will be provided for local construction and backfilling purposes.

2.11.1.2 Operational Phase

During the operational phase of the project the waste management has been planned to be fully developed in two stages. In stage one, a proper waste audit at the project site will be conducted, technologies, and waste management options will be explored and the Best Practical Environmental Option (BPEO) will be selected and the project’s waste management plan will be developed and improving the overall waste management at Gan will be explored in close consultation with the Island Council. It is expected that stage one will last approximately a year from the date of the start of the operations. In stage two, all necessary technical and technological capacity for the operations will be acquired and the waste management plan will be fully implemented. It is expected that in year two the plan will be in full implementation.

Determining the waste generated at the site is the initial critical step required for formulating a proper waste management system since there are no data on waste generated for a project of this nature available.

A waste management/disposal site would be established and demarcated within the project boundary, and appropriate mechanism to collect and transport waste generated at the site will be planned and executed. Workers will be employed to regularly clean, collect and manage waste on the site.

Based on consultant’s experience it is anticipated even from the beginning yard waste is expected to be the most significant component in the waste stream. Considering the major groups of wastes, organic wastes is expected to constitute the largest fraction and other categories of wastes are expected to be significantly lower compared to the organic fraction. All other major categories including combustible wastes, glass wastes and metal wastes are expected to be very small. Similarly, hazardous waste fraction is expected to be very small of the total waste generated. The actual contributions of these waste types will become clear following the planned waste audit.

During the project implementation waste management at the project site will be broadly based on waste minimisation, re-using, recycling and disposal.

Waste Minimisation

Minimising the waste at the site will be an important strategy even from the outset which will be achieved through reduction and resource use efficiency.

The following specific strategies will be in place to reduce waste generated.

- Doing proper planning and designing of the facilities and proper material list to ensure required quantities are brought to the site for construction purposes;
• careful siting of the buildings to avoid unnecessary removal of vegetation to minimize waste;
• site supervisor/store keeper to control the materials issued for construction and operations purposes;
• avoiding use of disposable items for the project purposes as far as possible;
• create awareness among workers on waste minimisation;
• establishing purchasing guidelines to encourage the use of durable equipment (which can be repaired easily) and high-quality, reusable products for the project;
• using refillable containers for such items;
• using plates with washable cups, dishes and utensils instead of plastic/foam cups, utensils;
• using cloth roll towels or hand dryers instead of paper products;
• using bulletin boards for memos, pamphlets and brochures instead of circulating copies to all staff;
• using e-mail;
• purchasing refillable pens and toner cartridges; and
• using shredded paper instead of bubble wrap or foam for packaging purposes.

Green Purchasing

Green purchasing is increasingly seen as an important approach to waste management. Purchasing “green” products makes good business sense since it can save money, addresses the problems of persistent toxic substances in the environment, conserves natural resources, reduces the quantity of solid waste generation and saves energy and resources in dealing with waste. The following three main dimensions will be implemented to adopt green purchasing policies when making purchasing decisions:

• Products that may release persistent toxic substances into the environment during production process, use and disposal shall be avoided;
• Products that considers conserving energy and resources during production, use and disposal shall be preferred;
• Products that contain little or no toxic substances to avoid any harm to humans and the environment;
• Consider the life cycle cost of products in selecting products;
• Substitute non-toxic cleaning products and try alternative methods of pest control.

The Recycling and Reuse Quality of Products

• Preference will be given to products made from recycled materials or renewable resources used in a sustainable way. Items with a recycled content include paper, packaging materials, plastic, glass and metal;
• Buying reusable products as opposed to those that can only be used once; and
• Choosing products that are easily recycle or composted, or are truly biodegradable.
Products That Used Minimal Packaging

- Packaging for the product is minimal but adequate to ensure protection;
- Purchase items shipped in bulk to avoid individual wrapping of items;
- Purchase from suppliers that are committed to the environmental improvement to encourage the use of green products; and
- Minimize non-recyclable packaging. Chicken, fish, and vegetables are often packaged in waxed cardboard. Asking vendors to pack materials in reusable or recyclable containers.

Waste Reuse and Recycling

Reusing items by repairing, selling or donating these to island community reduces waste. Reuse is preferable to recycling since the item does not need to be reprocessed. In addition to environmental considerations, sensitive reuse schemes can have important social and cultural benefits. Given below are some of the ways the project plans reuse items:

- Donation of used linens, towels and blankets to locals;
- Installation of a dispensing system for products such as shampoo, soap and lotions in toilets and washing areas;
- Using old linens to make aprons or cleaning rags;
- Donating the old furniture and equipment to locals; and
- Reuse waste paper as telephone answering pads or notes at project office.

Administrative and Office Functions

- Reduce paper use, e.g. double-sided photocopying;
- Donate old computers and equipment to schools or NGOs;
- Reuse bubble wrap and foam packaging for shipping;
- Re-label and reuse cardboard boxes for shipping; and
- Use refillable, reusable toner cartridges for laser printers.

Composting

Composting is an effective way to recycle food wastes and yard wastes. However, at this stage it is not clear the volume of wastes suitable for composting that will be generated. The type of technology and other specifications will be determined in year two of the operations. During the interim period the food wastes will be buried and yard wastes will be burnt in small volumes in an open area when the wind blows seawards and ashes will be buried. Similarly, gut waste will buried in a pit with organic waste to act as compost.

Waste Disposal

Disposal of waste is inevitable in any waste management system since there will always be the need to dispose residual waste at a landfill. In the waste management hierarchy disposal of waste at a landfill is least preferred and therefore efforts will be made to reduce waste needing to be
transported to Thilafushi (or when the south regional waste management facility comes into operations to S. Hithadhoo). All the metal wastes, glass wastes, hazardous wastes and residual construction waste will be packed appropriately and shipped to landfill at regular intervals.

2.11.1.3 Hazardous Waste Management

Hazardous waste such as used batteries, chemicals, waste oil, etc generated at the project site although is expected to be very little shall be dealt carefully. Efforts will also be made to reduce hazardous through appropriate strategies such as use of rechargeable batteries over the use of dry cells and button cells. All hazardous wastes will be carefully packed in a sealed containers and sent to Thilafushi.

Waste Management Equipments

In order to reduce the volume of plastics, glass bottles and yard wastes, the project will place the following equipment.

Placing Bins

In order to keep the project site clean and prevent littering, bins of appropriate size will be conveniently placed in its premises. The bins will be emptied by staff and kept in a clean and sanitary state, with the lid closed. Food and beverages, putrefying wastes will be collected separately by placing separate bins for those so will the toxic or hazardous waste will be kept in separate bins and will be labeled as such.

High Density Compactor

The machine can compact and bale tough materials such as PET – bottles, tin/steel cans, plastic jugs and containers, aluminum drink cans, paint cans etc. It will produce small and tight bales that can be secured by up to six straps including one cross strap.

Glass Crusher

This unit can be used to dispose of all glass products (broken glass, old bulbs, glass bottles etc). All glass can be crushed to sand fine particles which would be used for beach rehabilitation or easily disposed of with sand or could also be given to locals for preparing cement aggregates in building works.

Shredder

The shredder will be used to chop yard wastes and tree branches. Reducing the volume will have the advantages whether it is stockpiled, burnt or composted at a later stage.
Staff Involvement in the Waste Management

In setting out waste reduction strategies, it is intended to involve staff to make them part of the solution. Staff will be encouraged to provide new and innovative ideas on waste minimization. Project Environmental Policies (PEP) will be developed in which waste management will form an integral part. During the staff recruitment process, making newly recruits to understand the PEP will be made essential.

Overall Strategy

Overall waste management strategy proposed for the project thus involves reducing at source through various initiatives, collection, separation, resource recovery, storage, transport and final disposal as demonstrated in Figure 21.
Wastewater Management

Gan Island where the project will be sited has a proper sewerage system installed. However, discussions with the operator (FENAKA) revealed that their service area is limited to local population region and the network is not expected to be extended to the project location in the near future. The plan therefore is until the island’s main sewer network is extended to reach the project location to design and implement a septic system.

Hence until such time the island’s main sewer network reaches the facility, septic system will be used to manage grey and black water during the construction and operational phase. The septic
EIA for Sea Cucumber Culture in L Gan, Maldives

system, when performing properly, safely treats and disposes sewage without creating any danger to human health or to the environment.

The system will be constructed with concrete consisting of an airtight tank and a drainage system. The septic tank is divided into two chambers; the larger chamber will receive toilet effluents and this portion of the septic tank will provide a relatively quiescent body of water where the wastewater is retained long enough to let the solids separate by both settling and flotation. The scum will float on top of the water surface in the tank forming scum layer while the sludge will settle to the bottom of the tank forming sludge layer. The liquid layer or the effluent layer found in the middle of the top and the bottom layer will pass through an opening into the smaller portion of the tank from where it will flow into the soil absorption unit (settling tank) through a pipe.

Based on experience, and considering the smaller number of expected regular users (10 staff) of the toilet facility, the septic tank by this design with appropriate dimensions (detailed design to follow based on this concept) is expected to be in good condition for a period of 10 -15 years.

The high permeability of the sandy soil on the one hand is an advantage for the system, the high water table (approx. 1 m from the surface) on the other hand raises some concerns over its impact on the groundwater. However, since the septic system will be isolated and no groundwater abstraction will take place near the septic system any risks associated with the system is considered to be virtually nil. Figure 22 shows the septic tank concept design proposed to be used at the facility.

![Fig 22: Septic System Concept](image)

To lengthen the “retention time”, - of the wastewater in the septic tank for enhancing treatment, all possible measures will be taken to reduce unnecessary discharge and too a large a volume of water at once into the septic tank. Therefore, the amount of water entering the septic system will be controlled. In this regard, the laundry and kitchen wastewater will not be allowed into the tank instead it will directly pass into the settling tank. If allowed into the septic tank the laundry wastewater is believed to slow down the microbial processes in the tank.
Good practices such as installing water saving devices in the toilets such as low flush toilets and shower heads and fixing leaky faucets and checking the system regularly will improve the functioning of the system.

### 2.11.3 Operational Phase Wastewater Disposal

#### 2.11.3.1 Wastewater from Hatchery Processes

Waste effluents and sediment produced from hatchery process would consist of faecal matter, fertilizer, feed spill, chemicals, organic matter, uneaten food, fine sand particles, the proposed project would have special consideration to minimize quantity of effluents and sediments during culture process.

Effluent and waste water from culture facilities would be treated prior to discharge.

The waste generated during culture process would be collected in the effluent sedimentation tank and treatment tank.

The sedimentation tank is a combination of many compartments, with different types of filtering materials. These compartments able to remove every kind of waste produce during production process.

After the sedimentation process it would head to treatment tank, here the water will chlorinate and de-chlorinate.

The point of discharge of aquaculture effluents would conform to the specification as specified in the Table 8 and effluent concentration would be monitored after treatment process before discharge in to the sea.

If the effluent concentration is greater than the limits it would be further treated prior to discharge.

#### 2.11.3.2 Wastewater from Boiling Sea Cucumbers

Sea cucumbers are known to contain many different compounds of which saponins have been identified to be the most common and abundant group of secondary metabolites in their body (Bahrami, et al., 2014). These compounds are well known for their wide ranging medicinal properties (Caulier, et al., 2013). Commonly known as holothurins are the major saponins found in sea cucumbers (Song, et al., 2014). In the body wall saponins are found with a mean concentration of 1 gkg\(^{-1}\) of tissue wet weight while the highest number of saponins are found in the viscera of any sea cucumber species (Bahrami, et al., 2014). Saponins are also found in the Cuvieran tubules (Caulier, et al., 2013). Even though saponin are known for their multiple pharmacological effects, they act as a chemical defence against potential predators (Bahrami, et al., 2014). Because of their amphiphilic property, these molecules present deleterious membranolytic effect making them toxic for most organisms (Van Dyck, et al., 2011).

One of the biggest challenge in large scale sea cucumber processing is the large amount of waste water generated from boiling sea cucumber. Locals involved in sea cucumber processing have observed the deleterious effect of waste water dumping in the sea with resulting fish kill. It is believed that saponins found in the sea cucumber gets accumulated in water during the boiling
process and becomes the cause of fish kill. Saponins are found to be soluble in water or aqueous alcohols and forms adducts in with cholesterol. Pharmacokinetic studies conducted by (Song, et al., 2014) showed that when these chemicals are administered intravenously they get eliminated rapidly compared to administration of compounds orally. This suggested that effects of these chemicals are prolonged when ingested.

According to previous EIA’s and stakeholder consultations with MRC, it has been highlighted that discharging large amounts of these effluents to a calm lagoons or in the oceans may have negative impacts on biodiversity.

The underlying management of these chemical arising from processing involves dilution. Gut waste shall be cleaned thoroughly with aqueous solution to strip off the chemical. They can then be shredded and buried or used for composting. Solution used for cleaning and waste water from the boiling process will be mixed with wastewater from the hatchery for dilution and treated before being pumped out of the reef where effectively more dilution would take place (See Figure 13).

2.12 GENERAL SAFETY STRATEGIES

General safety strategies planned for the facility include but not limited to the following:

- Security personnel will be on duty to prevent unauthorized people walking into the facility to ensure illegal activities are prevented within the premises;
- The onsite use of protective clothing and equipments and provision of health and safety information for employees and contractors;
- The periodic inspection of various safety, fire and spill protection facilities and equipments; and
- Conducting on the job training to the relevant staff on storage, handling and use of harmful substances.

2.13 PEST MANAGEMENT

Common pests such as mosquitoes, rats, cockroaches and other pest insects are considered potential pests for the facility. Pest management will be given high priority to ensure that the produce from the facility are of high quality at the same time workers in the facility are provided a clean and safe working environment. It will be made part of the facility management. An Integrated Pest Management (IPM) program planned to be implemented at the facility involve proactive measures to discourage pests from infesting the buildings as well as the compound by limiting access to their basic necessities which are food, water and shelter. The facility’s approach to IPM relies on preventive methods to assess pest pressures, implement a science-based pest control strategy and monitor specific pest activity in order to help keep pests from checking in.

The facility’s pest control strategy involves the following major approaches:

**Exclusion**: During the construction of the buildings etc special specialist advice will be sought to seal potential pest entry points making the buildings less accessible to pests.

**Rat control** – Rats are likely pests that can be a major nuisance and cause property damage to buildings, roofs and ventilations systems. Controlling availability of food and maintaining general
cleanliness of the buildings and the compound would be key to controlling potential problems of rats.

**Mosquito control** – Due to the thick vegetation that surrounds the facility and poor waste management in the surrounding areas mosquito control will be a major challenge for the proponent. Insecticide fogging as a technique to control mosquito populations is often used in the Maldives to control mosquitoes. Whereas, the facility intends to adapt an IPM at combating mosquito populations. For example, mosquitoes breed in water, so the elimination of standing water around at and surrounding areas will be an essential part of the approach to controlling mosquitoes. The management will ensure that the facility premises and surrounding areas are free from any size of container such as empty jars or cans, pots, saucers, coconut shells, husks and other accumulated litter that can provide a habitat for mosquitoes to hatch if they remain filled with water for more than a few days. Killing mosquito larvae by draining water before they emerge as adults can reduce or eliminate the need to spray pesticides to kill adult mosquitoes. Because mosquitoes may travel several miles as adults, any management efforts may provide only temporary control. Hence, mosquito fogging in the surrounding areas may become necessary depending on the situation. Certain chemicals used in fogging are known to cause human health risks as well as are known to cause harmful effects on the environment. However, according to WHO synthetic pyrethroid used in insecticides is very similar to the insecticides used in most domestic insect spray cans are therefore not considered harmful to humans (WHO, 2017). Nevertheless, as described above, in controlling mosquitos, fogging will not be the preferred choice and where the use of fogging becomes inevitable, only those chemicals which are approved by a respected authority will be considered. Other precautions will include, seaward winds, providing protective gears to worker and informing guests and locals of the fogging activity.

**Flies, cockroaches and ant control** – The most cost effective method that can be applied in controlling these pests is to keep the buildings and the surrounding areas clean. Regular washing of the storage areas, sweeping of the compounds and proper waste management will ensure the facility areas are kept free from these pests. Chemical solutions will only be opted as a last resort and even in such cases chemicals that are approved by the WHO and local authorities will be used.

### 2.14 HAZARD AND RISK MANAGEMENT PLAN

#### 2.14.1 Genetic Risks

The species to be farmed at the facility will be *H. scabra* or the sandfish. The species is not native to the Maldives and is believed to be translocated from India (Bruckner, 2004). Since *H. scabra* has limited geographic range with strong genetic integrity (Uthicke & Purcell, 2004), it is not understood how the population in the host environment will be impacted by such translocation (Bruckner, 2004). Since the proposed project does not involve large scale translocation of young sea cucumbers genetic risks on the host population can be ruled out. When the facility starts its own hatchery program careful management for broodstock will have to be in place to avoid genetic inbreeding or genetic homogenization.
2.14.2 Risks of Diseases

Another important risk involved in the aquaculture of sea cucumber is outbreak of diseases. Dense populations of farmed sandfish contract diseases at various levels of the life-history (Lavitra, et al., 2009). Common diseases of farmed sea cucumbers is summarised in Error! Reference source not found..

Table 11: Diseases of cultivated sea cucumbers. Source: (Lavitra, et al., 2009)

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Symptoms</th>
<th>Infected stages</th>
<th>Responsible agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkening of the body edges; diseased specimens undergo autolysis and the body completely disintegrates within two days.</td>
<td>Auricularia</td>
<td>Juveniles</td>
<td>Bacteria</td>
</tr>
<tr>
<td>The stomach and/or the intestine walls of larvae are atrophic.</td>
<td>Auricularia</td>
<td>Juveniles</td>
<td>Bacteria</td>
</tr>
<tr>
<td>Presence of gas bubbles inside the body of the larvae, which results in anorexia.</td>
<td>Auricularia</td>
<td>Juveniles</td>
<td>Protozoa</td>
</tr>
<tr>
<td>Diseased specimens present oedema near the peristome. The juveniles’ tentacles cannot retract; they lose the ability to remain attached to available substrate. The juveniles may eviscerate. The body wall becomes covered of mucus; the epidermis disappears and the whole body can dissolve with autolysing process.</td>
<td>Juveniles</td>
<td>Juveniles and Adults</td>
<td>Bacteria</td>
</tr>
<tr>
<td>The wound appears near the cloacal orifice and extends over the whole body surface. The integument becomes whitish and spicules may be exposed. The highly infested specimens become weak and died</td>
<td>Juveniles and Adults</td>
<td>Broodstock</td>
<td>Copepods</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Isopods</td>
</tr>
</tbody>
</table>
The disease is highly contagious and expands quickly in farmed populations.

<table>
<thead>
<tr>
<th>In the days that followed.</th>
<th>Infected individuals are weak and anorexic. The body becomes stiff and is covered in excessive mucus. As the infection progresses, the entire viscera is usually expelled and eventually the infected specimen dies.</th>
<th>Juveniles and adults</th>
<th>Platyhelminth</th>
</tr>
</thead>
<tbody>
<tr>
<td>The papillae of diseased specimens become white. The body wall appears bluish white with the development of the infection. The body wall becomes thinner and the affected individuals develop oedema.</td>
<td>The protozoa live in the digestive tract and in the respiratory trees of holothuroids and may provoke internal wounds. The infected animals tend to be weak and sluggish. The body usually shows no conspicuous lesions, however the intestine, respiratory tree, etc. can be eviscerated in severe infections.</td>
<td>Juveniles and adults</td>
<td>Fungi</td>
</tr>
<tr>
<td>Juveniles and adults</td>
<td>Protozoan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the beginning of the operations since the juvenile sea cucumbers will be transported from another island to the project site, with those, the risks of introducing diseases into the new environment may exist. Additionally, in the grow out areas natural causes can also result in outbreak of diseases. In order to prevent and control introduction and spread of diseases the following measures have been planned to be in place:

- Requirement on the supplier to certify that stock supplied is properly inspected to ensure that they are free from diseases and pathogens;
- Careful inspection of stocks arriving at facility for any signs of pathogens and diseases before introducing into the natural environment;
- Establishing quarantine arrangements at the facility for inspection and isolating suspected organisms;
- Systematic inspection of animals and equipment to detect early signs of pathogens or disease;
- Prohibition of use of antibiotics at the facility as a measure to control diseases;
- Avoid overstocking (should not be more than 2 individuals/m²) and intensive farming;
- Protocols to destroy batches in the event of an large scale outbreak of a disease; and
- Regular cleaning of the cage nets.

### 2.14.3 Risks of Algal Blooms

Addition of supplementary food to the lagoon system will enhance the nutrient levels of sea-water. Also over long-term excess food may accumulate in the benthic environment raising the nutrient level of sediment. Increased nutrient level may cause pollution and algal bloom may be inevitable. Such an algal bloom may have a devastating effect not only in the natural environment but also on the sea cucumbers in the grow out area. Studies conducted in Nalandhoo showed that the risks of such an incident is relatively low as the DO levels in the fertilised water were only found be in good conditions compared to controlled environment even after repeated fertilisation (Saleem, 2005). The following measures will further decrease the risk of creating an algal bloom in the lagoon as a result of the project activities:

- Continuous regular monitoring of the seawater quality and sediments;
- Preventing addition of supplementary food into the lagoon;
- Discharging fertilised water from hatchery off the reef and into the deeper waters; and
- Prevent over stocking and maintaining extensive farming

### 2.15 LAND AND LAGOON RESTORATION

The proposed land is located in a heavily vegetation area which was previously used as a local dumpsite. The lagoon area and coastal area was found to be filled with solid waste that has accumulated overtime forming mounds of waste covered with grass and sea weed. Three significant mounds were observed at the area proposed for hatchery construction, these had a total area of 85 m². Approximately 200 m² of the lagoon area was found to be filled with industrial and organic waste. The DO level of this area was found to be significantly low. The accumulated waste had caused the area to become shallower than 1.5 ft. If left as it is, a huge area of the lagoon space cannot be used for sea cucumber farming. Moreover, industrial waste that has been discarded in the lagoon can cause physical harm to the workers during the construction and operational phase of the project.

Waste mounds formed on land and in the sea will be removed as part of the project to restore the environment so that they can be utilised and managed properly.
2.16 PROJECT BOUNDARY AND IMPACT ZONE

Project boundary has been defined based on the direct footprint area of the proposed sea cucumber farming facilities. The land areas approved for the facility is 30,000^2 ft and in the lagoon the area is 526,350^2 ft. Hence the project primary impact area has been determined to be 556,350^2 ft. However the actual impact boundary will be larger as the discharge outfall will reach beyond the lagoon space allocated for the project (see Figure 23).

The benthic environment of the footprint is almost exclusively composed sand and mud and does not contain any significant biodiversity, except little individual sea grass patches. The water column is highly turbid. No noticeably abundant fish species or bottom dwellers were observed.

In determining the impact boundary as a result of indirect impacts of the project a secondary impact zone has been identified.

Secondary impact boundary: It is quite difficult to predict the extent of the reach of the impacts from the project activities. During the construction phase except perhaps noise and light no other direct impacts are envisaged outside the project primary boundary. During the operational phase however, the project will involve abstraction of groundwater, use of septic tank, emissions into air due to power generation and discharge of wastewater into the marine environment. Also fogging (if needed) outside the project boundary to control mosquitoes. Considering the anticipated volume of the discharges, volume of groundwater expected to be abstracted and considering the characteristics of the existing environment it is believed impacts from the project may not be felt beyond a 100 m boundary from the project boundary. Hence, a zone enclosed within 100 m from the project boundary from all sides of the project has been considered to be the secondary impact zone. The identified primary and secondary impact zones do not contain any environmentally sensitive or protected areas, species, settlements or culturally important site.
Figure 23: Project area and impact boundary
2.17 CONSTRUCTION METHODOLOGY AND WORK SCHEDULE

2.17.1 The Approach

The typical approach to constructing the project facilities will be to complete all the construction activities in a single phase within the shortest possible time frame. With careful planning and putting in measures to minimise the project risks major delays will be avoided. The major steps in this regard involve the following:

- Obtaining all relevant approvals;
- Surveying and preparing all necessary layout drawings;
- Preparing BoQ and cost estimates;
- Selection of the contractor;
- Set out survey for locating the building footprints and bringing minor adjustments to minimise cutting down of trees;
- Land clearance;
- Set up project office;
- Stockpiling of the materials;
- Construction works (with supervision); and
- Completion and handover.

A contractor will be procured through direct negotiation. As soon as the EIA and other mandatory requirements have been completed, the Project work will begin. Once the contractor is selected the proponent will enter into a legal contract with the contractor. The approved EIA will become part of the legal contract and the contractor will be responsible for the implementation of the mitigation measures and taking necessary environmental safeguards as given in the EIA during the construction phase.

2.17.2 Organization

The key personal involved in the successful implementation of the Project will be

1. The Project Manager;
2. The Site Supervisor and
3. Foremen.

The key personnel on the project have the following responsibilities:

The project manager will be the key person responsible for overall managing and delivering the project within the allocated budget, accountable for such issues on the Project relating to health and safety, environmental safeguards and quality assurance.

Directly under the project manager, a site supervisor will be recruited, and is answerable to the project manager. Site supervisor will be involved in managing the daily operational duties of the construction activities on site with regards to programme, budget, health and safety, environmental safeguards and quality assurance.
The Foremen are responsible for individual areas of the project works and will work under the direct supervision of the site manager. In addition, the project will employ various support staff to the project manager that will undertake financial and commercial monitoring and administration roles.

### 2.18 CONSTRUCTION METHODOLOGY

All buildings will be constructed in the most cost effective way but not compromising the durability of the structure. Where applicable Maldives Building Code 2008 will be referred to.

Four major milestones are anticipated in the construction of the project; the initiation, planning execution, monitoring and control and closing. Prior to the starting the works on site, the chosen contractor will meet with the proponent’s team in order to confirm the full understanding of the project master plan, understanding stakeholders of the project, explaining their roles and responsibilities and discussion on project constraints, and the objectives. Thorough this consultative process, the contractor is expected to develop a robust, comprehensive and purposeful construction plan. The plan will explain how the construction works will be executed. The construction method statement including tools and techniques and inputs will be core to the construction plan. Other features expected in the plan include, final schedule, cost management, quality assurance, human resource, communication process, risk management and procurement of materials for the Project.

Project time management by identifying specific actions to be performed during a particular time during the project lifespan will be given highest priority for completion of the Project within the specified period as delays in project implementation not only incurs additional and unnecessary costs but also more environmental damage and losses. Therefore, the Project schedule will become part of the construction contract. In order to effectively implement the project, during construction phase of the project, the Contractor will be responsible to undertake the following tasks:

- Coordination of the works with the Project proponent and island authorities;
- management of health and safety including induction of all personnel;
- safeguarding the island’s environment and ensuring the mitigation measures proposed in the EIA report are fully implemented during the construction;
- setting out of the works;
- agree schedule of condition before work commences;
- control the flow of project information;
- keep full and accurate records;
- ensure compliance with Project specifications;
- supervise the works;
- attend meetings with the Proponent, Specialists as necessary;
- monitor progress against the contract programme and take necessary action to avoid delays; and
- prepare written progress reports on a regular basis to the design team.
2.19 CONSTRUCTION APPROACH

The typical approach to the construction of the facility, comprises the following, but not necessarily sequential, stages:

- Construct site compounds, lay down areas and other preparatory works;
- mobilization of equipments, machineries and vehicles, welfare and personnel to site;
- initial construction works – construct and/or improve access tracks to the site; and
- main construction works – construction of buildings, support facilities etc..

As soon as the EIA and other mandatory requirements have been completed, contractor will be selected for a fixed lump sum. Once the contractor is selected the proponent will enter into a legal contract with the contractor. The approved EIA will become part of the legal contract and the contractor will be responsible for the implementation of the mitigation measures and taking necessary environmental safeguards as given in the EIA during the construction phase.

The main responsibilities of the Contractor include:

- Providing all materials, labour, equipment and services;
- subcontracting with various trade and specialty contractors;
- applying for or assisting in the application process for building permits if necessary;
- monitoring work schedule and cash flow;
- maintaining accurate records; and
- ensuring a safe and secure project site for the workers.

Throughout every step of the project, the contractor will be required to work closely with clients, architects, and engineers to provide the information they need to determine how best to reach sustainability goals. This should be achieved through comprehensive cost analysis, accurate design input, material procurement, streamlined submittal processes, and experienced certified construction management.

The proposed development will have several sustainability goals set and these have been discussed throughout this EIA report. Some of these include but not limited to the following:

- Reducing the area of impact;
- Reducing construction waste;
- Promoting responsible construction; and
- Efficient use of resources.

2.20 SEQUENCE OF CONSTRUCTION WORKS

Given below is a general sequence of construction works expected based on experiences gained from similar projects. The contractor may modify the sequence depending to material availability and other factors that may affect the Project. The changes will be discussed and agreed between the contractor and the Proponent in advance.

- Site preparation, cleaning, layout and survey work;
perimeter fencing work;
- material procurement (cement, steel, iron, wood etc..) and stockpiling;
- set up temporary site office and material storages;
- earth excavation works;
- foundation works;
- construct structure of the building;
- construction of the walls;
- install internal plumbing;
- install exterior plumbing;
- install interior electrical;
- install wallboard;
- install exterior sanding;
- paint exterior;
- install flooring;
- paint interior;
- install exterior doors;
- install interior doors;
- install roofing;
- install growout pens;
- install equipments and interior furniture; and
- finishing and handover.

The sections below briefly describe the above developmental features of the project.

### 2.20.1Sourcing Materials

All major construction resources will be obtained from local vendors in the Maldives. They will be procured in bulk from Male’ and transported in a cargo dhoni directly to L. Gan. Only those materials that are not available locally will be imported. In the case of importing materials nearest available source will be selected so long as price is competitive enough.

### 2.20.2Material Transport

Two aspects of transport are involved as far as the proposed Project is concerned. These are materials transported from Male’ to Gan and from the island to the construction site. The Project does not require unusually large volumes of materials to the island hence cargo dhonis is expected to be suitable for transporting materials in bulk. This would ease the logistics as well as minimize transport costs and improve sustainability aspects of the Project. Three harbours are found at Gan of which the closest to the site is Maandhoo harbour. Although this is the preferred harbour for material unloading, the possibility of using this harbour depends on getting the permission to use the harbour from the management of Maandhoo. The distance from Maandhoo harbour to the project site was found to be approximately 500 m. whereas the next closest harbour to the site located at Mukurimagu is located at a distance of nearly 2 km from the site. In case Maandhoo harbour cannot be used for material unloading then Mukurimagu harbour will be used. In either case paved roads connecting to the site is available. From the harbour the materials will be
immediately transported to the construction site in trucks without delay. These operations can be carried out without causing any impacts to the public. The proposed land transport route is shown in Figure 24. Truck drivers will be required to observe the local speed limits.

![Image of transporting route](image)

*Figure 24: Proposed transport route options*

### 2.20.3 Material Stockpiling and Storage

Bulk supply and secure storage and recordkeeping of the materials needed for the Project will be critical during the construction phase to avoid delays, reduce the risk of theft and to ensure smooth workflow in keeping with the project schedule. Delays in material availability and supplies in small volumes can not only add to the cost of the project but also will lead to unnecessary environmental and social impacts. The material stockpiling and storage space for the project will be allocated.

Site preparation works will commence as soon the EIA approval has been granted. Site preparation is considered to be one of the key elements of any such project which include fixing of secure place for material storage and a site office attached to material storage site. Site clearance would be carried out according to this EIA report provided in this report. A site manager and site engineer would be present at all times once site preparation commences.
2.20.4 Workers Accommodation, Utility Services during Construction

Groundwater will be used for the construction purposes since the quality of it was found to be suitable. Since the island’s aquifer is believed to be relatively large (as it is related to the size of the island), water can be sustainably abstracted from its aquifer without compromising the quality given that Gan has a very low density population.

Electricity during the works will be provided by an onsite genset and sanitation facilities through septic tank system.

Bottled water will be provided for drinking purposes and rainwater harvesting will begin during as earliest into the project activities.

During the construction phase it is not advised to set up a separate camp requiring setting up of all services such as mess room, kitchen, shower etc. This will incur additional costs, create environmental impacts and benefits to the community will be reduced. Hence the contractor will be advised to use the island’s facilities that are available for food and accommodation.

2.20.5 Mobilisation

Workers will be brought to the site only once all necessary welfare arrangements for their stay has been arranged. Workers quarter has not been planned to be built on the site. Food, accommodation and other services will be arranged with the existing service providers on the island. It would be planned as such initially a few workers will make the preparations for the main construction activities to begin and the workforce to arrive at the site. These include making a temporary storage, guard post, small office and toilet facilities. All necessary plants, machineries and materials will reach the site as soon as the initial set up has been completed.

2.20.6 Set Out and Tree Survey

Before the construction related activities begin a professional surveyor will mark the boundaries of all buildings and walkways. Along with this a tree survey will be conducted. The survey will list all tree species in within the land boundary of the project, including the type, height, diameter and the estimated age. These two surveys will determine all the trees falling within the compounds and their characteristics. Following which the environmental consultant, project planner and the PM will discuss possible adjustments to the layout to maximise trees that can be saved.

2.20.7 Excavation, Foundations and Construction Method

A detailed method statement for all the construction works will be provided to the proponent by the selected contractor prior to the approval of the works. Even though the method statement was not available at the time of this report, conventional methods and materials commonly used in the Maldives will be adopted. Since the buildings will be all single story and carrying a simple structure shallow foundation is expected. Beam foundations however, require excavations along the beams with larger footings at the columns. This would mean excavations within a depth range of about 0.3 – 1.2 meters. Such shallow foundation based structures does not require dewatering
or major excavations. Since there are no buildings adjoining the proposed building, there is no need for protection while excavation. The excavation will be done using a back hoe excavator. Part of the excavated black sand will be later used for backfilling purposes.

All buildings would consist of masonry work with reinforced concrete and structural steel work using manual labour. All pipe networks will be properly sealed to prevent exposure. Electrical wiring will be done by a certified electrician. Sea outfall will be laid on the lagoon without trenching and anchored securely using weigh blocks.

The proponent shall carefully review the method statement as soon as it is submitted by the contractor and ensure that it is in line with the relevant parts of this EIA report. During construction works it would be the responsibility of the contractor to implement relevant mitigation measures related to construction activities.

2.20.8 Pollution Prevention

Appropriate precautions will be taken to prevent pollution from oil spillage or spillages of other hazardous materials. Any pollution will be swiftly cleared up to prevent contamination of soil and groundwater. Similar measures will be in place during marine-based construction activities. An oil spill kit will have to be maintained on site at all times. Spill kit and fire extinguisher to be kept in all areas where fuel is handled. All the machinery and equipment will be properly tuned and maintained to reduce emission leakage and spills and they will be switched off when not in use to minimize idle time. Fuel, paints, lubricants, and other chemicals will be stored appropriately and empty containers will be dealt as hazardous waste. The compound will be kept clean by regular sweeping of the whole area to remove the yard waste (see also Section 2.20.9).

2.20.9 Construction Waste Management

During construction phase solid waste as well as hazardous waste will be generated. No waste from the project will be discarded on the island. All residual waste generated during concrete works phase and finishing phase will be collected at the end of each work day and temporarily stored in a designated area within the Project at site. Hazardous waste such as empty paint cans will be kept separate and in closed containers and disposed at Thilafushi.
2.20.10 Health, Safety and Security during Construction

Since the project is taking place on an inhabited island, the project site will have measures to prevent members of the public getting unauthorised access to the worksite for safety and security concerns. Hence, contractor will be required to have security arrangements in place to prevent unauthorised access to the site. In addition, security officers will patrol the site to ensure unwanted activities do not happen from workers. In case of authorised access, upon arrival of all construction personnel will report to the site office where they will be required to attend safety introduction undertaken by a member of the Contractor, whereupon they will be provided with details of site rules and restrictions such as health and safety arrangements, First Aid provision, fire procedures etc. In addition to visitor book daily signing in book will be maintained throughout the Project.

Workers health and safety is aspect of utmost importance that needs attention during the construction works. Protection of employees from likely adverse effects will be one of the core duties of the contractor. All machineries and equipment must be operated by trained and experienced personals wearing necessary safety gears. Moreover, machine and plant operators will be required to provide Operator’s License etc copy of which will be retained by the Site Office for records. Specific health and safety regulations regarding works of this nature does not exist in the Maldives at present, in such cases, it is common to adapt similar practices from other countries in the EIA process in the Maldives. In this regard the following recommendations with regards to health and safety aspects of workers have been adapted from Adapted from US Department of Labour, (US Department of Labor, 2016).

Proposed Occupational Safety and Health Measures:

- First aid kit shall be made available at the work site;
- Wear personal protection to protect the skin from concrete, wear long sleeves as well as long trousers and water proof boots;
- Conduct concrete mixing in well ventilated areas;
- Properly fix and secure any objects that may fall;
- Label any openings with warnings such as dug trenches or wells
- Wear high visibility clothes when working with vehicles and machinery;
- Wear the required Personal Protective Equipment (PPE) when in risk of hazards such as atmospheric hazards, biological hazards, chemicals and high noise levels;
- Employ licensed personnel to operate machinery and vehicles;
- Provide all required safety training before commencing work; and
- Keep workers aware of all potential risks and hazards before commencement of work.

In the event of a serious injury arrangement shall be in place to take the injured to the health centre or to a hospital in Male’.
2.21 PROJECT RISK MITIGATION

Identifying Project risks and putting in place mitigation measures prior to commencement of work is critical to enhance project success as well as avoiding environmental, social and financial consequences. Project risks can arise during construction and operations phase. Table 12 summarises some of the perceived risks and their mitigation actions.

Table 12: Project risks and mitigation measures

<table>
<thead>
<tr>
<th>Phase</th>
<th>Risks</th>
<th>Risk Mitigation</th>
<th>Risk Magnitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>Work stoppage by authorities due to permit issues, illegal activities etc.</td>
<td>• Ensure all necessary permits are obtained prior to the beginning of the construction activities</td>
<td>Low</td>
</tr>
</tbody>
</table>
|          | Unskilled labour can create delays which in turn resulting financial and environmental costs | • Check for documents such as for operation of vehicles etc  
• Have in place information sharing arrangement with the local authorities | Low           |
|          | Loss of a key personnel                                              | • Selecting competent contractor with adequate human, technical and financial resources through a robust selection process | Low           |
|          | Conflicts with locals can arise due to poor planning, site management as well as poor coordination with authorities | • Resolve all ownership issues of trees.  
• Site shall be made secure and security guards to do regular inspections of the site | Low           |
|          | Injuries to workers can cause delays and project having to incur unexpected costs | • Follow safety procedures established for the project | Low           |
|          | Unavailability of materials for the construction and operation may cause delays and add costs to the project | • Proper BoQ shall be done and materials needed for the construction shall be stockpiled before construction begins | Low           |
|          | Lack of financing and poor cash flow into the project can cause long delays to the project | • Securing project financing before construction begins and selecting a contractor with good records of performance | Low           |
|          | Poor community acceptability of the Project                          | • Involving community participation as much as possible throughout the project planning and EIA preparation has been considered. Working closely with the Island Council and | Low           |
maintaining a good communication mechanism and making community benefit from the project

| Navigational hazards, accidents | • Avoiding night-time travel, choosing supply vessels with seaworthiness certification and insurance | Low |
| Natural disaster | (See Section X) | Low |

| Sudden changes in biotic and abiotic parameters in grow out areas such as drop in salinity due to low tide coinciding rainy periods | • Careful siting of the grow out areas so as not keep it too close to the shore to ensure that sea cucumbers are not exposed for too long even in the case of abnormal low tide. • Regular monitoring of the seawater quality to ensure that the ideal salinity for sea cucumber is attained in the lagoon which is between 28 ppt – 31 ppt. • Siting the pens within seagrass bed | Low |
| Overabundance of predators such certain types of fish, crabs sea stars and shrimps in the grow out areas | • Regular careful observation of the grow out areas | Low |
| Outbreak of diseases | • Regular careful observation of the grow out areas for signs of diseases, presence of parasites • Adopting semi-intensive farming (see Section 2.14.2) | Low |
| Loss of market for the project | • Ensuring quality of the products through a rigorous quality control mechanism • Identifying and making long term legal agreement with reputed buyers | Low |
| Natural disaster | (see Section 2.10.1.1) | Low |
| Fire breakout | | Low |

### 2.22 QUALITY ASSURANCE

Quality assurance has been one of the main important aspect in planning, design, construction and operations philosophy used in the project. Quality assurance was critical to ensure that the building structure, machines, equipments lasts the design life as well as to ensure minimum or no
requirement for the maintenance during their life-time of the structure. Frequent maintenance work would be associated with environmental and social impacts on the Project site, hence need to be avoided.

In order to ensure quality of the finished works, the most important aspect is selecting an experienced and reputed contractor through a rigorous process. For the proposed Project exact standards required and a detailed and specific inspection and test plan will be developed. The plan will identify items or elements within specification which need to be inspected, confirmed and/or verified before the subsequent work or activity can commence. Materials which require testing certification or inspection are also highlighted in the inspection and test plan and they too are check for correctness and the results recorded before the materials are released or incorporation into their works. In the prices any non-compliant materials will be quarantined in a specifically designated area to prevent accidental incorporation into the works.

Wherever possible, samples will be obtained or constructed of the standard of material and workmanship required and retained on site as a physical reference or datum of the project quality requirements. Approval of the proposed details/finishes by the Proponent’s design team will be sought in advance. Subcontractors can only be appointed once they have demonstrated their ability to produce work in accordance with the mock-ups, samples and project specifications.

In procuring equipment, tools and other materials for the project operations reputed suppliers will be selected and warranty and/or guarantee certification will be ensured where applicable.

During the construction of the buildings site engineer will ensure that the contractor adheres to design requirements. Hatchery, grow out pens, processing facility will be established under the supervision of a highly qualified and experienced aquaculture specialist. During the production phase, quality assurance protocol that takes into account international and local guidelines will be developed and followed. Full time quality assurance official will be employed by the project and training for all staff involved will be conducted.

2.23 EMPLOYMENT
The project has been designed to with the objective of creating employment opportunities for the locals. These include direct and indirect employment. It is estimated that approximately 20 workers will be on site during construction period and between 10 - 15 workers will be employed during construction phase of the Project. Contractor will be encouraged to hire locals as far as possible for the construction activities and specific works can also be subcontracted to local parties. Also during the operations phase, to enhance Project’s benefit to the community priority will be given to hire locals for various jobs. The community strengthening component of the project which

2.24 PROJECT INPUTS AND OUTPUTS
Project inputs being mostly the resources and services considerations will be given to the principles of sustainability with the objective of minimising environmental impacts associated in obtaining those. In this regard priority will be given to obtaining locally produced goods and services and purchasing those from approved sources. The major categories of project inputs and outputs for the project for both construction and operations phase are given in Table 13 and Table 14
Table 13: Major inputs of the project

<table>
<thead>
<tr>
<th>Project inputs</th>
<th>Quantity</th>
<th>Source/ Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land space</td>
<td>30,00 ft²</td>
<td>L. Gan</td>
<td>Establishing land-based facilities</td>
</tr>
<tr>
<td>Sea space</td>
<td>526, 350 ft²</td>
<td>L. Gan</td>
<td>Establishing grow out areas</td>
</tr>
<tr>
<td>Construction workers</td>
<td>10-15</td>
<td>Most of the semi-skilled workers are expected to be foreign labourers. Priority will be given to hire locals for the project.</td>
<td>Client will procure a suitable contractor for the construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Site clearing, Construction, assembling of hatchery, sea pens, fencing. Laying outfall pipe and installation of septic system, water system and electricity system of the facility.</td>
</tr>
<tr>
<td>Diesel Genset</td>
<td>2 (20-60 kW)</td>
<td>Sourced from the contractor. One genset will be used as a backup while the other will be used to provide electricity to the equipment and site.</td>
<td>These generators will be used temporarily.</td>
</tr>
<tr>
<td>Fuel</td>
<td>Approximately 370 L/month</td>
<td>Fuel needed for the construction will be purchased from L.Gan.</td>
<td>From Government approved suppliers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Fuel during construction phase will be used to operate generators, machineries and provide electricity to the site.</td>
</tr>
<tr>
<td><strong>Heavy Equipment</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydraulic excavator</td>
<td>1</td>
<td>Construction equipment will be used for the following main purposes:</td>
<td>Equipment/tools required for the construction of facility will be rented or</td>
</tr>
<tr>
<td>Crane</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pick-up truck</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4 Based on fuel consumption of 8-12 gallons per 24hr period (Diesel service, 2017)
<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bar cutting machine</td>
<td>2</td>
</tr>
<tr>
<td>Bar bending machine</td>
<td>2</td>
</tr>
<tr>
<td>Table saw</td>
<td>3</td>
</tr>
<tr>
<td>Submersible pump</td>
<td>1</td>
</tr>
<tr>
<td>Steel cutter</td>
<td>1</td>
</tr>
<tr>
<td>Circular saw</td>
<td>2</td>
</tr>
<tr>
<td>Cordless drill</td>
<td>3</td>
</tr>
<tr>
<td>Blower</td>
<td>1</td>
</tr>
<tr>
<td>Hammer drill</td>
<td>1</td>
</tr>
<tr>
<td>Rotary hammer</td>
<td>1</td>
</tr>
<tr>
<td>Grinding machine</td>
<td>1</td>
</tr>
<tr>
<td>Concrete mixer</td>
<td>1</td>
</tr>
</tbody>
</table>

Remove waste mounds in the lagoon/land and clear vegetation. Carry labours and material to and from site. Clear dried leaves and collect them for disposal. Install foundation of the facility. Assemble prefabricated materials. Assemble and construct hatchery structure. Install cladding, water, electricity and sewerage system of the facility. Lay outfall pipe and install rainwater and seawater harvesting system. Install roof system, fence lagoon area and construct nursery tanks sourced from the constrictor.

<table>
<thead>
<tr>
<th>手工具</th>
<th>数量</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheel borrow</td>
<td>3</td>
</tr>
<tr>
<td>Shovel</td>
<td>4</td>
</tr>
<tr>
<td>Hoe</td>
<td>3</td>
</tr>
<tr>
<td>Craw bar</td>
<td>2</td>
</tr>
<tr>
<td>Pointed trowel</td>
<td>3</td>
</tr>
<tr>
<td>Box bar - aluminium</td>
<td>4</td>
</tr>
<tr>
<td>Claw hammer</td>
<td>5</td>
</tr>
<tr>
<td>Hand saw</td>
<td>4</td>
</tr>
<tr>
<td>Hack saw</td>
<td>3</td>
</tr>
<tr>
<td>Measuring tape</td>
<td>2</td>
</tr>
<tr>
<td>Plumb bob</td>
<td>4</td>
</tr>
<tr>
<td>Chisel</td>
<td>4</td>
</tr>
<tr>
<td>Ink marker</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>安全工具</th>
<th>数量</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety belt</td>
<td>10-15</td>
</tr>
<tr>
<td>Safety helmet</td>
<td>10-15</td>
</tr>
<tr>
<td>Safety shoes</td>
<td>5-10 pairs</td>
</tr>
<tr>
<td>Rubber boots</td>
<td>5-10 pairs</td>
</tr>
<tr>
<td>Goggle</td>
<td>10-15</td>
</tr>
<tr>
<td>Material Description</td>
<td>Quantity</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Hand gloves - leather</td>
<td></td>
</tr>
<tr>
<td>Hand gloves - cotton</td>
<td></td>
</tr>
<tr>
<td>Rain coat</td>
<td></td>
</tr>
<tr>
<td>20,000 L water tanks</td>
<td>2</td>
</tr>
<tr>
<td>PVC pipes various sizes</td>
<td>2</td>
</tr>
<tr>
<td>Stilts</td>
<td>1</td>
</tr>
<tr>
<td>Heavy duty pumps</td>
<td></td>
</tr>
<tr>
<td>5000 L water tank</td>
<td></td>
</tr>
<tr>
<td>Kitchenware</td>
<td></td>
</tr>
<tr>
<td>Bedroom furniture</td>
<td></td>
</tr>
<tr>
<td>Laboratory glassware (beakers, conical flasks etc.)</td>
<td>2</td>
</tr>
<tr>
<td>Weighing scales</td>
<td>2</td>
</tr>
<tr>
<td>Laboratory equipment</td>
<td></td>
</tr>
<tr>
<td>Electrical wires and equipment</td>
<td></td>
</tr>
<tr>
<td>Pipes and mesh nets</td>
<td></td>
</tr>
<tr>
<td>Air blowers</td>
<td></td>
</tr>
<tr>
<td>UV sterilizer</td>
<td></td>
</tr>
<tr>
<td>Filter cartridges</td>
<td></td>
</tr>
<tr>
<td>Timber</td>
<td></td>
</tr>
<tr>
<td>Metal roof</td>
<td></td>
</tr>
<tr>
<td>PVC conduits</td>
<td></td>
</tr>
<tr>
<td>uPVC pipes dia. 160 mm</td>
<td></td>
</tr>
<tr>
<td>Precast anchor blocks</td>
<td></td>
</tr>
<tr>
<td>SS rods</td>
<td></td>
</tr>
<tr>
<td>Diffuser</td>
<td></td>
</tr>
<tr>
<td>Cladding material</td>
<td></td>
</tr>
<tr>
<td>Wire mesh</td>
<td></td>
</tr>
<tr>
<td>EPDM sedimentation and aeration tanks</td>
<td></td>
</tr>
<tr>
<td>CCTV cameras</td>
<td></td>
</tr>
<tr>
<td>Computers</td>
<td></td>
</tr>
<tr>
<td>Office equipment</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td></td>
</tr>
</tbody>
</table>

Concrete blocks will be at least 500 – 1,000 kg reinforced concrete per block at 5 m intervals. Materials required for construction will be purchased from Maldives and China. Air blowers will be 5-6 kW and will sufficiently aerate tanks and live feed production unit.

At this stage quantity and specific material inputs are unavailable since a BOQ for the project has not been prepared. All the materials required for the construction of hatchery will be procured by the proponent. Cement tanks maybe used during the initial stages of the project until tanks are upgraded.
<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weatherproof floor light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Industrial light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor garden light</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autoclave</td>
<td>1</td>
<td>(Defrosting type, non HCFC based)</td>
</tr>
<tr>
<td>Microscope</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air conditioning Units</td>
<td>2</td>
<td>(12000BTU)</td>
</tr>
<tr>
<td>Canvas Tanks</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Fiber glass tanks</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>HDOE geo-membrane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drums and pots</td>
<td>Approx. 10</td>
<td>Half cut drum or large aluminium pots (app 80liters capacity each)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Purchased locally if available.</td>
</tr>
<tr>
<td>Drying rack</td>
<td>Approx. 10</td>
<td>Constructed using metal or wood the drying rack will be used when sun drying cooked sea cucumber.</td>
</tr>
<tr>
<td></td>
<td>5 × 15 m</td>
<td></td>
</tr>
<tr>
<td>Smoke Oven</td>
<td>2</td>
<td>Prepared on site with metal box racks. Smoke from wood will be exposed to sea cucumber inside the metal box.</td>
</tr>
<tr>
<td>Wooden Paddle</td>
<td>5</td>
<td>Long handled wooden paddle for stirring sea cucumber in pots.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wooden paddles will be obtained locally.</td>
</tr>
</tbody>
</table>
**EIA for Sea Cucumber Culture in L Gan, Maldives**

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
<th>Description</th>
<th>Procurement Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broodstock</td>
<td>Approx. 100 pairs</td>
<td>Bloodstock pairs will be obtained locally from a reputed breeder. These will be used for husbandry.</td>
<td>Proponent to procure from an MRC approved facility.</td>
</tr>
<tr>
<td>Juvenile sea cucumber</td>
<td>Approx. 1000 - 2000</td>
<td>Juvenile sea cucumbers will be obtained from MRC approved facilities. Approximately 2000 juveniles will be obtained during the pilot run.</td>
<td>Considering 2 individuals per square meter, approximately 90,000 individuals could be raised at the lagoon area.</td>
</tr>
<tr>
<td>Algae feed</td>
<td>-</td>
<td>Algae feed will be obtained from MRC.</td>
<td>Proponent to obtain from MRC.</td>
</tr>
<tr>
<td>Sea cucumber feed</td>
<td>2000-4000 cells/ml</td>
<td>Mature sea cucumber feed includes kelp powder, fish meal, mud etc. At this stage of the project it is not clear the quantity of feed that will be used, as the project has been designed under the assumption that feed will be completely avoided if it is not required.</td>
<td>Proponent to obtain algae feed from MRC approved facilities initially. The hatchery will also produce micro algae one food culture unit becomes operational.</td>
</tr>
<tr>
<td></td>
<td>(larval stage)</td>
<td>Larval stage sea cucumber will be fed Algamac 200 at a density of 2,000 to 4,000 cells per ml.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1g/m³</td>
<td>During the juvenile nursery stage the sea cucumbers will be fed algae paste and blended seaweed, and shrimp starter food.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(juvenile nursery stage)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kerosene</td>
<td>10 l/day⁵</td>
<td>Kerosene will be required to cook the sea cucumber. Assuming that 80 L of 10 drums are cooked daily, approximately 10 L of kerosene will be consumed daily.</td>
<td>Proponent to procure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kerosene will be purchased from local gas supplier.</td>
<td></td>
</tr>
<tr>
<td>Mesh net with long handle</td>
<td>5</td>
<td>Will be used to removing cooked sea cucumber from boiling pot.</td>
<td>Proponent to procure.</td>
</tr>
</tbody>
</table>

⁵ Assuming that 1.6L of water is boiled per oz. of kerosene (The Summit Register, 2017)
<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>Details</th>
<th>Source/Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse salt</td>
<td>0.3 tons/month</td>
<td>Salt removes water from the body of sea cucumber. Coarse salt is preferred because fine salt may damage sea cucumber body. Assuming that 1 ton sea cucumbers are processed monthly 0.3 tons of salt will be required. Proponent will procure salt from local suppliers initially.</td>
<td></td>
</tr>
<tr>
<td>Freshwater</td>
<td>2.5 tons/day</td>
<td>Rainwater and groundwater will be used to meet the freshwater requirement of the facility. The sustainable yield of groundwater was calculated to be approximately 3 tons/day. -</td>
<td>-</td>
</tr>
<tr>
<td>Seawater for hatchery tanks</td>
<td>Approximately 50 m$^3$/day</td>
<td>Sea water will be sourced from the lagoon. Seawater will be required for rearing tanks, feed production unit and nursery tanks. The hatchery will have 20 ton seawater storage capacity.</td>
<td>-</td>
</tr>
<tr>
<td>Coconut husk/firewood</td>
<td>0.25 ton/month</td>
<td>It is proposed that only 25% of stock will be smoke cured since they will be salt cured as well. Proponent will obtain coconut husks locally from L.Gan</td>
<td>-</td>
</tr>
<tr>
<td>Diesel</td>
<td>6.4 l/hr</td>
<td>Assuming a 20-30 kW generator is used in the facility at full load. It is unlikely that the generator will operate 24hrs/day at full capacity. However, the maximum value is used for conservative calculation.</td>
<td>-</td>
</tr>
<tr>
<td>Dinghy/Paddleboat</td>
<td>2 (Un-motorised)</td>
<td>Two unmortised, dinghies/battle boats will be kept at the facility to monitor sea cucumber pens and to travel to and from security hut. Proponent will obtain boasts locally from L.Gan.</td>
<td>-</td>
</tr>
</tbody>
</table>

---

6 Calculation made based on 1 kg salt cures 3 kg of sea cucumber (Purcell, 2014)  
7 Based on a 1:1 ration of coconut husk to sea cucumber.  
8 At full load for a 24 kW generator (The Summit Register, 2017)
Table 14: All major Outputs of the Project

<table>
<thead>
<tr>
<th>Project Outputs</th>
<th>Quantity</th>
<th>Source/ Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hatchery &amp; all related facilities</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>General construction waste</td>
<td>Approx. 50 m³/month</td>
<td>Waste wood from concrete form works, spent concrete, waste steel, rebars from concrete re-enforcement equipment wrapping material.</td>
<td>Construction waste will be transported to Thilafushi.</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>Approx. 30 l/month</td>
<td>Empty fuel/lubricant drums, used oil/air filters, scrap batteries, vehicle parts and waste oils/grease, spent solvents/detergents and possibly spent acid/alkali from batteries maintenance</td>
<td></td>
</tr>
<tr>
<td>Municipal waste</td>
<td>100-150 kg/person/day</td>
<td>Generated from day to day activities of workers</td>
<td></td>
</tr>
<tr>
<td>Improved coastal zone</td>
<td>Approx. 0.5 km</td>
<td>Approximately 100,000 ft² of land, coastal area and lagoon space will be restored by removal of waste accumulated at site.</td>
<td></td>
</tr>
<tr>
<td>Sewage/(wastewater)</td>
<td>2,540 l/day</td>
<td>Assuming 10-15 workers.</td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>60-80 dBA eq within 5 m of construction site</td>
<td>Earthmoving equipment such as excavators produce noise in the range of 73-96 dBA. Partially mobile equipment such as concrete mixers/cranes range from 75 to 90 dBA. Stationary equipment such as pumps/generators range from 70 to 80 dBA (U.S. EPA, 1971).</td>
<td></td>
</tr>
<tr>
<td>Greenhouse gases</td>
<td>9.6 tons CO₂-e</td>
<td>GHG’s will be emitted from the generators, heavy equipment’s such as excavators, motorised construction equipment and vehicles.</td>
<td></td>
</tr>
<tr>
<td><strong>Operational Phase</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processed sea cucumber for export</td>
<td>12 tons/annually</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Sea cucumber larva</td>
<td>400,000 annually.</td>
<td>-</td>
<td>100,000 larvae will be produced per breeding</td>
</tr>
</tbody>
</table>
Sea cucumber will be bred four times per year.

<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>General waste</td>
<td>100-150 kg/day</td>
<td>These include waste generated by the workers, such as food waste etc.</td>
</tr>
<tr>
<td>Animal waste</td>
<td>Approx. 1 ton/month$^9$</td>
<td>-</td>
</tr>
<tr>
<td>Hatchery waste water</td>
<td>28 m$^3$/day</td>
<td>The amount of seawater discharged will be similar to the amount of seawater in taken for the various tanks in the hatchery.</td>
</tr>
<tr>
<td>Greenhouse gases</td>
<td>145 tons/year CO$_2$-e$^{10}$</td>
<td>GHG will result from producing electricity required for to operate the facility and from the processing sea cucumber.</td>
</tr>
<tr>
<td>Sewage (wastewater)</td>
<td>2,450 l/day</td>
<td>Waste water will be generated by workers.</td>
</tr>
<tr>
<td>Waste water from cooking</td>
<td>800 l/week</td>
<td>Assuming that 10 pots are used to cook each time, 800 L of wastewater will be generated.</td>
</tr>
</tbody>
</table>

$^9$ Assuming 50% of sea cucumbers is edible (Source: Al Rashdi, et al., 2012).

$^{10}$ Calculations based on (US EPA, 2017)
2.25 PROJECT MANAGEMENT

Under this section, various aspects of the project management will be highlighted. This includes the roles and responsibilities, Project duration, implementation schedule, and other management related aspects of the Project.

2.25.1 Institutional Arrangements

As described earlier the proponent of the Project is S.S Farming Pvt.Ltd which is also the Project executing agency. Procurement of works for the project will be in accordance with the Rules of Procedure for the procurement of goods applying best practices. Once the EIA for the works is approved a works contractor will be appointed for immediate commencing of work.

The roles and responsibilities of the key stakeholders during the construction phase of the proposed project is given in Table 15.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Roles and responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.S Farming Pvt. Ltd</td>
<td>Project owner, management of the Project, managing the civil works contract. Maintenance works in coordination with the island authorities</td>
</tr>
<tr>
<td>Works contractor</td>
<td>Implementation of the project as per the contract and implementation of the EIA</td>
</tr>
<tr>
<td>Environmental consultant (independent)</td>
<td>Environmental monitoring, reporting and environmental auditing</td>
</tr>
<tr>
<td>Ministry of Fisheries and Agriculture</td>
<td>Issuing necessary permits, reviewing progress reports, receiving licence fee, site visits, providing technical support</td>
</tr>
<tr>
<td>Island Council</td>
<td>Respective island councils will provide necessary facilitation, coordination and providing necessary information to the public, necessary local approvals</td>
</tr>
<tr>
<td>EPA</td>
<td>Reviewing monitoring reports, and site inspection if necessary</td>
</tr>
</tbody>
</table>

In parallel to the selection of the contractor an independent environmental consultant will be selected for undertaking the monitoring and auditing specified in the EIA report.

2.26 PROJECT SCHEDULE

Project is expected to be completed within a period of 12 months which has been divided into pre-constructions activities construction phase activities. Provisional schedule for the construction phase of the Project is given in Table 16.
### Table 16: Project Work Schedule

<table>
<thead>
<tr>
<th>Key Project Tasks</th>
<th>Year 2016/2017</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jun -16</td>
</tr>
</tbody>
</table>

**PRE-CONSTRUCTION PHASE**

- **P1** Financing and land approvals
- **P2** Selection of EIA consultant
- **P3** EIA preparation
- **P4** EIA approval
- **P5** Preparation of detailed design and methodology statements
- **P6** Selection of Works Contractor
- **P7** Logistical arrangements
- **P8** Mobilisation of equipment to site

**CONSTRUCTION PHASE**

- **C1** Vegetation Clearance and site preparation
- **C2** Building (office, lab, store etc) and boundary wall Construction
- **C3** Construction of Hatchery units
- **C4** Cleaning of lagoon grow out zone (remove debris and waste)
- **C5** Demarcation and fencing of grow out zone
- **C6** Construction of grow out cages
- **C7** Procurement brood stock and feeds
- **C8** Prepare and procure processing tools
- **C9** Testing and commissioning of machineries and pumps
- **C10** Commencement of farming
2.27 MAINTENANCE PLAN

As the proposed sea cucumber aquaculture infrastructure will be owned by S.S Farming Pvt.Ltd and to be established as a business venture, utmost care and maintenance will be maintained to sustain the facility. In the process of maintenance guidelines and best practices that have been proven will be followed for the maintenance of the facility in order to generate value added marketable product. As discussed earlier the value of the sea cucumber depends on the quality of the processed product. Hence the company is highly devoted in giving inputs for sustainable management of the facility while safe guarding the environment.

2.28 DECOMMISSIONING

Decommissioning of the sea cucumber aquaculture proposed in L Gan is not foreseen within the given 15 year’s period. This is because investment going towards the infrastructure development is not small and risks involved in the nature of business is relatively small. Sea cucumber demand is not foreseen to decline in a near future and the market price for processed sea cucumber remains very attractive. However, in the unlikely situation of not being able to operate the facility by S.S Farming Pvt. Ltd, the alternative arrangement would to sell the entire asset to an interested party rather than decommissioning the facility.

The timing and the activities that will take in the decommissioning phase are not well-known at this moment or if it will happen any time in a near future. In the worst case scenario if the owners were to abandon the project as the only choice left proper dismantling of the facilities and hand over of the site back to the authority will take place in accordance with the relevant laws. The site dismantling if it were to happen instead of bringing back everything to Male; auctioning of materials and equipment will be the preferred way. The parties who purchase will have to remove the items form the site within an agreed time-frame. Final cleaning of the site will be the responsibility of the project owner. The site will be cleaned and all structures removed before the site handover. All waste materials will be transported to an approved site for final disposal.
3. ADMINISTRATIVE AND REGULATORY FRAMEWORK

3.1 INTRODUCTION

This chapter describes the environmental governance arrangements pertinent for the proposed project. These include, the administrative arrangements, legal framework, relevant national policies, plans and strategies, international commitments and applicable permits for the project. Ensuring compliance to these is seen as an effective mechanism to ensure that the project is in adherence to the principles of sustainable development and appropriate mitigation measures are in place during all stages of the project.

3.2 ENVIRONMENTAL GOVERNANCE

Environmental governance in the Maldives is primarily driven through the established institutions of the state. The institutions are directed by the Constitution, laws, regulations, policies, national strategies, action plans as well as international legal instruments to which the Maldives is a Party to. The core of the environmental governance in the Maldives is the pertinent clauses of the Constitution in particular the Article 22 which states the importance of conservation and sustainable use of biological resources for the benefit of present and future generations. It also states protection of environment as a duty of the state as well as the local councils.

At institutional level; national and local administrations have distinct roles to play in the environmental governance. Central administration in the Maldives is conducted through national ministries headed by Cabinet Ministers based in the capital of Male’. Ministries are responsible for formulating relevant policies, planning development, coordination with donors and to a large extent formulating and implementation of projects in the country. Below the central government are 19 administrative units (roughly one per atoll) and each administrative atoll having an Atoll Council elected under the DA (2010). Each atoll in turn is divided into smaller administrative units comprising usually of inhabited islands and uninhabited islands. The governance system in the Maldives consists of 19 atoll councils, three city councils (Malé, Fuvahmulah and Addu) and 187 Island Councils. The specific roles and responsibilities of the councils in relation to the project are discussed in detail in the following sub-sections. The island councils are supported by advice from Islands Development Committees and civil society organizations etc. comprising of elected members from the community. In addition, Island Councils can seek opinion of youth groups, community elders and individuals on matters related to them. Public information on projects and other important matters is shared through formal and informal meetings organised by the council. In short it is through the existing environmental administrative framework that any new project is steered through and this project is no exception. For the proposed project as far as environmental aspects are concerned, certain key ministries of the central government and local authorities are of particular relevance.

In the following sub sections, the roles and responsibilities of the relevant government agencies pertaining to conservation of the environment ensuring project sustainability in relation to the proposed project are discussed.
3.2.1 Ministry of Environment and Energy

The MEE has a policy, law, regulation and standards making role for safeguarding environment under the Environment Protection and Preservation Act 4/93 of Maldives. The MEE has the following specific roles and responsibilities in relation to the governance, protection and conservation of the environment that has specific relevance to the various components of the proposed project:

1) Formulate policies, regulations and standards needed for the implementation of legislation related to environment, climate change, energy, water, sanitation, sewerage, and meteorology.

2) Protect the environment of the Maldives, and develop strategic action plans, action plans to promote the sustainable development and implementation of all aspects of energy, water and sewerage, and meteorology.

3) Develop concepts of projects related to the environment, climate change, energy, water, sewerage and meteorology; and acquire funds to the projects through collaboration with the related institutions; plan and manage all aspects of those projects. Establish a mechanism to maintain and provide service by allocating personnel and make arrangements to provide the service through the completed mechanism.

4) Develop monitoring guidelines and regulate projects related to environment, climate change, energy, water, sewerage and meteorology and infrastructure.

5) Carry out the following activities related to the environment, energy, water and sanitation, sewerage and meteorology:
   - Carry out the obligations of International treaties and activities related to organizations that the Maldives is party to.
   - Develop human resources at National level.
   - Take initiative in planning and implementing awareness programs at national and international level.
   - Introduce means of acquiring “innovative finance” to the Maldives.
   - Enhance the role of the private sector, and provide resources and facilitate to them to the extent possible.
   - Perform the administrative functions of the Advisory Committee on Energy.
   - Endeavour to make the natural environment the foundation of the national development.

6) Advocate and manage other activities related to the mitigation of the effects of climate change to the Maldives and other small island developing states, at regional and international level.

7) Develop projects to mitigate climate change, and to acquire financial assistance for this purpose from international agencies.

8) Coordinate projects conducted by relevant organizations to mitigate of climate change, and provide required assistance.

9) Formulate a sustainable development strategy to protect the environment, and execute all activities related to this strategy, plan and conduct activities proposed by the UN and other international NGOs in conjunction with relevant organizations.

10) Implement the Law number 77/78 (the law of unearthing/mining stone, rock, coral, sand from inhabited islands).
11) Advise the government and civic society on the technical and economic decisions in managing the energy sector, and producing, delivering and usage of energy.

12) Introduce, plan and manage renewable energy mechanisms to the Maldives.

13) Formulate guidelines, regulations and standards on the production, use, import, export and sale of water in the Maldives.

14) Conducting research into the available resources of water for daily life and for other purposes, and take necessary steps to introduce such resources nationally, as well as to develop and manage such resources in a sustainable manner.

15) Plan and implement activities to ensure protection and sustainable use of the water lens of the islands of Maldives.

16) Ensure the water security of the citizens of Maldives; design and implement all the components of water systems, storage facilities, and desalination plants.

17) Facilitate sanitation and waste water mechanisms; design and manage environment friendly sewerage systems in inhabited islands.

18) Plan and manage water and sanitation mechanisms; and provide technical and economic advice to the associated government authorities and the public.

19) Plan and implement policies, plan and implement a strategic plan which require to develop a competitive environment needed to extend the water and sanitation services in an affordable and convenient manner benefiting the recipients.

20) Ensure appropriate solid waste management mechanisms, and formulate the required laws and regulations.

21) Establish comprehensive facilities to dispose solid waste in throughout the Maldives; and provide assistance to the local councils in establishing a viable solid waste management system at island levels.

22) Develop and implement strategic plans to conserve the biodiversity, declare protected areas, and ensuring equal benefit of biodiversity resources.

### 3.2.2 Environmental Protection Agency

The Environmental Protection Agency (EPA) is a semi-autonomous regulatory body that functions under the MEE and operates under the guidance of the Minister in-charge of the MEE. EPA is responsible for the enforcement of regulations and standards endorsed by the MEE. Key regulations, standards and guidelines that are of relevance to the proposed Project are

- Implementation of the EIA regulations;
- implementation of waste management regulations;
- Implementation of environmental damage and liability regulations;
- Implementation of Wastewater Discharge Guideline;
- Implementation of Tree Cutting, Uprooting and Felling Regulation.

Since the EIA process is implemented by the EIA along with certain other regulations that of importance to the project, this organisation is of particular relevance to the proposed project. The EIA has been prepared in accordance with the direction and ToR provided by the EPA and the review of the EIA and decision making on whether to proceed with the project or not would also lie with the EPA. Once the EIA is approved the EPA would continue to engage in the project matters pertaining to monitoring and assessing the effectiveness of the proposed mitigation
measures. Additionally, EPA would ensure that the project complies other relevant legal instruments pertaining to conservation of the environment and would take appropriate actions in the events of non – compliance.

### 3.2.3 Ministry of Fisheries and Agriculture

Ministry of Fisheries and Agriculture (MOFA) is authorized to conserve all living and non-living marine resources in the ocean, reefs in the Maldives and it is also the main government intuition responsible for regulating aquaculture projects in the Maldives. It provides necessary guidelines and issues licences to carry out such projects. The processes of setting up of an aquaculture project begins initially by submitting a proposal in accordance with the guideline provided to the MOFA which then reviews it and decision is informed to the client. If the project gets green light from MOFA it would then ask the client to proceed with the EIA. Once the EIA is approved the proponent could apply for the aquaculture licence from MOFA. The main guidance for undertaking the aquaculture activities is provided by the Aquaculture Regulations. Although this regulation is still in draft form, the proposed project has given all due to considerations to adhere with the relevant directions provided init.

### 3.2.4 Ministry of Housing and Infrastructure

The Ministry of Housing and Infrastructure (MoHI) has the function of approving land for the proposed Project. The land approval and allocation function is played by Planning Department of MHI. The land approval process for the project hence was carried through the MoHI although the final approval was granted by the L Gan Island Council.

### 3.2.5 Island Council

Every inhabited island in the Maldives, except islands where city councils are established, is governed by an elected island council which prepares island development plans in consultation with the community, and submits them to the atoll council. They are also mandated to take all necessary measures to establish a safe and peaceful environment on the island in collaboration with the police. Island councils comprise elected members from that particular island. Each island council has a Island development committee advising on key issues, including: income generation and development, religious awareness, political participation, higher education, health, and collection of information and statistics on issues.

The role of council in the proposed Project is to allocate land and lease it to the client in consultation with MHI and the Atoll Council. All such decisions made by the island council are consulted with Atoll Council before finalizing. Since the project’s land lease agreement was signed between L. Gan Island Council and the proponent, the council has a critical role to play in facilitating the project progress. Hence, the proponent will be working very closely with the Island Council as the project progresses. Since it is also the responsibility of the Island Council to monitor the progress of development projects implemented in their jurisdictions, the proponent will provide all necessary information relating to the project progress to the island council.
3.2.6 Utility Services

The electricity and sewerage services on the island is provided by the state owned company of FENAKA. Hence discussions were held the company on ways of making use of these services at the project site. Initial discussions revealed that due to various constraints initially it may not be possible to get these central services connected with the project due to the isolated location in which the project is based. Discussions with FENAKA will continue and as soon as the services become available it will be made use of at the project site until which time a septic tank system and the project’s own generator system will be utilised.

3.2.7 Marine Research Centre

Marine research centre (MRC) is responsible for carrying out the necessary research and extension works on fisheries and aquaculture in the Maldives and provide technical policy advice as well as capacity development in these areas. During all stages of this project MRC will be consulted and its advice will be sought.

3.2.8 Maldives Energy Authority

The Maldives Energy Authority (MEA) is a semi-autonomous regulatory organization affiliated to the Ministry of Environment and Energy and operates under the guidance of a governing board. The mandate of MEA with regards to the proposed Project include that it is responsible for developing the regulatory code and standards on the production and use of energy in the Maldivian context, and developing and administering the regulations for the provision of energy in the Maldives. MEA also issues permits to parties that wish to produce electricity for their own use, and monitoring such parties to ensure adherence to relevant regulations. Issuing permits to electric technicians and setting the standards for consultants and investigating issues between parties arising from non-compliance to the terms of agreements between providers and users of electricity are also among the mandate of MEA.

During the design of the project’s facilities, electrical requirements will be determined to comply with MEA regulations before the construction works begin, wiring drawings will be submitted to MEA for approvals and the powerhouse will be registered with MEA.

3.3 LEGAL AND REGULATORY CONSIDERATIONS

3.3.1 Aquaculture Development Regulations (draft)

The Regulations is applicable to all projects intended to conduct of aquaculture in the territory and Maldives waters.

According to this regulation an application for an aquaculture license or renewal of an aquaculture license shall be made to the Ministry and upon receipt of the aquaculture permit the applicant shall apply for a lease in respect to the proposed site specified in the aquaculture permit following which an application for an aquaculture license shall be made in accordance with these regulations.
The following Table explains how the relevant clauses set forth in the regulations concerning conservation of the environment is complied with by the proposed project (Table 17).

**Table 17: Requirements under Aquaculture Regulations in relation to the proposed project**

<table>
<thead>
<tr>
<th>Provisions of the regulation</th>
<th>Compliance arrangement</th>
</tr>
</thead>
<tbody>
<tr>
<td>● The licensee shall not discharge waste generated on the aquaculture facility into Maldives waters, except biodegradable household waste.</td>
<td>As the proposal submitted to the Ministry explains all effluents will be treated to an expected level properly before discharging (see Section 2.8.10)</td>
</tr>
<tr>
<td>● Where an aquaculture facility is located on land or part thereof and for which discharge of water is required for the harvesting or treatment of fish or aquatic organism farmed or kept on the facilities must have an effluent reservoir built to a standard approved by the Ministry.</td>
<td></td>
</tr>
<tr>
<td>● No waste water from an aquaculture facility mentioned in sub-regulation, shall be discharged directly into Maldives waters, including lagoons, mangrove areas, etc. without first being treated at an effluent reservoir.</td>
<td>No waste from the facility will be discarded into the environment inappropriately. It will be done responsibly and in line with the existing regulations (See Section 2.11)</td>
</tr>
<tr>
<td>● In cases other than in sub-regulation including a marine aquaculture facility, the licensee shall take waste other than biodegradable household waste into a port, fish landing sites or other place and dispose of such waste in a manner satisfactory to the authority responsible for disposal of waste from aquaculture facilities in the port, fish landing site or other place in which such waste is landed.</td>
<td>The effluent treatment process is explained in the report in Section 2.8.10 which fully complies with this requirement.</td>
</tr>
<tr>
<td>● Unless circumstances render it costly or impractical, no form of treatment other than biological means of effluent treatment shall be used at any aquaculture facility.</td>
<td></td>
</tr>
<tr>
<td>● A licensee shall not transfer fish or aquaculture product to another place or location or into the possession of another person except in or at such place as specified in the license or approved in writing by the Ministry.</td>
<td>The broodstock and possibly juveniles in the beginning of the project will be obtained from a project that has been approved by the government. The MOFA will be notified and records properly placed of the details of the location, number and the type of sea cucumbers obtained to start the project. The export of the processed products from the farm will be in line with the existing rules and policies.</td>
</tr>
<tr>
<td>● Where a consent is granted and transfer effected, the licensee must by written notice confirm to the Ministry the quantity of fish or aquatic organism transferred.</td>
<td></td>
</tr>
</tbody>
</table>
A aquaculture license or exploratory permit holder shall maintain accurate data, information and records, information and records annually to the Ministry as it may specify in the aquaculture license or exploratory permit, with respect to the aquaculture facility and relating to:

(i) the origin, transport, transfer and stocking quantity of aquatic organisms;
(ii) the type and amount of food used in relation to the fish and aquaculture products at the aquaculture facility aquaculture license or permit holder;
(iii) the number and specific location of all aquaculture products;
(iv) a record of all disposals and sales of aquaculture products, including the date, number or weight and destination of each disposal and sale.
(v) the presence and occurrence of diseases;
(vi) the type of any medication used in relation to aquaculture products, including the dosage and treatment date and the duration of any veterinarian treatments; and,
(vii) any other data, information, statistics it may deem appropriate with respect to a particular aquaculture.

In order to facilitate control of serious disease outbreaks, all aquaculturists shall keep accurate and up-to-date records of the fish kept on their premises, from their arrival on premise until their final sale or disposal, including, among others, full information on any mortalities, any clinical signs observed, the nature and results of any diagnostic tests performed, and the nature and results of any treatments applied to farmed fish.

Aqua culturists may apply only those feed and feed additives produced by certified feed producers under internationally accepted standards and approved by the Ministry.

Application of locally produced feed and feed additives shall require Ministry pre-
approval in writing and supervision as to dosages, handling methods, application methods.

- In the instance where a serious outbreak of disease is identified within an aquaculture facility, the Ministry may mandate that all or a portion of a facility be placed under quarantine conditions as specified by the Ministry.

- During the period in which an aquaculture facility is under quarantine restrictions, the Ministry may require application of specific approved treatment methods specified in Annex, in the case of treatable diseases, or in the case on non-treatable diseases, the destruction of infected stocks, their sanitary disposal, and the disinfection of premises and all associated equipment to standards set by the Ministry.

- All details pertaining to the project has been submitted to the MOFA in the approval process and is believed that the Ministry took into consideration all these requirements in approving the project.

- The Ministry, in the exercise of its power to declare an aquaculture zone, shall have regard to at least the following factors:
  (i) the suitability of the proposed area for aquaculture;
  (ii) the risk of conflict posed in the proposed area by public and commercial fishing, navigation and recreational use;
  (iii) potential sources of damage to aquaculture from pollution;
  (iv) the potential environmental degradation posed by aquaculture facilities in the proposed area;
  (v) the sensitivity of the ecology of the proposed area;
  (vi) the desirability of restricting concentration of aquaculture activities in the proposed area;
  (vii) the desirability of restricting the species of aquatic organisms which may be used for aquaculture in the proposed area; and
  (viii) the relationship of the proposed area to the proper planning of land and water uses in the region.

- No marine aquaculture system shall be operated in such manner as to cause obstruction to navigation.

Will be fully complied with, in such a situation
### 3.3.2 Environment Act 4/93

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management for development projects.

a. An EIA shall be submitted to EPA and obtained approvals by EPA before implementing any development project that may have a potential impact to the environment.
b. Any project that has any undesirable impact on the environment can be terminated without compensation.
c. Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.
d. The penalty for breaking the law and damaging the environment are specified in the Law.
e. The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

This EIA report has been prepared to fulfil these legal requirements before proceeding with the construction and operational phases of the project.

### 3.3.3 EIA Regulations 2012/R-27

Projects that require EIA are listed in Annex D of revised EIA regulation No. 2012/R-27 that includes aquaculture projects. Clause 13, under second amendment of EIA regulation No. 2015/R-174, Annex D clearly says all aquaculture projects are required EIA to be carried out before any such project is approved. Hence this reported is intended to serve this regulatory requirement.

This is EIA report has been prepared as a fulfilment of this regulatory requirement and the report has taken into full consideration all relevant directions provided in the regulations.

### 3.3.4 Waste Management Regulations

The waste management regulation (2013/R-58) gazetted on 5 August 2013 is an important legal instrument for waste management across the country. The waste management regulation vested under Environment Protection and Conservation Act 4/93 covers wide range of aspects related to waste management. The aim of the regulation is to support national waste management policy through protection and conservation of natural environment. The Waste Management Regulations is of relevance to the proposed project as it involves generation of waste both during and post development of the Project. Chapter 2, Clause 2 (2) (7), Clause 8, Clause 10, Clause 11, Clause 12 are of relevance to the Project.

The waste produced from the initial site preparation works such as clearing of vegetation, as well as waste produced during the construction (which include waste such as building materials, excavations and waste generated by workers onsite) will be managed according to the Waste Management Regulations. The waste, properly sorted according to type, will be temporarily stored in a designated area and will be transported to Thilafushi. (See to Section 2.11.1).
3.3.5 Land Act

This Act (1/2002) governs the allocation of Maldivian land for different purposes and uses and other issues regarding the issuing of land, issuing of state dwellings for residential purposes, conduct regarding state dwellings or private dwellings constructed for residential purposes and the sale, transfer and lease of Maldivian land.

The Law states that all transactions concerning the issuing, receiving, owning, selling, lease, utilizing and using Maldivian land shall be conducted in compliance with this Act. The Ministry of Home Affairs, Housing and Environment\(^\text{11}\) shall entrust the land allocated for different purposes and uses in accordance with Sections 3 and 4 of this Act to the concerned Ministries.

Land in the Maldives can only be allocated a. for the construction of households and buildings for residential purposes. b. For commercial use. c. For social use. d. For environmental protection. e. For government use.

The land allocated for the project will be used for commercial purposes and has been allocated in accordance with the procedures set forth in the Act (see Annex 6).

3.3.6 Regulation on Cutting Down of Trees

The Regulation on Cutting Down, Uprooting, Digging Out and Export of Trees and Palms from One Island to Another is enforced by the MEE. Clause 5 (a) of the regulations states that prior to the commencement of any project(s) that would require the indiscriminate removal and export of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the Regulation to prepare and Environmental Impact Assessment Report stating clearly the details of the Project(s).

Article 8 (a) requires permission be obtained from Ministry of Environment, Energy and Water, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (Article 8 (c)).

This regulation applies in the case of the proposed project as the siting of the land – based facilities will require removal of trees. Hence this EIA report intends to address all impacts associated and propose robust mitigation measures to minimise impacts. The Section 9.2.1.2 of the report addresses these aspects in detail.

\(^{11}\) Presently the Ministry of Housing and Infrastructure
3.3.7 Environmental Liability Regulations

The Environmental Liability Regulation (Regulation 2011/R-9) that came into force on 17th February 2011 covers a wide range of issues which enables charging of penalties, and compensation on environmental polluters enforced by enforced by EPA. The regulation came into effect in order to ensure that any developmental activities conducted will ensure the protection of the environment as well as sustainable development. The regulation also ensures that the surrounding environment is not degraded or deteriorated, and any natural resources are not wasted during said developmental activities.

The project activities will be carried out fully in compliance with all existing laws and regulations and guidelines. The mitigation measures proposed in this report will ensure that the proposed project complies with the Environmental Liability Regulation. Since the EIA forms an integral part of the civil works and operations related activities, the respective parties shall be aware that Environmental Liability Regulation will be applied in instances where damage to the environment is caused.

3.3.8 Dewatering Regulations 2013/R-1697

Dewatering regulation no. 2013/R-1697 gazetted on 31 December 2013 has been one of the important regulations enforced by EPA as a measure of protecting and conservation water resources. It helps to protect groundwater aquifers from by avoiding direct pumping for a longer period continuously. Clause 7 (a) of this regulation says, if dewatering is required, dewatering permit is required obtained from EPA or an institute authorized by EPA through an application form. The proposed Project, does not foresee any significant dewatering during construction as only simple building structures have been planned to be opted (see Section 2.18 on building methodology). In case of any requirement for dewatering such as installation of pump station, then relevant permit will be obtained.

3.3.9 Regulation on Management, Use and Control of HCFC Substances 2010

Regulating phasing out of import, use, selling of HCFC substances by 2011 and completely eliminating use of HCFC substances in the Maldives by 2020 through controlling importers, registering importers, establishment of a quota system, control mechanisms for selling, maintenance of import, selling, purchase and service providers statistics. The proposed project will not procure or use any equipment or machine that uses HCFC substances. Responsible procurement will be practiced through the life time of the project.

3.3.10 National Waste Water Quality Guidelines

The National Waste Water Quality Guidelines (2006) implemented EPA since 2008 applies to all the islands in Maldives and special permission needs to be obtained from EPA for wastewater disposal from industrial activity or an industrial island.
The guidelines state islands that have less than 1000 people in residential population and produce an estimated wastewater volume less than 0.11Ml as exempt from the guidelines and only require the removal of solids. The guidelines state that in 2006, 80% of islands fell in this category. Island type 2 includes focus islands with only residential wastewater produced. Of these islands, those producing 0.11Ml to 0.5Ml of wastewater require septic tanks only and are required to apply the solid and microbiological domestic waste water guidelines. Such islands that produce greater than 0.5Ml of wastewater are required to treat the wastewater with primary and secondary treatment before deep sea discharge. Focus islands that produce both domestic and industrial wastewater and other major islands are required to conduct primary and secondary treatment of wastewater before deep sea discharge.

Under table 7.1 of NWWQG the guidelines “Maximum allowable concentrations in Domestic and Industrial waste water for deep sea discharge”, the guidelines state the maximum concentration of the components of the discharged wastewater. This includes 100 org/100ml for faecal coliforms, 1 org/100ml for E. coli, 150mg/l suspended solids, temperature not more than 44°C. The pH between 5-9.5 and COD and BOD at 50mg/l and 40mg/l respectively. In addition, the maximum allowable concentrations of oils, grease and metals are also provided under the guidelines.

The project will not result in generation of large volume of sewerage as in-house staff will be relatively few. Since the service of FENAKA does not reach the project site the only choice available at least in the beginning is to have a septic system in place. Hence no sewerage will be discharged into the open sea. However, wastewater generated from aquaculture related activities will be discharged out of the house reef into deeper waters. All effluents will be discharged in accordance with these guidelines and discharge water qualities where applicable will meet the guideline criteria.

1.11 Sewerage System Design Criteria

Sewerage systems, particularly those systems that are implemented on inhabited islands by private and government sector are designed in accordance with Sewerage System Design Criteria 2012 enforced by EPA. All such designs must get approval by EPA before implemented by the developer. At the same time the criteria for electromechanical components of the system need to be approved by Maldives Energy Authority (MEA).

The general design guidelines state that the sewerage system shall be designed for 35 years, with the pumps and other components designed for a duration of 15 years. The guidelines also include the technical specification of the materials to be used for the system, along with criteria for the electromechanical components and work methodology.

The detailed design of the septic system will be submitted for the approval of EPA prior to commencement of physical work.
### 3.4 RELEVANT NATIONAL POLICIES AND STRATEGIES

#### 3.4.1 National Biodiversity Strategy and Action Plan

National Biodiversity Strategy and Action Plan (NBSAP (2016 – 2025) is the government’s key policy document on conservation of the nation’s biological diversity. It sets out the vision as “a nation of people that co-exist with nature and has taken the right steps to fully appreciate, conserve, sustainably use, and equitably access and share benefits of biodiversity and ecosystem services” (MEE, 2016). The documents are guided by three key principles emphasising that the need for everyone’s participation in achieving the goal set forth in the NBSAP. The three principles of NBSPA include:

- The people of this generation and the generations to come reserves the right to access and share benefits of rich biodiversity and ecosystem services;
- Responsibility of conserving and sustainably using biodiversity lies on every one’s shoulders and shall be taken as a shared responsibility; and
- Biodiversity shall be mainstreamed into all sectors and in a manner whereby monitoring progress and accountability is ensured.

NBSAP identifies destruction of habitats, including reefs, lagoons, beaches and mangroves due to development activities as a major threat to conservation of biodiversity. In addition, NBSAP states, increase in population and economic growth intensified the demand on natural resources and space with resulting over-exploitation of biodiversity, decline in certain species such as turtles and tuna catch, clearance of vegetation to meet the demands of development as contributing factors threatening the country’s biological diversity. Importing of alien species and those listed in CITES have been included among the growing challenges. Improper waste management, disposal of dangerous chemicals, oils and non – biodegradable wastes into the surrounding sea has also been highlighted posing threats to biological diversity.

In order to address the threats faced to the nation’s biodiversity NBSAP identifies six strategies of which Strategy 1: Strengthen governance, policies and strategies for biodiversity, Strategy 4: Ensuring sustainable use of biological resources, and Strategy 5: Addressing threats to conserve biological diversity are particularly relevant to the proposed project.

Target 4 under Strategy 1 is about producer/extractor responsibility which states that private sector remains the main beneficiary of the biological resources of the country and thereby has the responsibility in being a benefactor. Hence a target by 2025 has been set for the government, businesses and stakeholders at all levels to taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Target 13 under Strategy 4 states that by 2020 all major fishery, including aquaculture and mariculture are managed and harvested sustainably.

Target 17 under strategy 5 states by 2025 pressures on coral reefs and other vulnerable ecosystems due to anthropogenic activities and climate change are minimized. While target 23 says by 2020
pollution from waste and sewage has been brought to levels that are not detrimental to ecosystem functions and biodiversity.

The proposed project will be managed responsibly in line with the relevant provisions of the NBSAP as detailed in this report. In order to reduce the likely impact to vegetation and reef, site locations have been carefully assessed. The effluent from hatchery units and processing units will be treated and discharged outside the house reef in a good mixing zone. The strong wave action and high energy associated in the effluent disposal zone at reef environment gives further assurance that the strength of the effluent weakens through dissipation and dilution. Project’s solid waste will be managed in a responsible manner, use of chemicals and feed will be of approved types and finally the project will not result in the loss of a unique species or habitat.

### 3.4.2 Maldives National Strategy for Sustainable Development

Maldives National Strategy for Sustainable Development (MNSSD) (2009) sets out the strategy on how the Maldives will fulfil its commitment to meet the challenges of sustainable development. The overall aim of the MNSSDS was to identify and develop actions to enable the people of the Maldives to achieve continuing improvement in their quality of life both now and in the future. This guiding policy recognizes seven sustainable development goals for the Maldives. The first goal is the adaptation to climate change. The objectives highlighted under this goal include making inhabited islands resilient against the threats posed by global climate change, protecting critical infrastructure such as international airports from sea induced hazards and predicted climate change impacts and Provide innovative coastal protection for selected islands and tourist resorts and Strengthen human, technical, regulatory and institutional capacity for coastal zone management (GoM & UNEP, 2009).

The proposed project has been designed with the prime objective of addressing the principles of sustainable development. Sustainable development is the managing and conserving of natural recourse based on technological and industrial changes in such a manner as to ensure the attainment and continued satisfaction of human needs for the present and future generations (Rio Summit, 1992). Such a development will conserve land, water, plants, animals and genetic resources in environmentally non- degrading, technically appropriate, economically viable and socially acceptable manner. Therefore, this project extensive polyculture farming system would be applied for grow-out cage culture of sandfish. Furthermore, this extensive polyculture system would be very suitable because it relies on natural food, no food waste and reduce water pollution. Extensive faming would be much more environmental friendly and lower requirements of inputs. The project also takes into resource conservation, maximising use of free resources such as rainwater harvesting and resource recycling such as composting. In addition, it will also explore use of building rooftops to install solar PV systems to generate renewable energy to minimise use of diesel based electricity use.

### 3.4.3 National Adaptation Programme of Action

National Adaptation Programme of Action (NAPA) (2007) presents the framework to climate change adaptation to enhance the resilience of the natural, human and social system to ensuring their sustainability against predicted climate change. NAPA lays out the national policy framework
for the Maldives. The document comprehensively describes the climate vulnerabilities faced to the Maldives. It also emphasizes wetland conservation through priority actions such as flood control, recognizes the importance of coral, and also includes enhancing capacity for solid waste management as a priority action to prevent pollution of the marine environment.

As described in various sections of the report the design of the project has emphasised on minimising impacts on the environment, recognizing the importance of sensitive marine and terrestrial environment thereby putting place appropriate mechanisms for solid waste management and pollution control as a priority action to prevent pollution of the environment.

### 3.4.4 Maldives Climate Change Policy Framework

Maldives Climate Change Policy Framework (MCCPF) (2015) highlights the climate vulnerabilities of small island developing states such as the Maldives and further states that these islands are in a special risk of being inundated as sea-level rise, land loss and beach erosion continues to increase and threatens food and water security. MCCPF calls for strengthening adaptation actions and building climate resilient infrastructure and communities as an adaptation and opportunity to address current and future climate vulnerabilities with the following specific objectives (MEE, 2015):

1. To develop effective adaptation and risk reduction responses and capacity in all climate change priority areas for adaptation and opportunities;
2. To promote and implement adaptation programmes that support and improve communities’ livelihoods to reduce the vulnerability and increase the resilience;
3. To make the inhabited islands and people of Maldives resilient against the threats posed by global climate change;
4. To protect critical infrastructure such as international airports, other inhabited islands and tourist resorts from sea related hazards and predicted climate change impacts;

### 3.4.5 Third National Environmental Action Plan

Third National Environmental Action Plan (NEAP3 2009 – 2013) was formulated to set the environmental agenda for the five-year period with an objective of creating liveable and sustainable places in which protection of the environment while making people and properties resilient. It was aimed at promoting resilient island communities, conserving environment, promoting healthy communities, providing safe water and environmental stewardship among other objectives.

### 3.4.6 The Strategic National Action Plan

The Strategic National Action Plan for Disaster Risk Reduction and Climate Change Adaptation (SNAP) (2010-2020) recognizes the islands of the Maldives by nature are low lying exposing the communities to the threat of beach erosion, sea level rise and saltwater intrusion into the groundwater lens and other climate change impacts as natural hazards faced to the Maldives. Among the key goals of the SNAP building resilient communities through empowerment and
incorporating disaster risk reduction into government’s decentralization policy have been stated (NDMC, 2009).

### 3.4.7 Consultation and Public Participation

In the EIA process the public participation has been limited to the review and community consultation stages of the EIA. It has been considered an important and integral part of the EIA process. Hence, this EIA has also taken public views into consideration. Public consultations are conducted in order to take public opinion, views and expectations into the project.

### 3.5 INTERNATIONAL COMMITMENTS

Some of the international conventions, treaties and protocols of relevance to the proposed project are identified as follows:

#### 3.5.1 Convention on Biodiversity

The objective of the Convention on Biodiversity (CBD) is “the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies, and by appropriate funding”. The Maldives signed the convention in June 1992 and ratified it on 28th October 1992. Maldives is one of the first nations to ratify CBD. Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002. The Maldives made its fourth national communication to CBD in 2010 and the fifth in 2015.

The proposed project involves some degree of habitat alterations as well as generation of wastes and pollution. The compliance arrangements under CBD will be achieved through the implementation of recommendations of NBSAP as described above.

#### 3.5.2 MARPOL Convention

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention which addresses pollution of the marine environment by ships due to operational and accidental causes. As a party to the MARPOL convention, Maldives is required to oblige and maintain the standards specified by the convention with regard to maritime pollution and their control.

These include pollution due to:

- Oil spillage
- Noxious liquid substances in bulk
- Spillage of harmful substances carried by sea in packaged form
- Sewage and garbage from ships
- Air pollution from ships
Marine pollution prevention during all project activities have been given highest importance as explained in the relevant sections of this report.

3.5.3 National Communication to UNFCCC

The Maldives has published its Second National Communication to UNFCCC in November 2016. The First National Communication Report was submitted to UNFCCC in 2001 as part of the obligation under Article 4.1 (a) and Article 12 of the UNFCCC Convention. The Second Communication report covers wide range of information regarding climate change impacts and challenges.

3.6 ENVIRONMENTAL PERMITS

3.6.1 EIA Decision Statement

The EIA Decision Statement, as it is referred to, shall govern the manner in which the project activities must be undertaken. The environmental permit to commence the proposed project is the decision statement to be made by EPA. The decision statement will be given to the proponent after independent review of EIA report. The decision statement will on the degree/significance of impacts to environment from the proposed development. This EIA report will assist EPA making informed decision relevance to the proposed project.

3.6.2 Aquaculture Permit

The project can proceed only once the MOFA issues the permit or licence to carry out the said project in the Maldives. A conditional approval has already been granted to the proponent by MOFA in which obtaining EIA clearance has been stated as a pre-requisite for obtaining the aquaculture permit.

3.6.3 Permit on Uprooting Coconut Palms and Trees

Before commencement of the land clearance, the proponent shall apply to EPA for permission to uproot and relocate trees.

3.6.4 Septic System Approval

Before the commencement of the implementation of the project, the final design of the septic system will be submitted to EPA for approval.

3.6.5 Electrical Wiring Approval & Power System Registration

All electrical drawings of the facility will be submitted to MEA for approval and so will be the registration of the powerhouse.
3.6.6 Land Approvals

Land approval for the project has already been given by the Island Council following the due procedure that exists in the Maldives for allocating land for commercial purposes (see Annex 9).
4. EXISTING ENVIRONMENT STUDY METHOD

4.1 INTRODUCTION

This section of the report addresses Task 2 of the TOR and provides descriptions of the methods used to collect data of the existing natural and socio-economic environment of the project site. The chapter also addresses sensitivity and limitations of methods used in the study. Efforts were made to collect as much primary data as possible within the time limitations. Information was also collected through interviews, discussions and formal meetings with stakeholders. Available information from reliable literature was also used to supplement the existing environmental study.

A team from MEECO travelled to L. Gan on 20 – 26th September 2016 to conduct environmental and socio economic surveys for this EIA report.

The environmental components of the study area were divided into three categories as follows:

1. Marine;
2. Coastal and
3. Terrestrial.

The different methods used in assessing and reporting the conditions of the existing environment of the island are given in the following subsections.

Figure 25 shows map of all environmental survey locations with GPS coordinates.
Figure 25: Map of all survey location
4.2 CLIMATE

Climate conditions at the project site was assessed after compiling 37 to 41 years of weather data for the period 1972-2015 for Velana International Airport (VIA) situated at Hulhule’ Island, Male’ Atoll, obtained from (MMS, 2016). VIA was chosen as it was the hosting the weather station which had sufficient long term data for assessment of weather patterns. The closest weather station although was located at Kadhdhoo Airport, data available was limited and considered not adequate for climate analysis. The weather station at VIA is maintained by the Maldives Meteorological Service (MMS).

The statistical data were analysed for the following parameters:

- Rainfall and sunshine;
- Mean high temperature and low temperature and
- Wind.

4.3 WAVES

Long term wave climate at the project area was determined using NOAA long term hindcast data of the region. As a first step, wave data was extracted from 2 latitude, 74 longitude coordinates as illustrated in Figure 26. The study accurately determined the wind wave and swell wave behaviour of L.Gan. The study was conducted within the limitations of a 0.5 grid. Data was extracted at a frequency of three hours for the most up to date full set of data available (2015).
Figure 26: NOAA wave data extraction points
4.4 TIDES

Tide climate at L. Gan was assessed after inferring tide data which have been collected by tide gauges installed in Baa atoll. Tide data was referenced from (Tides for Fishing, 2016). Tidal coefficient during field assessment and the general trend in tidal behaviour was determined. The time and heights of high and low tides were determined.

4.5 CURRENTS

Near shore currents were measured by conducting drogue tests at the lagoon area and outfall area. Drogue tests were carried out using a GPS tracker placed inside purposely built case which was left at the sea for at least 20 minutes. The tracker recorded the speed and position data which was later analysed using software to determine surface current direction and speed at the time of data collection. To obtain more concrete data, measurements need to be taken for a longer period of time.

The method used for determining current speed had limitations. The drogue method employed in the study was able to determine surface current speeds only. Since data was collected over a single day, the changes in surface current regime was not determined. Current data should be logged for longer period of time to understand the overall current regime.

4.6 GEOLOGY AND SEDIMENTS

Soil profile and geological properties of project area was inferred after referencing soil analysis done for R. Vandhoo. Vandhoo was a significant in size and elongated in shape. It was a mature island that is comparable to L. Gan. Since geological formation of islands in the Maldives a quest similar soil analysis of Vandhoo was considered as reliable for the EIA purposes. Samples were collected from the two distinct zones (top soil and bottom soil layer). The samples were stored in airtight sample bags, transported to Sweden and tested for the following parameters:

- Grain size distribution;
- Frost heave cap and
- Permeability of two layers.

4.7 TOPOGRAPHY AND BATHYMETRY

The coastal features of the island, and topographical features of the island was mapped using a GNSS RTK system. The shore line of the island including the high tide, low tide and vegetation lines of the island was surveyed during the field work. The island cross sections and beach profiles were analysed to better describe the coastal features and elevations of the island. Bathymetry of the project area was done using an echo sounder.
4.8 WATER QUALITY

Water quality assessments of was carried out after testing the following parameters on site using the using *Horiba* Multi Parameter Water Analyser:

- Temperature;
- pH;
- Turbidity(NTU);
- Dissolved Oxygen (mg/L);
- Electrical conductivity (µs/cm);
- Salinity (ppt); and
- Total dissolved solids (mg/l).

Parameters listed below were tested from the MWSC laboratory.

- BOD₅ (mg/l);
- Faecal coliform (mg/l);
- Total coliform (mg/l);
- Phosphates (mg/l);
- Nitrates (mg/l); and
- COD (mg/l).

The location of data collection sites was marked using the handheld GPS. Survey map in Figure 25 shows the groundwater and seawater data collection and sampling locations. Groundwater was collected and sampled from wells across the island.

The samples were analysed for the following parameters as indicated in the environmental monitoring manual issued by the EPA (See Table 18). The groundwater data was also compared with WHO guidelines for drinking water attached in Table 19.

*Table 18: EPA guideline for water quality*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Optimal range</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>18°C and 32°C Changes should not surpass 10 °C above the average long term maximum</td>
<td>GBRMPA, 2009</td>
</tr>
<tr>
<td>Salinity</td>
<td>0.032 - 0.042 ppm</td>
<td>GBRMPA, 2009</td>
</tr>
<tr>
<td>pH</td>
<td>8.0-8.3 Levels below 7.4 pH cause stress to corals</td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>3-5 NTU &gt;5 NTU causes stress to corals</td>
<td>Cooper et al. 2008</td>
</tr>
<tr>
<td>Sedimentation</td>
<td>Maximum mean annual rate 3 mg/cm²/day Daily maximum of 15mg/cm²/day</td>
<td>GBRMPA, 2009</td>
</tr>
<tr>
<td>Nitrates</td>
<td>&lt;5 mg l⁻¹ NO₃-N</td>
<td>UNESCO/WHO/UNEP, 1996</td>
</tr>
<tr>
<td>Ammonia</td>
<td>Max. 2-3 mg l⁻¹ N</td>
<td>UNESCO/WHO/UNEP, 1996</td>
</tr>
</tbody>
</table>
### Table 19: WHO guideline for drinking water. Source: (WHO, 2006)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Physical appearance</td>
<td>Clear &amp; Colourless</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>&lt;1500 µs/cm</td>
</tr>
<tr>
<td>Total coliforms</td>
<td>0/100ml</td>
</tr>
<tr>
<td>Faecal coliforms</td>
<td>0/100ml</td>
</tr>
<tr>
<td>Turbidity</td>
<td>&lt;5NTU</td>
</tr>
<tr>
<td>Total dissolved solids (TDS)</td>
<td>&lt;1000 mg/l</td>
</tr>
<tr>
<td>COD</td>
<td>10mg/l</td>
</tr>
<tr>
<td>BOD₃</td>
<td>6mg/l</td>
</tr>
</tbody>
</table>

### 4.9 MARINE ENVIRONMENT

Coral communities was assessed by combination of underwater visual observations and underwater transect and photography.

The **equipment** used for reef survey are:

- Fiberglass tape 20m
- Handheld Global Positioning System (GPS)
- Still photograph camera
- Writing sheets

The reef community is characterized using life form categories which provide a morphological description of the reef community. These categories were recorded on data sheets by snorkelling along a 20 m long line which was placed at two randomly selected locations on lagoon area of project at a depth of less than 1m. GPS location of the starting point of the line was recorded for future reference and monitoring. Previous surveys with varying length of transect lines revealed that a 20 m long transect is enough to cover all the main different types of corals in a particular site as shown by the species area curve. It has been established that the length of the transect line increases up to about 20 m, the number of different types of corals recorded under the line increases but not beyond 20 m. This means 20 m long transect covers all the different types of corals in a particular site, therefore not necessary to deploy a transect line longer than 20 m in order to assess all the different types (categories) of corals.

Series of photographs were taken along the transect to capture all features that intersected with the tape. The photographs were later analysed to assess the benthic types and coral species at the survey sites. The assessment was done to identify coral forms which include laminar, encrusting,
free living, columnar, foliaceous, branching, massive, digitate tabular, sand bottoms, grass beds and rubble. Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes.

**Coral Reef Fish Visual Census (CRFVC) Qualitative Survey**

In this survey quantitative assessment of the reef benthos and fish populations were conducted at Site Transect 1. Coral Reef Fish Visual Census (CRFVC) (See Survey Manual for Tropical Marine Resources pp. 35-51 and 69-79 respectively for details) were used in the assessment.

In this survey only the number of individuals of different species was counted but sizes of the fishes were not estimated. Fish species counted were visually and numerically dominant and associated only with sea grass and reef flat habitats, cryptic species were not counted. Number of individual fish in large schools (consisting of more than about 20 individual fishes) were not counted but recorded as schools. The same observer recorded all the data both on coral cover and fish abundance and diversity at Site 1 and 2 to ensure consistency.

**Procedure followed to conduct CRFVC.**

Ten to five minutes after laying out the tape it was swum (using mask, snorkel and fins) very slowly along, photographing, counting and recording, number of individual and species of fishes seen within five meters to either side of the tape. At the reef edge where it is too deep to lay the tape, observer swam in a straight line for approximately 100 m.

The photographs and videos collected during the study were later analysed to identify the type of fish species using two sources; (Anderson & Hafiz, 1987) and (Kuiter & Godfrey, 2014).

Fish abundance was assigned by counting, and comparing the count to a selected range which was specific for the area. The count and range band as given in **Table 20.**

<table>
<thead>
<tr>
<th>Fish Abundance</th>
<th>Count Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rare</td>
<td>0 - 10</td>
</tr>
<tr>
<td>Common</td>
<td>10 - 35</td>
</tr>
<tr>
<td>Abundant</td>
<td>35+</td>
</tr>
</tbody>
</table>

The method encompasses certain degree of uncertainty. These include:

- Some species may be cryptic in the presence of surveyors; hence these species would not be accounted for in the survey.
- Fast moving fishes may not be captured during the timed swim hence these species would also be under estimated.
- Time of swim may impact observation of certain species as some species are more active at night.

Hence the results obtained through the analysis should be considered as an underestimate of the actual marine biodiversity at the site.
4.10 VEGETATION SURVEY

The flora and fauna survey is an important component in undertaking environmental impact assessments. It defines faunal and floral species types and helps to understand differences among the types and species for its conservation and future environmental monitoring. In order to undertake the fauna survey on project sites, a literature review on conservation status of faunal taxa and potential impacts to it from proposed development has been carried out.

In order to determine the number of coconut trees and significant trees that may have to be uprooted as a result of the proposed development, a tree survey of the sites was carried out using the total station.

A combination of visual observations and aerial photos were used to identify the major types and extent of vegetation. Photographs taken at the sites were used to identify other types of flora and fauna in the project area.
5. EXISTING ENVIRONMENT

5.1 INTRODUCTION

This Chapter of the report addresses the existing environmental baseline conditions at Project site in L Gan. The analysis of existing environment is fundamental for the assessment of the projects feasibility and its impacts and determining the effective mitigation measures to avoid or minimise the effects of project activities on the environment.

5.2 CLIMATE

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MMS, 2016) and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm.

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: The Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. Monsoons can be best characterized by wind and rainfall patterns. These are discussed in more detail in the following subsections. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November. However, according to Elliot et al, 2003 due to proximity to the equator, the monsoon seasons in Maldives are not as well defined as they are in Sri Lanka. The monsoons in Maldives are best defined in the northern part of the country where distinct monsoon seasons including the strong southwest monsoon from June through September and a noticeable northeast monsoon from December through February. Table 21 below shows a summary of four seasons in Maldives.

<table>
<thead>
<tr>
<th>Season</th>
<th>Months</th>
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<tbody>
<tr>
<td>North East-Monsoon</td>
<td>December</td>
</tr>
<tr>
<td>(Iruvai Moosun)</td>
<td>January</td>
</tr>
<tr>
<td></td>
<td>February</td>
</tr>
<tr>
<td>Transition Period - 1</td>
<td>March</td>
</tr>
<tr>
<td>(Hulhangu Halha)</td>
<td>April</td>
</tr>
<tr>
<td>South West-Monsoon</td>
<td>May</td>
</tr>
<tr>
<td>(Hulhangu Moosun)</td>
<td>June</td>
</tr>
<tr>
<td></td>
<td>July</td>
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<tr>
<td></td>
<td>August</td>
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<tr>
<td></td>
<td>September</td>
</tr>
<tr>
<td>Transition Period - 2</td>
<td>October</td>
</tr>
<tr>
<td>(Iruvai Halha)</td>
<td>November</td>
</tr>
</tbody>
</table>

General meteorological conditions expected to prevail in the project environment was based on meteorological data collected at Hulhulé. These findings are briefly discussed in the sub sections below.
5.2.1 Temperature

The Northeast monsoon is classified as the dry season and brings less rainfall and higher, high temperatures and higher low temperatures while the opposite is observed for the Southwest monsoon which is the wet season. This is evident from maximum high temperature and minimum low temperatures logged for the past 38 years at Hulhule’ island.

The daily mean high and low temperature throughout the thirty-eight-year period was found to be very consistent with fairly small variations. Temperature analysis of the past 38 years showed that:

- Temperature gradually increases at the start of northeast monsoon and reaches a peak at around April;
- The mean yearly high temperature for the past thirty-eight years was 30.9 °C; (Figure 27)
- The mean yearly low temperature for the past thirty-eight years was 24.7 °C; (Figure 28);
- The maximum high temperature remained above the mean high temperature during the north east monsoon and below the mean high temperature during the southwest monsoon;
- The onset of southwest monsoon gradually decreased the high temperature where, temperature reaches its lowest at the end of December;
- Temperature fluctuated from the mean in accordance with the monsoons, where highest and lowest registered temperatures were observed during monsoonal transition periods;
- Yearly temperature variance for the past thirty-eight years was extremely consistent with 0.4 °C;
- The daily low temperature showed that on average temperature was lower than the mean low temperature (24.7 °C) during the south west monsoon and vice versa during the north east;
- The average variance in low temperature was found to be 0.8 °C; and
- The average high and low temperature was found to be extremely similar between the southern, northern and central atolls of the Maldives. (See Figure 29).
**Figure 27: Mean high temperature (1978-2015)**

**Figure 28: Mean low temperature (1978-2015)**

**Figure 29: High and low temperature variance between atolls of the Maldives**
5.2.2 Wind

Summary wind data since 1964 indicate that the Maldives experience southwest to northwest winds (~225 – 315°) from April to November (westerly monsoon) with a mean wind speed of 0.5 ms\(^{-1}\). In contrast, winds from the northeast-east (~ 45-90°) prevail from November to March (northeast monsoon) with a mean wind speed of 4.8 ms\(^{-1}\). Wind strength is most variable during the cross-over between northeast and westerly monsoons with mean wind speed falling to 3.5 ms\(^{-1}\) in March (DNP, 2016).

These winds approach with great constancy, primarily from the northeast and southwest directions. Some seasonal changes occur within this pattern, as a result of the relative position of the sun and the earth’s surface. Strong winds and gales are infrequent although storms and line squalls can occur, usually in the period from May to October.

Wind pattern influencing project area was assessed after compiling wind data obtained from Hulhule’ from 2014 - 2012 via Yearly Climate Statistic provided by DNP. Variance of three-year monthly rainfall was determined through standard deviation calculations.

It was found through historical wind velocity analysis that:

- Westerly winds were dominant throughout the year (W – 50% and WSW – 16%). (See Figure 30 and Figure 31);
- Easterly winds were observed only during the northeast monsoon for the months December, January and February (ENE 33%);
- The yearly average wind speed was 4 ms\(^{-1}\) (9 miles/hr);
- Lowest wind speeds were recorded during March 3 ms\(^{-1}\) (7 miles/hr), April 3 ms\(^{-1}\) (6.7 miles/hr) and November 3 ms\(^{-1}\) (6.7 miles/hr); and
- The highest and most variable wind speeds were logged in February, where average wind speeds were 5 ms\(^{-1}\) (12 miles/hr) with a variance of 2.6 ms\(^{-1}\) (6 miles/hr)

![Figure 30: Annual monthly wind speed (2012-2014)](image-url)
5.2.3 Rainfall

Rainfall pattern was assessed after compiling rainfall data obtained for Hulhule’ for the past Forty-one years sourced from the Yearly Statistic provided by (DNP, 2016). Variance of forty-one-year monthly rainfall was determined through standard deviation calculations.

Rainfall data analysis showed that:

- The mean yearly rainfall was 1988.8 mm;
- Rainfall was lowest during the northeast monsoon. The average annual rainfall during the northeast monsoon was 98 mm, this was significantly lower than the mean yearly rainfall (See Figure 32);
- February was found to be the month that received the least amount of rainfall (34 mm) with a variance of 44 mm. This was also the month that had the least variance in rainfall;
- Following February, March and April were found to be driest months with the least incidence of rainfall for the past forty-one years;
- The highest rainfall was observed for the months of May, October, September and December where the average rainfall was 227 mm 276 mm and 240 mm respectively;
- The highest variance in rainfall was observed for the months of January, September, October and November where the variance calculated was 88, 101, 122 and 137 mm respectively; and
- On average rainfall during the southwest monsoon was always higher than annual average;
- The annual average rainfall in the northern atolls is lower than the southern atolls based on historical climate data analysis from southern atolls.

![Rainfall Data](image)

*Figure 32: Annual monthly rainfall (1972-2015) compared with average yearly rainfall (1972-2015)*

### 5.3 TIDES

Tides experienced in Maldives are mixed and semidiurnal/diurnal. Typical spring and neap tidal ranges are approximately 1.0 m and 0.3 m, respectively. The tide varies from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year. In the Maldives, tides may have significantly important influence on the formation, development, and sediment movement process around the island.

Tidal data for the assessment period was inferred from (Tides for Fishing, 2016). The first high tide was at 4:35 h followed by 16:20 h. The first low tide was at 11:10 h followed by 22:55 h.

The heights were 0.9 m, 0.5 m, 0.7 m and 0.4 m respectively referenced to Mean Lower Low Water (MLLW) (see *Figure 33*).
Figure 33: Tide variation during field assessment

Tidal coefficients are calculated from the sun and the lunar cycles: straight ascension, declination, parallax and the distance between the Earth and the celestial body. The highest possible tidal coefficient is 120, corresponding to the greatest high or low tide there can be, excluding meteorological effects. The tidal coefficient during field trip was 49 in the morning and 47 which was the lowest observed for the month of September. However tidal coefficients were observed to fluctuate through the year as illustrated in Table 22. April was observed to have the greatest variation in tides. Tidal coefficients were mostly average to high throughout the year.
### Table 22: Yearly tidal coefficient, 2016

<table>
<thead>
<tr>
<th>DAY</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
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<tbody>
<tr>
<td>1</td>
<td>46/43</td>
<td>39/39</td>
<td>40/37</td>
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<td>57/63</td>
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<td>36/38</td>
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<td>59/56</td>
<td>62/62</td>
<td>60/59</td>
<td>57/62</td>
<td>73/77</td>
<td>75/78</td>
<td>76/78</td>
</tr>
<tr>
<td>28</td>
<td>70/65</td>
<td>58/53</td>
<td>62/57</td>
<td>49/47</td>
<td>56/54</td>
<td>62/64</td>
<td>59/61</td>
<td>66/71</td>
<td>81/84</td>
<td>81/83</td>
<td>79/80</td>
</tr>
<tr>
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<td>61/56</td>
<td>49/43</td>
<td>53/47</td>
<td>46/47</td>
<td>56/58</td>
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<td>64/68</td>
<td>75/80</td>
<td>86/88</td>
<td>84/85</td>
<td>81/81</td>
</tr>
<tr>
<td>30</td>
<td>52/47</td>
<td>44/40</td>
<td>48/52</td>
<td>61/65</td>
<td>73/77</td>
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<td>83/87</td>
<td>89/89</td>
<td>85/85</td>
<td>80/78</td>
<td>80/78</td>
</tr>
<tr>
<td>31</td>
<td>44/41</td>
<td>39/39</td>
<td>70/75</td>
<td>80/83</td>
<td>89/90</td>
<td>84/82</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

[ Coefficient 12 am / Coefficient 12 pm ]

- Low
- Average
- High
- Very high
5.4 CURRENTS

Studies on current flow within a reef flat in Male’ Atoll suggested that wave over wash and tides generate currents across the reef platforms, which are also capable of transporting sediments (Binnie & Veatch, 2000). However, available information suggests that tidal currents are not noticeably strong due to small tidal range.

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westward flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April the westward currents flow are weak and eastward currents flow will slowly take place. Similarly, in December eastward currents flows are weak and westward currents will take over slowly.

Data on current speed and direction at the project area was assessed using drogue method. The current speed and direction measured during the field visits are tabulated in Table 23.

*Table 23: Mean speed and direction of currents*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Av. Velocity (m/s)</th>
<th>Stdev (m/s)</th>
<th>Average Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>0.13</td>
<td>0.07</td>
<td>SE</td>
</tr>
<tr>
<td>C2</td>
<td>0.18</td>
<td>0.11</td>
<td>SE</td>
</tr>
</tbody>
</table>

5.5 WAVES

The wave environment of the project area was subjected to constant waves from the South western direction. Figure 34 shows peak wave heights and Figure 35 shows wave periods.

- The average annual wave height was between 0.6 – 1 m from the southwest and northeast side.
- Waves from the north with moderate wave heights and short wave periods were observed suggesting that these were wind generated waves during the easterly monsoon. This was further evident based on wind analysis, strong winds from the ENE direction was experienced during easterly monsoon (See Figure 30 above).
- The analysis showed that south-western waves were swell waves with high wave periods while waves from the southeast were solely wind generated waves with shorter periods.
- L.Gan was exposed to waves from southwest and southeast throughout the year.
Figure 34: Monthly wave heights based on NOAA data
5.6 TERRESTRIAL ENVIRONMENT

5.6.1 Landform and Soil

The land allocated from the terrestrial environment for the proposed development had a flat terrain and was densely vegetated. The plot of land adjoins the island’s coast. Physical inspection of the soil in the area does not show any dissimilarities compared to soils found near the coast in other islands in the Maldives. In the case of island’s soils the basis for soil was calcareous material derived from coral rock fragments intermixed with various amounts of plant litter forming a top soil layer which is generally darker in colour. This thin topsoil layer is underlain by a layer of sand before reaching the water lens. Several past studies indicate that the water lens is generally overlain by just about a meter of sand (FAO, 1974) (SWECO, 2009) which can be safely applied to be the case for the land allocated for this project.

Grain size distribution analysis of top soil extracted from 0.25 m from the surface and bottom soil extracted from 1.3 m below surface from a similar island showed that the soil did not contain silt or cobble. See Figure 36 for grain size distribution of the top soil and bottom soil layer.

One of the most important physical features to consider is the hydraulic conductivity of the soil which indicates soil’s ability to prevent water transport. The high infiltration capacity of the soils would mean susceptibility of the groundwater lens to ground surface pollution.

Figure 35: Monthly wave period extracted from NOAA
Although L. Gan being the largest island in the Maldives its soil can be considered to be mature and better developed compared to many other smaller islands in the Maldives. FAO (1974) described its soil to be generally good to fairly good on average. However, soil maturity generally increases further towards the middle of the island. The project being sited very close to the coast humus containing soil layer at the location is believed to be very thin. Visual observations of the top soil in the vegetated area looked brown to dark brown and sandy in nature. The loose sandy nature of the soil means high drainage capacity and poor ability to resist contaminants from reaching the groundwater layer (SWECO, 2009).

<table>
<thead>
<tr>
<th>Location</th>
<th>Sieved legend</th>
<th>Soil classification</th>
<th>Quantity sieved</th>
<th>d10</th>
<th>d50</th>
<th>d90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom Soil Layer Vandhoo</td>
<td>Sand</td>
<td></td>
<td>310</td>
<td>0.149</td>
<td>0.336</td>
<td>0.476</td>
</tr>
<tr>
<td>Top Soil Layer Vandhoo</td>
<td>Sand</td>
<td></td>
<td>309</td>
<td>0.273</td>
<td>0.453</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 36: Grain size profile of Maldivian Island (Vandhoo)**

The structure analysis for a soil sample obtained from a coastal location in the Maldives showed that:

- Bottom soil contained less fine sand compared to top soil. Fine sand was the least prominent type of sand in both layers.
- Medium sand with lower grain size (approximately 0.2 mm) comprised of about 40% weight percent of the topsoil while bottom soil comprised of 35% weight percent.
- The difference between sand composition between the top soil and bottom soil layers decreased significantly as grain size increased.
- Coarse sand and fine gravel (grain size of approximately 1-3 mm) comprised the majority of the two soil fractions.

Permeability of water is a crucial factor of soil as it determines infiltration rate or potential to contaminate the groundwater should a pollutant is spilled on the soil surface. In other words, it indicates soil’s ability to transport fluids through it.

Graph illustrated in Figure 37 shows the permeability test and results of top soil.

![Permeability Test and Results of Top Soil](image)

**Figure 37: Permeability of top soil**

Top soil had a density of 1.59 g/cm³ with a water ratio of 8%. The mean permeability of top soil was found to be $2.4 \times 10^{-5}$ m/s.

Graph illustrated in Figure 38 shows the permeability test and result of bottom soil layer.
Bottom soil had a density of 1.59 g/cm³ with a water ratio of 6%. The mean permeability of bottom soil was found to be $7.0 \times 10^{-5}$ m/s.

The lower the permeability figure, the better for protecting the groundwater, since it represents a large resistance to water transport, i.e. transport of possible pollutants into the water table which is generally found a meter below the surface. Hydraulic conductivity tests carried out for soils collected from near coastal areas elsewhere in the Maldives demonstrated very similar figures to the ones described above with low resistance to water transport. Hydraulic conductivity for a soil samples taken from 40 m from shoreline at 1m depth from the surface of ADh. Bodukaashihuraa was measured to have hydraulic conductivity of $6.8 \times 10^{-6}$ ms⁻¹ (SWECO, 2009). The separation distance between the project boundary and the coastline being approximately 20 m further indicates high hydraulic conductivity of the project soil implying susceptibility of the groundwater lens to ground surface pollution. In some European countries such the Germany, according to (Stepniewski, et al., 2011) hydraulic conductivity in the range of at least $10^{-7}$ m/s is usually required to effectively mitigate fluids from leaching into the ground in the case of landfill constructions.

### 5.6.2 Topography of the Coast

The project land area was on average 1.25 m above MSL. The coastal area consisted of fine sand. Distance between vegetation line to high tide line was 0.76 m and low tide line was 5.54 m. Beach profiles of the island were taken as shown in Figure 39.
Gradients of beach profiles were between 2-5%, which suggested that the beach was exposed to very low wave energy. Coastal area was found to be stable with no erosion.

5.6.3 Flora and Fauna

The assessment of flora and fauna is focused on mainly at the Project site and its primary and secondary impact zones. The most abundant trees found at the Project area is *Hibiscus tiliaceus* (beach hibiscus). The second most abundant tree is *Scaevola taccada* (sea lettuce) and *Cocos nucifera* (Coconut palm). Other coastal species commonly found throughout the Maldives such *Cordia subcordata* (sea trumpet) was also observed. No faunal species have been observed during the survey (see Table 24 and Figure 40).
A tree survey was conducted at the project site to determine the number of coconut palms and significantly large trees that may be required to be uprooted to clear land for construction (See Figure 41)
Figure 41: Type and number of trees that needs to be uprooted

At least 20 coconut palms, 1 large sea trumpet (kaani) tree and 5 large barlingtonia (kinbi) tress fell within the land area allocated for buildings. All these trees were common to the area and can be utilized for numerous purposes. They can be used for timber or some can be replanted elsewhere.

### 5.6.4 Solid Waste Mounds

The project site appears have been used by for disposing solid waste both from the community and from nearby industrial sites. During the visit made to the site for survey, the team observed solid waste dumped into piles on land and in the near shore lagoon also mixed industrial waste including plastic, metal sheets, broken glass, bottles, cans, polyethylene bags, jumbo bags etc have been observed. The waste dumped into the lagoon appears aged and area appears risky of going to in bare foot as sharp metal sheets and broken glass are seen in the near shore muddy area. South end and south east corner of the site are found with huge piles of solid waste dumped as marked in Figure 41.

These mounds were also observed on the northern coastal lagoon area where it had depleted the benthic and seawater quality of the lagoon.
5.7 GROUNDWATER WATER QUANTITY

Generally, lens thickness is positively correlated to island width, with the lens thickness on large islands limited by the presence of the Holocene-Pleistocene contact at a depth of 15 m (Bailey, et al., 2015). Based on fresh groundwater estimates carried out, the volume of groundwater in L. Gan is believed to be significantly large owing to its large size. It is estimated to be 14,200 million litres (Bangladesh Consultants Ltd, 2010). Water lens thickness has been estimated to be 16 m. Water quality is an essential part of the environment, especially considering that the islands of Maldives has vulnerable and limited fresh water resources and the majority of biodiversity and natural resource available to the island nation depends on the sea.

5.8 WATER QUALITY

Baseline water quality assessments were done for both sea water and ground water. Chemical parameters tested for sea water include, temperature, pH, conductivity, turbidity, total dissolved solids, salinity, specific gravity, coliforms, BOD and nitrate/phosphate levels.

It is important set baseline water quality of the lagoon area since nutrient will be loaded during the operation of the project. Groundwater quality is also crucial to monitor the effects of waste and sewage management on the groundwater table.

Table 25 shows the groundwater and seawater quality results. See Annex 8 for MWSC lab reports for nitrates, phosphates and BOD of groundwater and seawater samples.
### Table 25: Water quality assessment results

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>ID</th>
<th>Temp/°C</th>
<th>pH</th>
<th>Conductivity (mS/cm)</th>
<th>Turbidity (NTU)</th>
<th>DO (mg/l)</th>
<th>TDS (g/L)</th>
<th>Salinity (ppt)</th>
<th>Faecal coliform (MPN/100ml)</th>
<th>Total coliform (MPN/100ml)</th>
<th>BOD (mg/l)</th>
<th>Nitrate (mg/L)</th>
<th>Phosphate (mg/L)</th>
<th>COD (mg/L)</th>
</tr>
</thead>
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<td>7.88</td>
<td>53</td>
<td>1.7</td>
<td>9.64</td>
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<td></td>
<td>11:33:27</td>
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<td>SW2</td>
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<td>SW4</td>
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<td>8</td>
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<td>31.8</td>
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<td>25/09/2016</td>
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<td>GW001</td>
<td>26.91</td>
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<td>0.839</td>
<td>27.6</td>
<td>8.33</td>
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<td>3.21</td>
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<td>0.54</td>
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<td></td>
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<td>Average</td>
<td>27.78</td>
<td>6.93</td>
<td>0.863</td>
<td>6.9</td>
<td>4.05</td>
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</tr>
</tbody>
</table>
5.8.1 Temperature

The average seawater temperature was observed to be 30.75 °C and the average groundwater temperature was 27.78 °C. The mean temperatures were observed to be within the acceptable range.

5.8.2 pH

The average pH of seawater was 8.51. The mean pH measured was basic and relates to oceanic pH determined by (SCOR, 2009).

The average pH of groundwater was at 6.93. This was within the WHO guideline.

5.8.3 Turbidity

Turbidity is a measure of water clarity; how much the material suspended in water decreases the passage of light through the water. The turbidity depends on the fineness and concentration of particles present in water. High turbidity levels could impede light penetration.

Due to fine nature of sediments in the lagoon sediment was found to suspend fairly rapidly, which resulted in high instant turbidity at certain location as evident from graph in Figure 42. Average turbidity within the lagoon was 10.3 NTU while outside the reef edge turbidity was 0.

![Figure 42 Turbidity in the lagoon](image)

Baseline, turbidity of groundwater was 0 NTU, high turbidity reading for GW001 was observed due to debris that had fallen into the uncovered well.
5.8.4 Total Dissolved Solids

Dissolved particles in the water, along with ionic species, are referred to as dissolved solids. These solids pass through a water filter and are usually less than 1 micron. TDS measurements of seawater showed a very constant reading with little variation. The mean TDS for seawater was 31.8 g/l which is the normal TDS measurement of seawater.

WHO sets a maximum of 1000 mg/l for the amount of TDS, with levels higher than that increasingly becoming unpalatable TDS of groundwater samples tested were all within WHO accepted levels. The highest TDS was observed for sample GW003 with a measured value of 0.609 mg/L.

5.8.5 Salinity

All groundwater tested were observed to be non-saline with salinity levels reaching an average value of 0.4 ppt (0.4 g/l) which is lower than WHO recommended benchmark of 600 mg/l (WHO, 1972). In seawater inside the lagoon was found to be 35 ppt (35 g/l).

5.8.6 Electrical Conductivity

Conductivity is one way to measure of the inorganic materials including calcium, bicarbonate, nitrogen, phosphorus, iron, sulphur and other ions dissolved in a water body. While TDS is a measure of the total ions in solution, EC is actually a measure of the ionic activity of a solution in term of its capacity to transmit current. Typical conductivity of water is:

- Ultra-pure water: $5.5 \times 10^{-6}$ S/m
- Drinking water: 0.005 – 0.05 S/m
- Seawater: 5 S/m

Electrical conductivity of seawater was very constant with a mean of 5.3 S/m typical of seawater.

Conductivity of groundwater tested on site was found to be 0.08 S/m which was within the WHO specified guideline.

5.8.7 Coliform

Coliforms are a broad class of bacteria found in our environment, including the faeces of man and other warm-blooded animals. Specifically, anaerobic, rod-shaped, gram-negative, non-sporulating bacterium from warm blooded animals are known as faecal coliform. The presence of coliform bacteria in drinking water may indicate a possible presence of harmful, disease-causing organisms.

Total and faecal coliform in seawater was found to be 0.

Graph in Figure 43 shows the total and faecal coliform profile of groundwater samples. It is clear from the result that all groundwater samples tested positive for coliform. Sample GW001 registered the highest concentration of faecal coliform. WHO stipulates that water used for drinking shall not have coliform. Hence groundwater in L. Gan is not suitable for drinking purposes at least without pre-treatment.
**5.8.8 BOD$_5$ and COD**

BOD is a measure of, the amount of oxygen that require for the bacteria to degrade the organic components present in water. COD or Chemical Oxygen Demand is the total measurement of all chemicals (organics & in-organics) in the water. Hence COD is usually higher than BOD as it is not limited to biological pathways.

BOD of seawater was below the limit of quantification which suggested that pollution by organic matter was non-existent at site. BOD of seawater was within the EPA guideline.

Graph in **Figure 44** shows the BOD$_5$ and COD profile of groundwater samples.
Apart from GW001, the other samples had a low BOD level that can be considered satisfactory. COD exceeded the WHO recommended threshold level of 6mg/L in all ground water samples.

### 5.8.9 Dissolved Oxygen

Dissolved oxygen refers to the level of free, non-compound oxygen present in water. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. Dissolved oxygen enters water through the air or as a plant by-product. From the air, oxygen can slowly diffuse across the water’s surface from the surrounding atmosphere, or be mixed in quickly through aeration, whether natural or man-made.

Graph in Figure 45 shows DO level of seawater at project site.
It can be seen from the results that DO was significantly lower at sites SW4, SW5 and SW6. DO was observed to gradually increase moving away from the reef flat towards the ocean. DO level in the ocean ranged from 8-10 mg/L. The average DO concentration of the lagoon was 6 mg/L.

However, the notable decrease in DO level along the coastal area of the lagoon was a concern and can be attributed to the large amounts of organic and inorganic waste thrown into the area. Waste has created mounds which made the lagoon shallower increasing the temperature of water along the coast. The solubility of oxygen decreases as temperature increases. This means that warmer surface water requires less dissolved oxygen to reach 100% air saturation than deeper, cooler water. Moreover, the waste prevented seagrass to grow in the coastal area. Hence the excess organic matter decreased DO level in this area.

Although bottom feeders can survive in minimal amounts of oxygen, the level of DO recorded along the coast was lower than the concentration preferred for sea cucumber growth. The waste also made access to the lagoon extremely difficult. Hence in order to restore the environment to its natural state it is important to remove the waste from coastal lagoon area.

The average DO of groundwater was 4 mg/L. located at GW001 was connected to an aerator which is why the DO level in that site was significantly higher compared to the other well.

**5.8.10 Nitrates and Phosphates**

Nitrates and phosphates occur naturally. However, an influx of nitrates and phosphates in a water body can cause eutrophication. Algae can cause extreme fluctuations in dissolved oxygen. Photosynthesis by algae and other plants can generate oxygen during the day. However, at night, dissolved oxygen may decrease to very low levels as a result of large numbers of oxygen consuming bacteria feeding on dead or decaying algae and other plants.
The baseline nitrate level of seawater was 3.3 ppm which was within the EPA guideline. However, baseline phosphates concentration which was 0.16 ppm was slightly higher than EPA recommended level 0.020 ppm.

Drinking water that has high nitrate concentrations, can interfere with the ability of red blood cells to transport oxygen. Figure 46 shows the nitrate concentration and Figure 47 shows the phosphate concentration of groundwater samples.

**Figure 46: Nitrate concentration of groundwater samples**
GW003 was found to have the highest nitrate levels which exceeded guidelines. GW003 was located in a heavily populated area. GW001 was closest to the project site and had a nitrate level which was within the stipulated threshold of 5 mg/L. All samples tested had high phosphate levels compared to the guideline.

**Figure 47: phosphate concentration groundwater samples**
5.9 MARINE ENVIRONMENT

5.9.1 Bathymetry

Bathymetry of the proposed sea cucumber grow out zone in the lagoon and the wastewater effluent discharge zone outside house reef is shown in Figure 48

- The average depth of the lagoon proposed for sea cucumber grow out is at 0.5m – 0.09m
- The depth beyond house reef where outfall discharge to be located is at 40 – 75m

Reef top and beyond house reef

- The depth profile of reef top and house reef slope was also measured during the survey. The average depth on reef top is recorded at 0.5m and at reef slope and deep zone is recorded at an average of 40 -75m
Figure 48: Bathymetry lagoon and reef area
5.9.2 Benthic Cover and Fish Study

The benthic cover was assessment was focused at grow out zone in the lagoon and reef top at wastewater discharge. In grow out area the lagoon shallow with an average depth of 0.25m to 0.5m average. The entire area is covered with matured patch sea grass except with denser sea grass portion towards the north of the marked grow out area.

**Marine Analysis - Grow Out Area in the Lagoon**

**Observations**

Transect (T1) laid at an average depth of 0.5m on the 24/9/2016 at between 10.0am to 11.0am. As discussed the aquatic floral benthic cover is dominant with sea grass grown in patches except a dense portion at north corner of proposed sea cucumber grow out area. However, the large area of grow out zone consisted of muddy sand. More than 90% of the lagoon area is covered with silty muddy sand. No corals and coral rubbles are seen at grow out area. Although fish were observed when looking at the area from shore no fish was identified at the grow out area during the analysis. This may be due to the fact that these species were cryptic and hid away.

![Figure 49: Average benthic cover at the transect sites](image)
Reef Survey (Outfall location)

Observations

The reef was found to consist of live corals and a healthy population of reef fishes. Figure 51 shows a photo profile of the reef edge and Table 26 shows the fish study.
Figure 51: Photo profile of reef at proposed outfall site
## Table 26: Fish study at the reef edge

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family: Acanthuridae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthurus Lucosternon</td>
<td>Powder-blue surgeon fish</td>
<td>Rare</td>
</tr>
<tr>
<td>Acanthurus Lineatus</td>
<td>Lined surgeon fish</td>
<td>Common</td>
</tr>
<tr>
<td>Acanthurus Xanthopterus</td>
<td>Yellowfin surgeon fish</td>
<td>Rare</td>
</tr>
<tr>
<td>Acanthurus Tristis</td>
<td>Mimic Surgeonfish</td>
<td>Common</td>
</tr>
<tr>
<td>Ctenochaetus striatus</td>
<td>Striated surgeonfish</td>
<td>Common</td>
</tr>
<tr>
<td>Naso brachycentron</td>
<td>Humpback unicorn fish</td>
<td>Rare</td>
</tr>
<tr>
<td>Zebrasoma scopas</td>
<td>Brown tang</td>
<td>Common</td>
</tr>
<tr>
<td>Acanthurus Nigricauda</td>
<td>Epaulatte surgeonfish</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Pomacentridae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chromis dimidiata</td>
<td>Two tone chromis</td>
<td>Abundant</td>
</tr>
<tr>
<td>Pomacentrus Nagasakien</td>
<td>Nagasaki damsel</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Balistidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melichthys indicus</td>
<td>Indian triggerfish</td>
<td>Abundant</td>
</tr>
<tr>
<td>Balistapus Undulatus</td>
<td>Orange striped triggerfish</td>
<td>Common</td>
</tr>
<tr>
<td>Balistoides conspicillum</td>
<td>Clown triggerfish</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Caesionidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caesioxanthonota</td>
<td>Yellow back fusilier</td>
<td>Abundant</td>
</tr>
<tr>
<td><strong>Family: Chaetodontidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chaetodon trifasciatus</td>
<td>Oval butterfly fish</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Serranidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cephalopholis Argus</td>
<td>Peacock rock cod</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Pomcanthidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pygolites diacanthus</td>
<td>Regal Angelfish</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Mullidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parupeneus macrornema</td>
<td>Long barbell goat fish</td>
<td>Rare</td>
</tr>
<tr>
<td>Parupeneus cyclostomus</td>
<td>Yellow stripe goatfish</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Family: Lutjanidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lutjanus biguttatus</td>
<td>Two spot snapper</td>
<td>Rare</td>
</tr>
</tbody>
</table>
5.10 PROTECTED AREAS AND SENSITIVE SITES

There is no legally protected site at Gan Island, although an enclosed small water body with some mangrove species on its periphery which can be considered as a sensitive environment is located some 0.8 km to the north of the project site. A culturally important site known as Kuruhinna is located 1.8 km further north of the project site. In the island’s land use plan, these two sites have been earmarked for protection though neither of the sites are being managed to any extent resulting degradation of and loss of ecological and cultural values of the sites. The project activities proposed in no way will have any direct or indirect effect on any of these sites (see Figure 52). The coastal vegetation band measuring a width of 15 m from high tide line toward the land is protected as environmental protection zone in all islands in the Maldives.
Natural hazards vulnerability for the project site was analysed based on the Detailed Island Risk Assessment in Maldives (DIRAM) assessment carried out by UNDP for L. Gan (UNDP, 2007) according to which the following hazards are relevant to the project location.

- Wind storms;
- Swell waves and wind waves;
- Flooding due to heavy rainfall/storms;

**Figure 52: Environmentally sensitive sites in relation to the project location**

**5.11 HAZARDS AND VULNERABILITY**

Natural hazards vulnerability for the project site was analysed based on the Detailed Island Risk Assessment in Maldives (DIRAM) assessment carried out by UNDP for L. Gan (UNDP, 2007) according to which the following hazards are relevant to the project location.
- Gravity waves (sea swells and udha); and
- Tsunami.

Historical information on hazards for Gan compiled by UNDP demonstrates that flooding caused by heavy rainfall and swell surges and wind storms as the most important hazard issues experienced in Gan as given in Table 27.

**Table 27: Historical hazard analysis of L. Gan**

<table>
<thead>
<tr>
<th>Hazard</th>
<th>Time</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding caused by heavy rainfall</td>
<td>Commonly during SW monsoon</td>
<td>Flooding occurs in settlements situated at low areas of the island. Minor disruption to daily activities are caused by flooding (UNDP, 2007)</td>
</tr>
<tr>
<td>Flooding caused by swell surges</td>
<td>1950’s 5th July 1966</td>
<td>A major flooding event occurred during the 50’s which mostly effected the northern part of L. Gan. However, this event did not have a huge impact on settlements since most of them were located on the western side of the island.</td>
</tr>
<tr>
<td>Windstorms</td>
<td>1960’s – 1980’s</td>
<td>No major recent wind storms have been recorded. There have been recorded wind storms from 60’s until the 80’s. Written records show that no major, damage was cause as a result of these wind storms.</td>
</tr>
<tr>
<td>Droughts</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Earthquake</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Tsunami</td>
<td>26th December 2004</td>
<td>70% of the island was flooded. The primary reason for Tsunami inundation was due to the low ridge of the island and low areas located at the center of the island (UNDP, 2007)</td>
</tr>
</tbody>
</table>

Based on the analysis it was concluded that flooding due to rain and waves were potentially the most likely risk facing the project area although severe impacts of these are not envisaged. It was highlighted in the (UNDP, 2007) assessment that swell waves with significant heights greater than 3 m could penetrate 200 – 700 m inland (See Figure 53). However, wave analysis (See Section 5.5) showed that waves exceeding 3 m were not logged for the year 2016 and the frequency of
waves between 2 -3 m were less than 1%. Furthermore the project area contained a large lagoon area hence was more shielded from swell waves compared to the northern part of the L. Gan.

Figure 53: Swell wave risk analysis. Source: (UNDP, 2007)

Based on the UNDP (2005, 2009) reports and the Feasibility Study (RHDHV, 2015), the main threat to the Maldivian island remains to be flooding of the islands as a result of wave inundation.
and heavy rainfall. In the recent flooding occurred across Maldives 52 islands including L Atoll were flooded in 2012 with 3 severe cases due to heavy rainfall (NDMC, 2016). Looking at the historical natural hazards events L Gan has faced flooding from heavy rainfall, swell surges, wind storms and tsunami (UNDP, 2007).

A questionnaire was used to collect the information on natural disasters of significance faced to Gan in the recent history. Information collected as part of this EIA further confirms, heavy rainfall and associated flooding as the most common natural hazards for the island. It should also be noted that tsunami incident of 2004 caused significant damage to the island.

Due to its north – south orientation, Gan is particularly exposed to NE monsoon generated winds and waves and storm activities (UNDP, 2007). The project being sited on the east coast northeast monsoon can affect the project activities. Such incidents are largely unavoidable as the nature of the project does requires it’s grow out areas to be based in the sea. As far as the project site considered, it could be said that it is fairly protected from strong winds and waves generated during southwest monsoon although some windy conditions can be expected during the northeast monsoon the effect of which is expected to be during the first few months of the year.

5.12 SAFEGUARDING FROM THE ENVIRONMENTAL HAZARDS

Based on the above findings it could be said that the environmental effects on the project can be relatively low. However, during the easterly monsoon at times of strong wind turbulent conditions can be expected in the lagoon with resulting damages to fine net cages. With proper attention and regular obtaining of weather forecast information and with repair materials available on site such issues can be quickly rectified. The other biophysical issue to consider is the sudden changes in salinity at times of heavy rain. Findings indicate *H. scabra* are tolerant to reduced salinity (Mills, et al., 2008) even though their preferred salinity range is 30 – 34 ppt. Experience from elsewhere shows that *H. scabra* farmed in cages survived even during exceptionally heavy rains (Mills, et al., 2008). During the heavy rain storm water carrying sediments and nutrients may also affect the near shore areas affecting the sea cucumbers in the grow out area. Hence it is important that sea cages are not placed too close to the shore.
6. EXISTING SOCIO-ECONOMIC CONDITIONS

6.1 INTRODUCTION

This Chapter covers socioeconomic environment L Gan in the context of the proposed project as required in the ToR for the EIA study. The demographical, income situation, natural resource use, accessibility, transport services, basic infrastructure services such as water supply, wastewater disposal, solid waste disposal, energy supply and social services (health, education, security and recreation) and community needs of the local population is covered in the chapter.

The project island of Gan is situated in Laamu Atol which is the 2nd largest atoll in terms of total land area of all inhabited islands belonging to the atoll is considered (Figure 54).

Although the Atoll’s total peripheral area is relatively small in comparison to other atolls of the Maldives (13th largest) (see Figure 55) it possesses the 8th largest reef system among the 20 administrative atolls (see Figure 28). The atoll capital is the island Fonadhoo. In total Laamu atoll consists of 73 natural islands where 12 are inhabited and 68 are uninhabited, one resort island is privately leased to operate the tourist resort Six Senses Laamu and the rest are uninhabited. Laamu Atoll forms the southern limit of Central Maldives. Kadhdhoo Domestic Airport is located in Kadhdhoo Island. In addition to being the largest island in the atoll, Gan is the largest and the longest island in Maldives.
Figure 55: Atoll area of the administrative atolls of the Maldives. Source: (DNP, 2010)

Figure 56: Reef area of administrative atolls of the Maldives. Source: (DNP, 2010)
6.1.1 Population and Demography

According to Census (2014) results, the Laamu Atoll has a population of 12,075, making it 6th most populous administrative atoll of the Maldives of these 11,858 are Maldivians. The population distribution in the Atoll is given in Figure 57 A. In the inhabited islands, a population of 768 foreigners also reside as shown in Figure 57 B. The 12 administrative islands of the atoll have 5,855 males and 6,003 females. Resorts and industrial islands have a registered population of 1,094 people. Of the 12 inhabited islands, Gan by far has the largest population (locals as well as foreigners) accounting for 28% of the entire atoll followed by Fonadhoo and Maavah. These three islands accounts for 55 % of the registered Maldivian population in the Atoll as shown in Figure 58. Of the registered population of 4574 for Gan 2368 are males and 2206 are females with population density of 7 (NBS, 2015).

Figure 57: Population distribution in the islands of Laamu Atoll (A) Maldivians (B) Foreigners (NBS , 2015))

Kalhaidhoo was inhabited island in 2006 but uninhabited now. L. Kalhaidhoo population is residing in L. Gamu since 2010. Since 2013 Kalaidhoo is treated as a separate administrative island. It was a ward of L. Isdhoo in 2006. L. Kalhaidhoo and some proportion of L. Mundhoo population has been relocated to L. Gamu in 2006 following Indian Ocean Tsunami of 2004.
Average annual population growth rate for the period (2006 – 2014) show nearly half of the islands in Laamu Atoll with a negative population growth (Figure 59). Gan registered highest population growth in the atoll. The negative population in some islands could be attributed to migration to Male’ and other islands in the atolls where better services and opportunities are available. Consequently development challenges and opportunities differ from island to island. Due to its large size and low population density L. Gan has been identified by the government for development as one of the host islands for population consolidation and it intends to develop affordable housing, range of social services, better economic opportunities, improved transportation, and better infrastructure (May, 2016)
6.1.2 Economic Activities and Income Situation

Like most other atolls in the Maldives, fishery and agriculture are the two largest employers of the workforce in Laamu Atoll with fishery having a slightly larger percentage. Government is a significant employer for Fonadhoo Island, the atoll capital.

Number of fishermen in the Atoll in 2013 was 767 which is the second highest number of fishermen population in an atoll in the Maldives. In the year 2013, 8243 metric tons of fish was landed in in Laamu Atoll accounting for approximately 8% of the total landing by all the atolls (excluding Male’)(Figure 60). On average 39 mechanized fishing vessels are engaged in Laamu Atoll in a month (DNP, 2014).

According to UNDP (2013), tuna catch is declining nationwide in the Maldives, including in Laamu Atoll, although the precise reason is unknown, the following has been identified as likely causes contributing to the decline in the tuna catch (UNDP, 2013).

- Destructive bait fishing by fishermen from other atolls which damages the coral reef ecosystem and juvenile bait fishes
- Ice availability limits the amount that fishermen can catch. While Horizon Fishery provides free ice to fishermen who sell to it, the amount of ice provided is not sufficient.
- Lack of harbor for vessels to dock on to.
Tourism was only recently introduced into Laamu Atoll in 2011. Although the sector offers a lot of potential in efforts to strengthen the Atoll’s economic resilience and diversify its economic base, the total bed capacity remained at 194, with percentage share of just one percent to the total bed capacity of the Maldives. Currently there is only operational resort in the atoll. The recently opened mid-market Reveries In Laamu Atoll, only one island, (Olhuveli Island) is privately leased to operate a luxury tourist resort; two additional resorts are planned for two more islands (Gasgandufinolhu and Bodufinollhu). Boutique resort would also benefit the local economy with better job opportunities and market linkages. Laamu Asseyri Project, a large mid-market tourism initiative currently under development, was conceived to cater for the growing calls to start mid-market tourism in the country. The project would consist of two resorts with 300 beds each, 79 guesthouses and recreational facilities (UNDP, 2013).

The government is also building an integrated resort at L. Baresdhoo and with the introduction of mid-market tourism, Laamu atoll is also a focus of medical and health wellness tourism as seen as by the soon to be opened Green hotel in Kadhdhoo Airport. This would also support other related service industries like local tourist operators, tour guiding, transportation and local restaurants (UNDP, 2013).

![Figure 60: Fish catch by atoll, 2013](image)

Agriculture is one of the strongest sectors in Laamu Atoll. People of Gan is renowned for their agricultural farming. Farmers in Laamu grow a variety of crops with some of the most valuable being coconut, chilli peppers, watermelon and banana. Others include papaya, brinjal, taro, pumpkins, gourds, Chinese cabbage, red onions, eggplants, cucumber, mangoes, and a few others. Most agricultural produce from Laamu is sold to the Male’ market, some is traded locally, but very little is sold to the high-end tourist markets in the atoll. The resorts have reported that local produce is more expensive in Laamu than the produce available in Male’. Therefore, while private companies could be sourcing their food from Laamu farmers, local prices are not competitive. There is also a gap between the market demand and supply (UNDP, 2013).
In most islands not much job opportunities are available on the island itself. School, Health Centre, Magistrate Court, Island Council Secretariat are the only State institutions offering a few jobs in islands. Shops and small cafes mostly employ foreign workers. Building and carpentry works within the islands are also mostly undertaken by foreign workers. See Figure 61. Youth (15 – 20) unemployment at L.Gan was at 24%.


6.1.3 Electricity Services

People of Gan has 24 hrs electricity services provided by the state owned company of FENAKA. However, due to the large size of the island and high cost of expanding the services, electricity services and sewerage networks have not reached to the region where the project will be sited. Hence a separate arrangement will have to be made initially by the developer.

6.1.4 Water and Sewerage

In L Gan at the moment do not have a piped water supply system in place although designs of the system is underway. For the ordinary people currently the main source of drinking water is rainwater which is collected on roofs and stored in tanks. Rainwater is collected and stored in community water tanks within household compounds. Well water is contaminated and is not suitable for drinking purposes. There is a modern sewerage system developed with road sewers, road manholes, house connections and sewage treatment. The entire island is covered and sewerage service is provided to all houses. The service is provided by FENAKA Cooperation. The modern sewerage system for the first time in L. Atoll was built in Mundoo Kalaidhoo in 2007 after
the 2004 tsunami. The modern sewerage system in the 3 wards of L Gan was built in 2015. The island wide sewerage system was built with secondary treatment facility

### 6.1.5 Health

Basic health services are available in most islands. Other than Gan, where the Regional Hospital provides 24 hrs. services, the remaining islands have Heath Centres where at least one resident doctor and 1-3 nurse work provide basic health services to the people. Although not all islands have laboratory services some Health Centres provide limited diagnostic service. Pharmacies are also established in most inhabited islands.

In L Gan there is one referral regional hospital it service began from Atoll Health Centre commenced in 1993. It provides health care services to all the people living in the L Atoll and also to all those who seek services. The hospital provides medical care for General Medicine, Paediatric care, Gynaecology, Surgical, Orthopaedic, ENT, Ophthalmology Communicable Diseases and Nursing Care. The hospital also handles accidents and an emergency case for that emergency response plan is in place.

For those treatments that are not available at Gan hospital those in need will travel to Male’.

### 6.1.6 Education

As of March 2015 in L Gan there are 1014 students of them 279 are Pre-Primary, 487 are Primary, 204 Lower Secondary, 44 Higher Secondary of these students 47.2% are male and 52.8% are female. In the atoll 412 teachers are teaching in islands across the atoll including L Gan. Among these teachers 387 teachers are trained teachers and 25 teachers are un-trained teachers. The percentage of untrained teachers in the atoll is 6% where student trained teacher ratio is at 10. There are three Primary Schools with 4 Pre-Schools.

Hamad Bin Khalifa Al Thani School donated by the Qatari government one of the reputed educational institute in L Gan. The school is formerly known as Qatar Ameer School, and later renamed as Hamad Bin Khalifa Al Thani School. The school started with Grade 6 in 1998 now reached new milestones by commencing Higher Secondary in 2010.

### 6.1.7 Access Social Services and Work

Numerous government projects have been implemented on the island in the past and even today development projects are taking place on the island. Government sponsored projects and donor assisted projects have resulted heavy investments on the island. Most notable such project includes the construction of the road project. Successful completion of such development projects have resulted in improvements to quality of life enjoyed by the people. Almost all facilities that are generally required for a comfortable life are available on the island. Many teashops, restaurants, guesthouses, and convince stores, taxi services and sports facilities, are available on the island.
6.1.8 Communication

Telecommunication services to the island are provided by Dhiraagu and Ooredoo. Landline telephone communication service to the island is provided by Dhiraagu. However Ooredoo along with Dhiraagu provides mobile communication services. Almost all the people in the working population have a mobile phone. Internet services are provided by Dhiraagu and focus Infocom private limited.

Establishment of communication services in the island had led to further development in the island. It had brought many employment opportunities to island and had connected the island to the rest of the country. Other amenities available on the island include cable and satellite TV service. Post office provides postal service to the island.

6.1.9 Transport

Gan is approximately 6 hours from Male by speedboat and 55 minutes by airplane. The atoll has 293 registered marine vessels of which 156 are dhonis. It has 62 high speed launches, 13 traditional cargo and passenger boats (baththeli). Limited transport services are offered by the intra-atoll ferry operator although this services does not meet demand. There is no regular ferry to/from Male to Gan although private operators can arrange upon request. Small boat harbours facilities have been developed in almost all inhabited islands and two such harbours are found in Gan island; one at Mukurimagu with harbour size 250 x 500 feet built in 2007. The second harbour is at Thundi measuring 700 x 250 feet built in 2007. Domestic airport at Kadhoo located within very close proximity to Gan has been in operation for almost 20 years and is connected by land to Gan. Since opening of the resorts most tourists arrive in the atoll via this airport.

Limited transport services presents a vulnerability as communities lack access to supplies and services such as medical supplies during emergencies, specialized health care services and emergency water supply during prolonged dry season.

The land transport has become convenient due to the recent 15.1 km link road that has been developed from between L Gan and Fonadhoo. Similar to other such islands in Maldives, the most common modes of land transport used in Gan are by bicycles, motor cycles and cars. Use four-wheeled vehicles such as cars, lorries and pick-ups are on the rise.

6.1.10 Waste Management

The island of L. Gan faces a serious environmental and health issues due to improper waste disposal. Littering is common across the island and degradation of sensitive environments such as beaches, wetland and historical sites have occurred as a result. Some efforts have been made to improve the waste management situation faced to the island. Towards this effect island waste management centre has been built and some equipments have been provided. Recently a contract has been awarded to a private party to construct a small incinerator on the island. UNDP is also active on the island and has been making efforts to improve the waste management issue on the island. Urgent and immediate intervention is need to consolidate the efforts on waste management to come up with an integrated solution to the problem.
7. STAKEHOLDER CONSULTATION

7.1 INTRODUCTION

Stakeholder consultations were carried out as part of undertaking the EIA exercise to firstly to inform the stakeholders of the proposed project and to seek their views and opinions on the project components. The stakeholder consultations were carried out in two stages. The first stakeholder meeting was the scoping meeting held 28 April 2016 at EPA attended by invited stakeholders. The scoping meeting was attended by EPA, L Gan Island Council members, EIA Consultant and representatives of the proponent. In the second stage consultations were held on bilateral basis with important stakeholder to cover the specific stakeholders identified in the TOR. Those identified stakeholders to be consulted include EPA, Marine Research Centre, Ministry of Fisheries and Agriculture, Island Council, Ministry of Housing and Infrastructure, FENAKA Cooperation and the general public.

7.1.1 Island Council Meeting

In order to organize the meeting, a formal request was made to Island Council by the consultant. The meeting was held at Island Council on August 2016 attended by Island Council, Client and Consultant. Following council members attended the meeting (See Table 28).

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Mohamed Shiyam</td>
<td>Council President</td>
<td>9711019</td>
</tr>
<tr>
<td>Mr. Farooq Hassan</td>
<td>Council Member</td>
<td>9822662</td>
</tr>
<tr>
<td>Mr. Abdullah Qaasim</td>
<td>Council Member</td>
<td>7671999</td>
</tr>
</tbody>
</table>

Table 28: Attendance of meeting with island council

In the process of consultation discussion has been held on various aspects of the proposed Project as follows

- When the council was asked if there was any alternative location for the proposed Project, the council replied there was no such alternative location except the area provided.
- The council also confirmed that information about the proposed Project was already shared with the public.
- Council members expressed that such projects will allow making use of the natural resource that belongs to the Island such a way that benefits to the community.
- Also the council expressed that the project going to be an opportunity to create more employment opportunities and improve the livelihood of general public.
- Council highlighted that they do not foresee any issue or problem that may cause to the proposed Project.
- The council was not aware of the plans anticipated with the on-going land reclamation project in the island.
### 7.1.2 Consultation with EPA

In the consultation meeting held at EPA on 10th November 2016 was attended by seniors from Waste Management Department, Water and Sanitation, Biodiversity Department and Coastal Zone Management Department includes the following. See **Table 29**.

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Office</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Hussain Ibrahim</td>
<td>Asst. Environment Officer</td>
<td>EPA</td>
<td>9184724</td>
</tr>
<tr>
<td>Rifath Naeem</td>
<td>Senior Environment Analyst</td>
<td>EPA</td>
<td>3335949</td>
</tr>
<tr>
<td>Adam Mubeen</td>
<td>Engineer</td>
<td>EPA</td>
<td>7555960</td>
</tr>
<tr>
<td>Aminath Mohamed</td>
<td>Engineer</td>
<td>EPA</td>
<td>7504494</td>
</tr>
</tbody>
</table>

**Table 29: Attendance of meeting with EPA**

Key points made by the representatives of the EPA during the consultation with the EIA consultant include the following:

**Vegetation clearing:**
- EPA recommends relocating trees that could be relocated and replanting if mature palms are removed.

**Sewage and wastewater outfall:**
- EPA has expressed it is highly recommended to use existing sewerage system in L Gan, if that is possible. The existing sewerage facility developed in L Gan is 1.9 km away from the project site.
- EPA also highlighted to consult with FENAKA Cooperation and seek the possibility of getting their sewerage connections to the project area.
- According to the common law sewerage services shall be provided by utility service provider. However, as the proposed project is an industrial setup and is far from existing community sewerage system the possibility of getting access is difficult at this point in time. This can be explored in consultation with FENAKA Cooperation.
- If proponent installs a separate sea outfall for sewage and wastewater discharging, ensure sufficient power is made available for the operation. If the power is to be taken from island grid, ensure sufficient power is available.
- Wastewater disposal sea outfall should be in line with national wastewater guideline (10 m from reef edge)
- If a septic tank is installed a sludge management plan shall be in place during operation.

**Gut Waste:**
- EPA does not recommend disposing sea cucumber gutting waste in to the ocean.
- There is no waste management centre in L Gan recognized by EPA.
• EPA suggested to explore Maandhoo Fisheries, to see if gut waste can be managed at a waste management centre in Maandhoo
• If not discard it into the open ocean with proper care.

Monitoring
a. A groundwater sampling point shall be located at 1 m from the septic tank
b. Operations of grow out area shall justify and detail carrying capacities of pens etc.
c. Habitat destruction shall be monitored at grow out area and wastewater discharge zone beyond house reef.

Sand mining location
The current sand extraction point of L. Gan identified and assigned by MoFA and EPA is located in the project lagoon area. The council shall write to EPA requesting to change the location and identify a suitable alternative.

7.1.3 Consultation with MHI
The consultation meeting with Ministry of Housing and Infrastructure (MHI) was held at MHI on 29\textsuperscript{th} November 2016 at 10am at the presence of following members. See Table 30.

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Office</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Anoosha Hashim</td>
<td>Assistant Project Officer</td>
<td>MHI</td>
<td>-</td>
</tr>
<tr>
<td>Mr. Hussain Rasheed</td>
<td>Director</td>
<td>MHI</td>
<td><a href="mailto:emu@housing.gov.mv">emu@housing.gov.mv</a></td>
</tr>
</tbody>
</table>

Following points have been made by MHI
• The Planning Department of MHI has already issued the approval letter to L Gan council for allocation of land for the proposed aquaculture, also expressed all regulation complies.
• MHI informed they expect the newly constructed road in L Gan get provided electricity by 2017
• MHI also highlighted regarding the technical aspect of the project shall be consulted with MRC and EPA.
• MHI requested to check “Land Act of Maldives” to see the specific requirements needed to build powerhouse at an inhabited island.

7.1.4 Consultation with FENAKA
The consultation meeting with FENAKA Cooperation was held on 23\textsuperscript{rd} September 2016 at L Gan FENAKA Cooperation office. The meeting was attended by the following members. See Table 31.
Table 31: Attendance of meeting with FENAKA

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Office</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Ali Hammadh</td>
<td>EIA Consultant</td>
<td>MEECO</td>
<td>7433241</td>
</tr>
<tr>
<td>Mr. Abdullah Sulaiman</td>
<td>Regional Manager</td>
<td>FENAKA</td>
<td>7776280</td>
</tr>
</tbody>
</table>

Key discussion held with FENAKA includes

- How sewerage services can be given by FENAKA through the existing sewerage system in L Gan. FENAKA has mentioned it is not possible to extent existing service from L Gan to proposed project site due to the long distance from the sewerage network to proposed Project site.
- Giving electricity service is also a challenge due to long distance (approximately 1.2 km) from main cable to Project site. However, once the main road gets completed with main cable and transformer installed, it is likely that the electricity be given to the project site.

7.1.5 Public Consultation

Public consultation was held on 24 September 2016 at 9 am in L Gan council office. The meeting was attended by members from public as given in Table 32.

Table 32: Attendance of public consultation meeting

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Office</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mr. Hussain Ibrahim</td>
<td>Resident</td>
<td>L Gan</td>
<td>7787562</td>
</tr>
<tr>
<td>Mr. Adnan Moosa</td>
<td>Resident</td>
<td>L Gan</td>
<td>7551115</td>
</tr>
<tr>
<td>Mr. Ahmed Musthafa</td>
<td>Resident</td>
<td>L Gan</td>
<td>7841599</td>
</tr>
<tr>
<td>Mr. Ali Waheed</td>
<td>Resident</td>
<td>L Gan</td>
<td>7835669</td>
</tr>
<tr>
<td>Mr. Ahmed Areef</td>
<td>Resident</td>
<td>L Gan</td>
<td>7659354</td>
</tr>
<tr>
<td>Mr. Ziyad Khalid</td>
<td>Resident</td>
<td>L Gan</td>
<td>7890992</td>
</tr>
<tr>
<td>Mr. Usman Abdullah</td>
<td>Court Officer</td>
<td>Magistrate Court</td>
<td>9959935</td>
</tr>
<tr>
<td>Mr. Mohamed Mushad</td>
<td>Fenalia</td>
<td>L Gan</td>
<td>7710601</td>
</tr>
<tr>
<td>Mr. Ahmed Hussain</td>
<td>Resident</td>
<td>L Gan</td>
<td>7406494</td>
</tr>
</tbody>
</table>

Following issues were noted from the public consultation carried out in L. Gan on the proposed project.

- The proposed will help in improving livelihood of L. Gan community
- The community has a view that growing sea cucumber in sea pen or cage similar to the proposed project will have a positive impact to the abundance of sea cucumber species
- Proposed project will create job opportunities and improve living standards of families who engage in the work
- As an economic incentive it appears that the proposed project will assist in increasing the overall income to L. Gan
- Further to improve the project, the community foresee the business get expanded in L. Gan for allowing community to participate it.
When asked if the community supports in developing the Project in L Gan, community very positively expressed that they fully support it, they have a strong view that the project will benefit the community in so many ways.

- The project will help in bringing a cease to on-going harvesting of sea cucumbers by hand pick through diving
- The project will help in reducing sea weeds in near shore lagoon where sea cucumber pens are developed
- The project will assist in avoiding damages to reefs
- Create opportunities for engaging locals in the sea cucumber farming practice through that it will create manpower within the community
- The project will help in creating more small business outlets and will assist in circulating incomes generated by locals engaged in the farming work
- Open such opportunities to other interested companies

7.1.6 Consultation with MRC

Consultation with MRC was held on 3rd Jan 2017 at MRC in the presence of following members (See Table 33):

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
<th>Office</th>
<th>Contact No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms. Shafiya Naeem</td>
<td>Aquatic pathologist</td>
<td>MRC</td>
<td>7971586</td>
</tr>
<tr>
<td>Mr. Hussain Ahmed</td>
<td>Aquaculturist</td>
<td>MRC</td>
<td>9555373</td>
</tr>
</tbody>
</table>

Outcome of the consultation

- MRC highlighted two main impacts as follows:
  - Increase in nutrients at the lagoon as a result of feed
  - Toxic waste management
- MRC suggested to conduct monthly nutrient monitoring and take action if nutrient level exceeds baseline level. They anticipated standard feed, used semi intensively will not have a significant impact.
- However, it is important to specify the number of sea cucumber that will be in the lagoon during full capacity and amount of sea cucumber that will be processed annually.
- In terms of cooked waste, they do not suggest to discard in the open ocean as waste generated from sea cucumber processing effects bait fisheries etc. MRC suggested to consider small scale composting and burying these waste.
- MRC said upon request they can provide algal culture and feed management training. They do not provide broodstock. They recommended to source broodstock from Maldives. Alternatively if broodstock is obtained abroad, quarantine facilities should be present in the hatchery.
- MRC said they see no issues in placing just the hatchery outfall inside the lagoon. They also did not oppose to the idea of using the same outfall to discharge sewage and
wastewater from hatchery provided that wastewater from hatchery is subjected to filtration etc prior to mixing with sewage wastewater before discharging.

- MRC highlighted that the depth should be at least 1.5ft during low tide for sea cucumber to survive.
- MRC highlighted that, they would provide assistance upon request to train staff in proper handling and management of sea cucumber during the initial stages of the operation.

A summary of the findings from the stakeholder discussions is given in Table 34.
**Table 34: Summary of stakeholders consultations**

<table>
<thead>
<tr>
<th>Key Stakeholder Consultation Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public (general)</strong></td>
</tr>
<tr>
<td>The island is in full support to the Project as they believe the Project will have direct and indirect benefit to the community and increase social well-being of the community</td>
</tr>
<tr>
<td>I will create more job opportunities and improve the overall livelihood of the community</td>
</tr>
<tr>
<td>I will have benefits marine environment, particularly the improve in abundance of sea cucumber</td>
</tr>
<tr>
<td>The community foresee the business get expanded in L.Gan and opportunity created for the community to carry their own farming</td>
</tr>
<tr>
<td><strong>Environment Protection Agency</strong></td>
</tr>
<tr>
<td>Care to be given in disposing hatchery waste, gutting and processing waste and wastewater</td>
</tr>
<tr>
<td>Regular monitoring to be undertaken during and operation of the farm</td>
</tr>
<tr>
<td>Existing utility service such as sewerage, electricity to be explored before developed own their own</td>
</tr>
<tr>
<td>Care to be taken while removing or cutting down trees, if any mature tree or coconut palm is removed, replace it by replanting trees or palms under the Tree Cutting Regulation</td>
</tr>
<tr>
<td><strong>Ministry of Housing and Infrastructure</strong></td>
</tr>
<tr>
<td>All technical dialogue regarding the proposed sea cucumber farming to be consulted with MRC and EPA</td>
</tr>
<tr>
<td>MHI has issued no objection letter to L Gan Council in leasing the land for SS Farming Pvt. Ltd</td>
</tr>
<tr>
<td><strong>FENAKA cooperation</strong></td>
</tr>
<tr>
<td>Due to the long distance from existing sewerage system in L Gan, it is unlikely that sewerage service be given to Project site from L. Gan sewerage system</td>
</tr>
<tr>
<td>Due to unavailability of main cable and a transformer nearby to the Project site, at this point in time it is not possible to provide electricity to Project site by FENAKA.</td>
</tr>
<tr>
<td><strong>Marine Research Centre</strong></td>
</tr>
<tr>
<td>MRC supported the project and highlighted two main impacts which needs to be monitored and addressed. These were:</td>
</tr>
<tr>
<td>1. Management of sea cucumber processing waste</td>
</tr>
<tr>
<td>2. Monitoring nutrient loading of the grow out area</td>
</tr>
</tbody>
</table>
7.1.7 Project Awareness

In the public stakeholder consultation sessions held in L Gan the participants stated that they were aware of the proposed sea cucumber farming Project.

At the beginning of each consultative meeting, an overall brief of the project was provided to various groups. Impacts, both negative and positive, that are common with any infrastructure development programme acquiring land were discussed with the stakeholders. People interacted with interest to learn about the project and shared their views as well.
8. ALTERNATIVES

This section explores alternatives for the proposed project as required by the TOR for the EIA. Other aspects explored include:

- No development option;
- Alternative location to develop the hatchery and grow out area;
- Alternative operational waste management options;
- Alternative hatchery discharge options and
- Alternative sewage management options.

These are compared in detail in this chapter. When comparing the alternatives, environmental, economic and social considerations were taken into account. The principle of sustainable development is used as the guiding principle in selecting the preferred alternative. Sustainable development has been broadly defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (UNWCED, 1987).

Hence, the aim is to ensure that all project activities are undertaken without any adverse long term irreversible environmental damages that cannot be mitigated. This is the principle that is applied when discussing the preferred alternative through the discussions that entails in the sections below.

8.1.1 No Development Option

This alternative considers taking no action or not proceeding with the proposed aquaculture farming project in L. Gan and leaving the existing environment as it is. The advantages and disadvantages are given in the following Table 35.

Table 35: Comparison of the no development option

<table>
<thead>
<tr>
<th>Option</th>
<th>Environmental</th>
<th>Social</th>
<th>Economic</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Project</td>
<td>Plot largely remains in its current form where waste is being disposed without treatment or management. Large waste mounds are formed in the lagoon and coastal areas reducing the natural DO level and creating a suitable environment for pests such as mosquitoes to flourish. If the project is not implemented vegetation and trees from the area will not be cleared.</td>
<td>Benefit to the society by the project will be missed and there is the chance to use the empty plot for illegal activities.</td>
<td>No significant improvement to the local and regional economy. New job opportunities will not be created Income opportunities missed. Aquaculture farming knowledge remain unavailable to the community</td>
</tr>
</tbody>
</table>
Waste generated from the project can be avoided.

Project

The project involves restoring the existing environment to a better state that’s environmentally and economically appropriate by removal of industrial and municipal solid waste from the coastal and lagoon area. The facility will also come with environmental guardianship with strong measures to conserve the environment through better waste management, efficient resource use, energy conservation and overall contributions to improving the existing environmental condition of the island. Significant unfavourable aspect to the environment include nutrient increase in the lagoon and improper management of sea cucumber processing waste. However these impacts will be managed through appropriate mitigation measures. The location may not be as suitable for alternative uses such as for tourism development without major alterations to the existing environment as such removing the extensive seagrass beds, improving the beach etc..

Increased direct and indirect employment opportunities for the locals.

Increased visitors to island as the facility expands and develops, indirectly promoting local tourism.

Knowledge transfer and development of technical capacity in farming sea cucumber

Unattended vacant space is subjected to littering and illegal activities which can be controlled as a result of the Project.

Enhanced opportunity for locals to start and diversify related services such as management of grow out cages.

Direct contribution to government revenue through taxes and duties.

Creation of job opportunities and skilled labour in the region.

As Table 35 shows no project would mean, the project site retaining its alternative land use value. Since once all project facilities have been established and project implemented, it becomes difficult to reverse it for another use. Even with retaining the current status only a limited alternative uses may be feasible at the plot allocated for the project. Perhaps a more lucrative use could be
developing the plot as a tourism product. However it does not seem to be suitable for tourism development unless a major alteration to the site takes place as such it possess muddy substrate in the lagoon and extensive seagrass beds etc..

Site investigation and studies confirmed that it does not possess special features of interest for conservation. Due to its neglected state the site; both land and coastal areas had deteriorated and further degradation is expected if left in its current state and the land may be abused. In addition the economic benefit as a result of no project cannot even be compared to what it can yield with the project. Currently the site does not generate any direct or indirect income or benefit. The project when developed will inevitably create environmental impacts none of these have been found to be of concern at national or Atoll level. With proper mitigation measures all the foreseeable impacts can be avoided or mitigated. In addition, development of project is expected to contribute to the government’s revenue through land rent as well as BPT. Other direct benefits include job opportunities for the locals, business opportunities for the local communities other social benefits from the project.

Given the range of benefits that the proposed development of the project will bring to the economy and people, the no project option has been rejected.

8.2 DEVELOPMENT OPTIONS

In evaluating alternatives focus was given to exploring alternatives that may improve the project performance and improve environmental sustainability of the project. In this regard, locations, the design, construction and operational aspects were looked into.

8.2.1 Alternative Location

An alternative location for the project was explored in the EIA process. In order to considering an alternative location for the Project, EIA team has consulted with the council on phone on 27 December 2016 for a second time. The council member mentioned that the council had already approved the most appropriate site and, and suggested that a site on the eastern side at Mukurimagu not too far from the Haiyiheli area may be considered in the alternatives assessment. This alternative location is shown in Figure 62. The site was evaluated against the preferred site (see Table 36) and also the option of relocating the project to an alternative island was also considered in the comparisons.
Table 36: Location comparison advantages and disadvantages

<table>
<thead>
<tr>
<th>No</th>
<th>Alternatives</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alternative location (east coast of Mukurimagu)</td>
<td>a. Easy to get access to electricity as the Mukurimagu is close to a</td>
<td>a. The farming facility may not be as secure due to the living community close to the facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b. Existing sewer in Mukurimagu can be used to dispose hatchery wastewater</td>
<td>b. The location may not be approved by the concerned authorities as there is a historically sensitive site (Stupa or Haiythei) close to it</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c. Less impact to marine environment</td>
<td>c. Appears to be a nuisance to the community due to likely bad odour during gutting and processing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d. Avoids breaking reef to lay marine outfall</td>
<td>d. Increased cost on strengthening the security of the facility to monitor vandalism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e. Aids in reducing point source of pollutions</td>
<td>e. The lagoon substrate is sandy, hence may not be suitable for grow out</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f. Avoids operation of power generators on developer’s own</td>
<td>f. Blocks community to sea</td>
</tr>
<tr>
<td></td>
<td></td>
<td>g. Less operational cost of utility service on developer</td>
<td>g. Bans community from doing fisheries in that water that will affect livelihood of the community</td>
</tr>
<tr>
<td></td>
<td></td>
<td>h. Easy access to labours who engage the farm as employees</td>
<td></td>
</tr>
</tbody>
</table>

Based on these findings a scientific approach was used to determine the most appropriate location. The options analysis was done using a 3×3 matrix. The options compared were the alternatives

A. Proposed location (current location);
B. Alternative location (See Figure 62 for alternative location) and
C. Alternative island.

For each parameter applied, a score was given to the options ranging from 3 to -3 with 3 being major positive -3 being major negative. 0 is used in situations where the impact may be negligible or there are no impacts from the implementation of the option. The alternatives are scored against the other, with a total of three combinations; A vs B, A vs C, and B vs C. The scores are given accordingly and the sum of the scores are compared. The alternative with the least negative score (or the most positive score) is deemed the best alternative from the three. The scoring criteria used in the evaluation is shown in Table 37 and various parameters used in comparing the alternatives is given in Table 38. The final evaluation matrix of various options compared for Tourist Hotel Development locations are given Table 39.

For the purposes of this analysis the following resources have been used for the evaluation of options:
- Existing studies
- Site survey
- Public/stakeholder consultation
- Literature review
- Past EIA reports
- Expert opinion

**Table 37: Scoring criteria used in the option analysis for an alternative location**

<table>
<thead>
<tr>
<th>Range</th>
<th>Major Negative</th>
<th>Moderate Negative</th>
<th>Minor Negative</th>
<th>No Change</th>
<th>Minor Positive</th>
<th>Moderate Positive</th>
<th>Major Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-3</td>
<td>-2</td>
<td>-1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 38: Parameters used in option analysis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Parameter</th>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Land availability</td>
<td>S1</td>
<td>If the land is available or designated for mar-culture</td>
</tr>
<tr>
<td>2</td>
<td>Coastal vulnerability</td>
<td>S2</td>
<td>Coastal condition including, erosion etc.</td>
</tr>
<tr>
<td>3</td>
<td>Land acquisition cost</td>
<td>S3</td>
<td>Cost required to acquire the land for development. Rent/shares etc.</td>
</tr>
<tr>
<td>4</td>
<td>Environmental benefits</td>
<td>S4</td>
<td>Evaluation of whether the proposed area is suitable to culture sea cucumber.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Check whether the area is environmentally sensitive or vulnerable</td>
</tr>
<tr>
<td>5</td>
<td>Resource and utility</td>
<td>S5</td>
<td>Accessibility to electricity, water and sewerage systems.</td>
</tr>
<tr>
<td>6</td>
<td>Land use aspects</td>
<td>S6</td>
<td>Surrounding area land use. Private properties, Industrial areas, impacts to adjacent land use aspects</td>
</tr>
<tr>
<td>7</td>
<td>Public view</td>
<td>S7</td>
<td>Opinion of public and their views regarding location</td>
</tr>
<tr>
<td>8</td>
<td>Economic benefits</td>
<td>S8</td>
<td>Trade, employment and development benefits to community and island</td>
</tr>
</tbody>
</table>
Figure 62: Alternate location for the project
Table 39: final evaluation matrix of various options compared for the project locations

<table>
<thead>
<tr>
<th>(A) Proposed Location</th>
<th>(B) Alternative Location</th>
<th>(C) Alternative Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) Proposed Location</td>
<td>(B) Alternative Location</td>
<td>(C) Alternative Island</td>
</tr>
<tr>
<td>S1</td>
<td>S1 3</td>
<td>S1 3</td>
</tr>
<tr>
<td>S2</td>
<td>S2 3</td>
<td>S2 3</td>
</tr>
<tr>
<td>S3</td>
<td>S3 2</td>
<td>S3 2</td>
</tr>
<tr>
<td>S4</td>
<td>S4 3</td>
<td>S4 3</td>
</tr>
<tr>
<td>S5</td>
<td>S5 -1</td>
<td>S5 -1</td>
</tr>
<tr>
<td>S6</td>
<td>S6 2</td>
<td>S6 2</td>
</tr>
<tr>
<td>S7</td>
<td>S7 3</td>
<td>S7 3</td>
</tr>
<tr>
<td>S8</td>
<td>S8 3</td>
<td>S8 3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

(B) Alternative Location

<table>
<thead>
<tr>
<th>(B) Alternative Location</th>
<th>(C) Alternative Island</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 2</td>
<td>S1 0</td>
</tr>
<tr>
<td>S2 -1</td>
<td>S2 0</td>
</tr>
<tr>
<td>S3 -2</td>
<td>S3 -2</td>
</tr>
<tr>
<td>S4 1</td>
<td>S4 3</td>
</tr>
<tr>
<td>S5 3</td>
<td>S5 0</td>
</tr>
<tr>
<td>S6 -1</td>
<td>S6 0</td>
</tr>
<tr>
<td>S7 2</td>
<td>S7 -3</td>
</tr>
<tr>
<td>S8 3</td>
<td>S8 -3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
The options analysis shows that the option C (Alternative island) had the most negative score of the three options making it the most unfavourable option. Option B (alternative plot) scored the second highest. Option A (Proposed location) scored the highest from the three options making it the most favourable option.

The first parameter compared was land availability. As the existing site has been awarded to the proponent for 15 years under a contract it received the highest score. The alternative location was selected based on consultation with the council. The council identified it as a potential alternative. However, since the land has not been awarded it was scored less than option A. Available lands at other islands for aquaculture cannot be compared on equal footings as the social, economic and environmental conditions can significantly differ from island to island even within the same atoll hence this option scored a zero in the parameter due to its uncertainty factors.

Considering vulnerability criteria, the current site scored the highest, based on the existing environmental studies the coastal area and lagoon area of the proposed location was quiet favourable. Alternative location sored lower since it is close the harbour and the coastal area was subjected to higher energy which would make it more unstable compared to option A. Option C was given a neutral score since the conditions were unknown.

Land acquisition cost for option A is considered to be positive since it has been awarded to the proponent. Hence, option A scored the highest for this criteria. Acquisition of alternative land will depend on the council’s procurement policies. Moreover, since the area has not been designated for aquaculture, in the land use plan it scored lower. Option C also scored lower due to the uncertainty in land accusation costs.

When considering the environmental condition Option, A scored the highest. Although both option A and B are in the same area option B scored lower since the lagoon area in alternative location is smaller.

Accessibility to resources and utilities such as water, electricity and sewerage will be much easier if the sea cucumber facility was located close to Mukurimagu (Option B). The allocated plot location is situated away from the local population hence utility services are not readily available which is why it scored lower in this criteria. Due to the uncertainty of option C, it is considered least favourable. Although option A scored lower in accessibility to utilities it was more favoured in terms of land use aspects. Since location proposed in option B involves development of an industrial sea cucumber farm close to locals it has been considered less favourable. During stakeholder consultations, it was noted by the participants that they would prefer industrial facilities to be situated further away to avoid impacts of industrial waste, especially since waste from cooking sea cucumber produces harmful chemicals. Moreover, the alternative location is used for surfing by the locals and is historically significant due to Havita. The area is prone to erosion which poses a significant risk to the coastal area.

In summary there are advantages and disadvantages of relocating the farm to Mukurimagu, the main advantage being easy access to utility services such as sewerage and electricity with resulting savings on the investment. Although adequate lagoon space is available from the location from the land side, adjacent land uses appear to be in conflict with the nature of the planned project. First a historical site earmarked for conservation is to the south and sewerage wastewater treatment plant is to the immediate west of it. In addition to these disadvantages, changing the location would also involve a lengthy administrative process and re-doing all the survey works, planning and designing...
of the facilities etc. In addition, the lagoon substratum does not appear to be as suitable for grow out as it was the case in the preferred location. The area was identified to experience erosion and is used by the locals for swimming and surfing. For these reasons it is not considered feasible to change the project location.

From this analysis, it can be stated that the most favourable location with the least amount of potential negative impacts is the proposed development location (Option A).

### 8.2.2 Alternative Disposal of Gutting Waste

Since waste generated from gutting sea cucumbers will be a major waste product from the facility and that it is known to contain chemical compounds that are harmful to marine organisms three different alternatives were identified and evaluated to determine the most feasible alternative which are discussed below.

#### 8.2.2.1 Option A – Burying Gut Waste

The proposed method of disposal involves burying the gut waste on land and discharging the cooked wastewater through the hatchery outfall. It is recommended to consider the option of composting gut waste so that it can be used as plant nutrition. This is especially favorable since chemical found in sea cucumbers are not known to have a toxic effect on plant (Song, et al., 2016).

#### 8.2.2.2 Option B – Grinding Gut Waste

The alternative method of disposing gut waste and cooked wastewater is to grind it in a well fixed with a grinding pump. The gutting waste will be collected in bins and cleaned before grinding. Gut waste will be mixed with water for efficient grinding which is then pumped into the main discharge pump well together with the wastewater from cooking. These will get diluted by the hatchery wastewater at the main discharge well before being discharged through the outfall pipe. A schematic diagram of grinding and discharge pump well is illustrated in Figure 63

![Figure 63: Alternative Gutting’s Disposal](image.png)
8.2.2.3 Option C – Disposal into Deep Sea

The third option involves collecting gut waste packing them in gunny bags and transporting them into the open ocean via a sea vessel and sinking them into deep sea. Routine transport will be arranged based on amount of waste produced as a result of processing.

The following matrix was used to make pair-wise comparison of the alternatives. Matrix is drawn with all options listed above both horizontally and vertically. Each option is then compared with every other one and a score of 1 assigned to the preferred option or 0.5 if no preference is agreed and 0 if not preferred. In choosing the preferred option 5 criteria have been used. The option analysis is given in Table 40.

Table 40: Option analysis for processing water management

<table>
<thead>
<tr>
<th>Factors</th>
<th>Option A</th>
<th>Option B</th>
<th>Option C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on marine environment</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Potential for groundwater contamination</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cost and economic viability</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Maintenance costs</td>
<td>0.5</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Potential for reuse</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Score</td>
<td>2.5</td>
<td>1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Based on the outcome of the score, it can be seen that, the proposed option scored highest.

All three options involving final dumping into the sea was found to contribute to negatively to the marine environment hence did not score. As discussed above visceral parts of the sea cucumber contains more holothurin than the body walls implying that waste generated from gutting will have higher levels of holothurin than that is found in the cooked water. Hence option C was considered to have the biggest impact out of the proposed options, so it was the most unfavourable.

In terms of cost and maintenance option A scored the highest unlike option B which required shredding equipment and option C that required transporting waste long distances. Moreover, option A will allow harmful holothurin containing waste to be converted into a useful product as it decays and ultimately would enrich the soil.

8.2.3 Alternative Wastewater from Hatchery Discharge

Two options were considered to discharge waste water from the hatchery facility. These include:

1. Discharging waste water from the hatchery to the lagoon (Option A); and
2. Discharging wastewater from the hatchery out of reef through an outfall (Option B).

Pairwise comparison matrix was used to compare the two options in which 2 factors were compared. Table 41 shows the outcome of the analysis.
Table 41: Option analysis of hatchery discharge location

<table>
<thead>
<tr>
<th>Factors</th>
<th>Option A</th>
<th>Option B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impacts on marine environment</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Cost and economic viability</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Total score</td>
<td>0.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>

The analysis showed that Option B scored slightly higher than option A. This was mainly because, although wastewater from the hatchery will mostly consist of very low level of nutrients and impurities, over time nutrients and traces of chemicals used to clean the hatchery tanks may accumulate in the lagoon. Moreover, since the lagoon is relatively calm it could become favourable for nutrient accumulation and algal growth. Hence even if the initial cost of discharging into the lagoon is going to be low due to reduced costs of laying the pipe and pumping wastewater, it might have cumulative negative impacts on the environment in the long run. For this reason, discharging hatchery wastewater through the outfall into the ocean where significant mixing takes place is the better option for the environment and project for the future if production is scaled up.

The option to discharge wastewater through the western side into the atoll was dismissed through consultations with EPA. Main reasons for this option to be unfavourable include, the huge cost and impacts of trenching land to bury the pipe before it reaches the western side. The area is also used actively for transportation and recreation which would exacerbate the impacts. The distance between coast and the reef is smaller which could prevent proper diffusion of waste water. Based on these disadvantages this option was dismissed during the initial screening of alternatives.

8.2.4 Alternative Sewage Management

The alternative option in treating wastewater will be to discharge wastewater into the existing sewerage system in L. Gan. As discussed an island-wide modern sewerage system with secondary treatment facility is already in place in L. Gan which will be an ideal facility for disposing wastewater from the facility. By disposing wastewater through the sewerage system would eliminate cost of constructing the septic system and wastewater treatment, its maintenance etc and ensure proper treatment at the same time. In addition wastewater from the hatchery could also be discharged through the system eliminating the need for construction of the outfall and the treatment system and all impacts related to installing and operating it. This is also a suggestion given by the EPA. The difficulty at this stage however is the limited reach of the sewerage network which does not cover the region where the project is sited. Discussion with FENAKA will continue and as soon as the network line reaches the project area, effluent discharge will be connected to the sewerage system which would be the most economically and environmentally feasible way to manage the wastewater. However at this stage this alternative has been rejected and more practical two alternatives have been evaluated for the preferred option.

The two options of sewage treatment explored in the study include:

1. Installation of septic tank (Option A); and
2. Installation of a sump well connected to the main outfall (Option B)
Option A

A septic tank is essentially a multi-chambered tank with an outlet. The ‘primary tank’ facilitates ‘primary treatment’. the separation of liquids and solids by gravity - to take place. Raw sewage flows into the tank and the heavy solids, ‘sludge’, sink to the bottom, lighter solids, grease and oils or ‘scum’ float to the surface. Some of the sludge is degraded by naturally occurring anaerobic (without oxygen) bacteria. The liquid effluent flows via gravity out of the tank and discharges to land by soakaway.

Advantages

- Relatively low installation and maintenance cost; and
- Some treatment is achieved.

Disadvantages

- Require emptying on a regular basis;
- Potential for leakages and contamination of groundwater; and
- Potential health risks for workers involved in cleaning and maintaining the system.

Option B

A sump well connected to the outfall basically pumps out the wastewater and solid components through the outfall without treatment. Although it avoids desludging, there is no treatment involved at all and is costlier and chances of blocking and damages to the outfall pipe is high which would lead to higher maintenance costs. This method of treatment would result in a higher operation cost and it would be more energy intensive.

Since the proposed facility will employ approximately 10 workers during the day time the amount of sewage and wastewater produced will be very less. This makes option A very suitable for the facility as it avoids costs and due to the relatively small number of workers desludging will not be extensive.

8.2.5 Alternative Grow-Out Approach

Grow out cages in the proposed project are to grow only sea cucumber *H. scabra*. However, co-culturing with shrimp may be a suitable alternative approach. The co-culture of juvenile sea cucumber *H. scabra* for example with juvenile blue shrimp *Litopenaeus stylirostris* tested in co-culture and monoculture in tanks find successful although the growth of two species varied (Steven, et al., 2006). The research also says co-culturing juveniles of the two species in earthen ponds appears feasible, with no harm to shrimp production, presenting a cost-effective method for growing sandfish to larger sizes for restocking, with care in managing ponds. In a similar research carried out by co-culturing *H. scabra* with red seaweed finds *H. scabra* a highly viable species for lagoon co-culture with seaweed that offers a more efficient use of limited coastal space over monoculture and is recommended as a potential coastal livelihood option for lagoon farmers in tropical regions (Marisol, et al., 2014). Co-culturing would help in reducing impacts to environment by proving extra species with little cost on it apart from sourcing juvenile.
8.2.6 ALTERNATIVE BUILDING CONSTRUCTION OPTIONS

Two types of construction options have been considered for the hatchery facility. These include use of:

1. Pre-engineered/prefabricated materials (Option A); and
2. Concrete materials (Option B).

**Option A - Pre-engineered/Prefabricated Structure and Materials**

Prefabrication is the method of construction which includes assembling components of a structure in a manufacturing or production site, transporting complete assemblies or partial assemblies, to the site where the structure is to be located. It is combination of good design with modern high performance components and quality controlled manufacturing procedures. This style of construction is ideally suited to industrial buildings and warehouses; it is cheap, very fast to erect, and can also be dismantled and moved to another site.

The structural system of pre-engineered steel buildings gives it its speed and flexibility. This system consists of factory-fabricated and factory-painted steel column and beam segments that are simply bolted together at site. This is one form of construction in which the structures are designed to carry exactly the loads envisioned, and no more.

Once foundation is laid, it is a matter of installing the structure and using prefabricated vinyl/plastic cladding.

**Advantages**

a) Due to the efficiency and large quantity of prefabricated materials produced it will be significantly cheap;
b) They are easy to install and will reduce the time taken for construction considerably;
c) Working with prefabricated materials means that the work environment is usually dry and clean which would avoid many impacts on the health of workers and physical environment, and
d) Use of prefabricated materials means that, raw materials such as cement, sand and water is not required in significant amount effectively mitigating strain on local resources.

**Disadvantages**

a) Since these materials have to be transported from source factory, transportation costs will be high. Especially since they will have to be imported from abroad;
b) These structures will require erection equipment such as cranes and skilled laborers to successfully install, and
c) Prefabricated structures are not designed to carry dynamic loads.
Option B – Use of Concrete structure and materials

Concrete frame structures are a very common and most of the modern building are made from concrete. Concrete structures consists of a frame or skeleton of concrete. Horizontal members of this frame are called beams, and vertical members are called columns. For the purpose of strengthening concrete structures, they are reinforced with steel meshes. Concrete building are designed to carry dynamic and live load. The concrete requires at least a month to mature and attain its full strength. Concrete is made by mixing the raw materials, cement sand aggregate and water.

Advantages

a) Extremely strong and durable. It can withstand heavy loads;

b) Concrete can be easily transported from the place of mixing to place of casting before initial set takes place;

c) Concrete can be pumped or sprayed to fill into cracks and lining of tunnels, and

d) Using steel as reinforcement it is possible to build any structure; be it lintel or a massive fly-over.

Disadvantages

a) Concrete possess low tensile strength. Therefore, concrete is required to be reinforced to avoid cracks;

b) Due to drying shrinkage and moisture expansion concrete may crack;

c) If soluble salt is present in concrete, then it may lead to efflorescence when comes in contact with moisture;

 d) Concrete made with ordinary Portland cement, gets integrated in the presence of alkalies, sulphates;

 e) It takes a long time to finish concrete structures as opposed to prefabricated structures, and

 f) Preparation of concrete will require raw materials such as sand and water from the local environment.

Analysis of the two options based on their advantages, disadvantages and local context and setting of the proposed project, it was concluded that Option A was more preferred. This is because:

a) the proposed hatchery facility is a simple structure which will be used for only a single purpose. Hence it will not require dynamic load bearing capacities.

b) A cheap prefabricated structure can be quickly installed which would mitigate construction phase impacts.

c) Being close to a coastal environment it is more appropriate to use prefabricated materials that are not chemically affected by salt spray.

d) Use of prefabricated materials will prevent high costs and impacts associated with sourcing raw materials. Sourcing sand and water locally will be expensive and difficult and
e) By using prefabricated material, it will be easier to expand or make changes to the building.
9. **ENVIRONMENTAL IMPACTS AND MITIGATION**

9.1 **INTRODUCTION**

This section aims at addressing tasks 4 and 6 of the TOR. The aim of the section is to identify all the impacts that may arise during the construction and operational phase of the project, and propose mitigation measures to address the negative impacts to make the project environmentally sustainable. The methodology applied is described in detail in Section 1.5.

In assessing the impacts, a differentiation was made between the construction and operational phase of the project, since impacts during the construction phase of the project and operational phase of the project are vastly different. Environmental receptors were classified under three main subheadings which include physical environment, biological environment and social environment. Under each component environmental receptors were adapted from the Leopold method based on consultation with the stakeholders and findings of the existing environment. Impact identification follows from the alternative evaluation (see Chapter 8) in that environmentally unfavourable alternatives had been rejected and most preferred alternative considered for further evaluation so as to enhance the project’s environmental sustainability. For the selected alternatives regardless of the impact magnitude, mitigation measures for all relevant activities that may have an effect on the natural and socio-economic environments have been identified. Elaboration of the assessed effects of impact factors on environmental components have been discussed in the following Sections.

9.2 **CONSTRUCTION PHASE IMPACTS AND MITIGATION**

Leopold Matrix for the construction phase of the project is shown in Table 42. Figure 64 illustrates the impact magnitude of each activity and their relative importance. Figure 65 illustrates impact on the environmental receptors during the construction phase of the project. A summary of the major activities and their associated overall impact represented by colour codes are given in Table 43.
### Table 42: Impact matrix for the construction phase of the project

<table>
<thead>
<tr>
<th>Envisaged impact factors</th>
<th>C1 Settlement of Workers</th>
<th>C2 Site Preparation (Vegetation clearing)</th>
<th>C3 Material Storage</th>
<th>C4 Material Transport</th>
<th>C5 Construction of Hatchery and Sea pens</th>
<th>C6 Water Consumption</th>
<th>C7 Electricity Consumption</th>
<th>C8 Sewage Generation</th>
<th>Total (Impact Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seawater</td>
<td>-1</td>
<td>-7</td>
<td>-1</td>
<td>-2</td>
<td>-5</td>
<td>-2</td>
<td>-2</td>
<td>-5</td>
<td>-25</td>
</tr>
<tr>
<td>Ground water</td>
<td>-1</td>
<td>-4</td>
<td>-3</td>
<td>-2</td>
<td>-6</td>
<td>-2</td>
<td>-5</td>
<td>-2</td>
<td>-24</td>
</tr>
<tr>
<td>Air</td>
<td>-2</td>
<td>-3</td>
<td>-5</td>
<td>-2</td>
<td>-2</td>
<td>-5</td>
<td>-5</td>
<td>-4</td>
<td>-19</td>
</tr>
<tr>
<td>Noise</td>
<td>-1</td>
<td>-1</td>
<td>-5</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-3</td>
<td>-13</td>
<td>-16</td>
</tr>
<tr>
<td>Coastal Zone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-12</td>
</tr>
<tr>
<td><strong>Biological Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-5</td>
</tr>
<tr>
<td>Flora</td>
<td>8</td>
<td>-3</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Endangered species/protected areas</td>
<td>-7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Coral Reef</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fauna</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Socio-Cultural Component</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesthetics</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-9</td>
</tr>
<tr>
<td>Health/Well being</td>
<td>-1</td>
<td>-4</td>
<td>-3</td>
<td>-1</td>
<td>-2</td>
<td>-3</td>
<td>-2</td>
<td>-13</td>
<td>-12</td>
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<tr>
<td>Landscape</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-12</td>
</tr>
<tr>
<td>Cultural heritage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Local economy</td>
<td>4</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>-2</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Total (Construction Activity/Risk)</td>
<td>-3</td>
<td>-32</td>
<td>-22</td>
<td>-12</td>
<td>-29</td>
<td>-6</td>
<td>-16</td>
<td>-25</td>
<td>8</td>
</tr>
</tbody>
</table>
Figure 64: Impact magnitude and importance based on construction phase activities.

Figure 65: Impact magnitude on environmental receptors during construction phase
### Table 43: Summary of impact magnitude for construction phase activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1 Settlement of workers</td>
<td></td>
</tr>
<tr>
<td>C2 Site Preparation (Vegetation clearing, waste removal)</td>
<td></td>
</tr>
<tr>
<td>C3 Material transport</td>
<td></td>
</tr>
<tr>
<td>C4 Material storage</td>
<td></td>
</tr>
<tr>
<td>C5 Construction of hatchery and sea pens</td>
<td></td>
</tr>
<tr>
<td>C6 Water consumption</td>
<td></td>
</tr>
<tr>
<td>C7 Electricity consumption</td>
<td></td>
</tr>
<tr>
<td>C8 Sewage generation</td>
<td></td>
</tr>
<tr>
<td>C9 Landscaping/rehabilitation</td>
<td></td>
</tr>
</tbody>
</table>

#### 9.2.1 Impact from Site Development

##### 9.2.1.1 Settlement of Workers (C1)

The construction of hatchery and grow out area will require a total of 15-20 workers including technical staff and labourers. Since the scale of the construction is small and simple, the workforce/contractor required to construct the facility is planned to be sourced from L. Gan. This will avoid transportation and settling impacts associated with bringing equipment and workers from another island. Since the workers/contractor is already based in the island there will be no need to setup a temporary workers camp or equipment shed. Hence this will significantly reduce additional resource consumption and social issues that may arise due to addition of new people who are foreign. However, when a site that has been left idle for a long time and when the activities begin the fauna habiting in the area would get disturbed. Workers activities may result in disturbance to netting and roosting birds both inland and on the coastal areas. Unwanted damages to trees and habitats may also result from workers activities. Overall multi criteria impact for this activity was -3, which meant that the activity would have a neutral to slightly negative impact on the environmental receptors.

**Mitigation Measures**

a) Workers rules must be in place before the work begins;

b) Avoid setting up of workers camp and use available resources and facilities from the island;

c) Hire locals for the workforce as much as possible;

d) Recruit skilled and experienced workers as much as possible;

e) Give proper instruction for environmental safeguards before work is commenced;

f) Awareness signs shall be placed on the site to display “dos” and “donts” with respect to protecting the environment;

g) Catching, killing or keeping birds and other animals will be prohibited;

h) Any turtle nest that may occur on the beach shall be prohibited;

i) Waste generated by workers and work shall be managed as per Section on Waste Management;
j) Orient foreign workers on how to communicate with locals and personal hygiene and sanitation and prevention of sexually transmitted diseases and other infectious diseases; and
k) Ensure proper documentation for foreign labourers to avoid use of illegal expatriates for the Project.

**9.2.1.2 Impact of Site Preparation (C2)**

Site preparation of the project involves clearing:

- 30,000 ft² of vegetation (worst case) which is approximately 0.4% of the total vegetation on the southern part of L. Gan;
- Removal of vegetation to create a pathway to access the project site; and
- Removal of waste mounds and accumulated waste at the coastal area and in the lagoon, to restore the environment.

Site preparation will involve uprooting at least 20 mature coconut palms and some mature tree that are in the project site. It was noted during field visits that none of the coconut palms at the project site was privately owned, hence no compensation issues are expected. Since removal of waste mounds are not only localised on the land, site clearing will involve marine works at the near shore area of the lagoon which has been polluted with industrial and municipal waste. The activity would have a notable positive impact on seawater quality. The overall impact of the activity was calculated to -32 during construction phase. This activity is considered to have a moderate negative impact on environmental receptors although the percentage of vegetation removes is going to be very small.

**Mitigation Measures**

a) Site area shall be clearly demarcated to ensure the workers involved clearly understands the project boundary and their activities shall be limited within it;
b) Set out survey and tree survey will have to undertake and all necessary building adjustments will have to be brought before the site clearance work begins;
c) All trees needing removal will have to be marked by a qualified surveyor;
d) Once the final number of tree removal is determined it shall be communicated with the island council and EPA for approval;
e) Topsoil generated from tree removal activities shall be retained used in replanting for compensations;
f) Vehicles shall only be allowed to travel through pre-determined routes as not effect vegetation outside the primary impact area;
g) During site preparation, paths for vehicle movement should be identified and explained to workers;
h) Uprooted coconut palms shall be replanted close to the environment from which they were removed, in this case preferably the space created at the coastal area after removing the waste mounds. If all trees cannot be replanted it should be relocated to an area identified by the council. However, this option was limited based on existing environment surveys since there are no empty lands within 3 km of the project site that can be easily accessed to relocate coconut palms. Hence the alternative, will be to replant two young palm trees for each mature palm tree removed;
i) If a sediment plume forms during removal of waste from the nearshore coastal area, it is recommended to install a silt screen;

j) Trees that cannot be replanted or relocated can be cut and timber used as firewood;

k) Waste removal from the lagoon shall be carried during low tide hours and during calm weathers;

l) All waste collected from the project site shall be securely packaged and transported to the closest waste management centre (Thilafushi);

m) Oil refuelling or servicing of the vehicles shall not be done at sea; and

n) All waste oils and soiled clothes shall be carefully collected and treated as hazardous wastes.

9.2.1.3 Impacts of Material Transport (C3)

The project will require construction material and equipment to be transported to project. Two options to transport material have been explored in the report. Transportation of material from nearest public harbour which is situated 2 km from project site at Mukurimagu (Option A) and Transporting material from Maandhoo private harbour (Option B). Option B was identified to mitigate impact associated with material transportation. Predicted impacts associated with transportation of materials are summarized below:

- Noise and vibrations caused by vehicles and heavy machineries;
- Wear – and – tear caused to the road surface;
- Tail pipe emissions from vehicles;
- Dusting and spillage of materials;
- Transportation of the materials from source to L. Gan and from the port to Project site would require fuel for the vessels and vehicles releasing global warming gases into the atmosphere; and
- Transportation process also involves the risk of road accidents.

These occurrences represent indirect, short-term, reversible, moderate negative impacts on the environment.

Sea going vessels carrying materials and machineries may run on reef due to navigational failures or carelessness causing damages to coral reefs. One such example is the recent accidental aground of cargo vessel carrying materials to Gn. Fuvahmulah for water supply and sewerage project (www.vnews.mv, October, 2016). However, these incidents can be completely avoided by careful planning and by adapting safe navigation. The overall impact of the activity was calculated to -22 during construction phase. This activity is considered to have a moderate negative impact on environmental receptors.

Mitigation Measures

a) Design to optimise the volume of materials required and materials shall be supplied in bulk;
b) Procure materials from nearest source country to minimise transport distance;
c) Select material storage within the site or location as close to the work site as possible to minimise land transport distance;
d) Vessel selected to transport materials to the island shall have proper navigation equipments and seaworthiness certificate and shall avoid night time travel and travelling in rough weather;
e) Stockpile area work site shall be enclosed and secure;
f) Avoiding land transport of materials during night time;
g) Avoid idle time for vehicles and plants to reduce emission;
h) Ensure land vehicles used meets the local road-worthiness requirements;
i) Implement proper traffic safety measures;
j) Trucks used for that purpose should be fitted with tailgates that close properly and with tarpaulins to cover the materials;
k) Sea transport vessel shall operate during daylight hours as far as possible;
l) Minimise the trips on land an on sea by using vessels and vehicles of right size;
m) Vehicle drivers observe prescribed speed limits especially when traversing road sections along residential areas;
n) Clean-up of spilled earth and construction material on the main roads should be the responsibility of the Contractor and should be done in a timely manner so as not to inconvenience or endanger other road users;
o) The transportation of lubricants and fuel to the construction site should only be done in the appropriate vehicles and containers, i.e. fuel tankers and sealed drums; and
p) Existing road network shall be used.

9.2.1.4 Material Storage (C4)

Material required for the construction of the facility is planned to be stored at the project site. This means materials will be stored away from public areas and within the compound of the proponent, which would avoid additional delivery costs and storage charges. However even though the area is shielded and protected by vegetation storing materials without fencing could potentially invite people to steal the material. Improper storage of chemicals, fuel, lubricants etc could cause spills and may contaminate the soil and groundwater. The overall impact of the activity was calculated to -12 during construction phase. This activity is considered to have a minor negative impact on environmental receptors.

Mitigation Measures

a) Before storing materials, the site shall be secured with proper fencing. Security and safety measures, such as hiring security guards etc, shall be installed before storing material at the project site;
b) Oil, lubricants and chemicals shall be separately stored in a concrete paved area with firefighting equipment and signs such as ‘No Smoking’, ‘No Naked Flame’ or similar;
c) Proper inventory of the materials shall be maintained;
d) Proper materials from nearest source whether is from abroad or within the country; and
e) Minimise material volume by design optimization and good workmanship.

9.2.1.5 Construction of Hatchery and Sea Pens (C5)

Since the development will take place at an industrial zone, situated far away from urban areas visual and noise impacts are not envisaged to be important. However, machines used in the project mainly
run on diesel fuel, which will have fuel management and handling issues in addition to emission of greenhouse gas. Poor handling and management of diesel and other fuel as in many islands may lead to contamination of the aquifer. Some degradation of the marine environment is also likely. Impacts on health and safety of workers are also highlighted as notable impacts as improper and careless work method and arrangement often times lead to accidents.

The proposed sea pens will be mesh type circular tube type pens anchored to the bottom in which sea cucumbers will be placed. The grow out area will be fenced using pvc pipes and nets hence installation will be very simple. A security hut will be installed in the middle of the lagoon area measuring 3.6 × 3.6 m. This will be constructed on stilts without a wall enclosing. A pyramid truss roof will be installed to protect from weather. Construction and installation of these are likely to have a short term negative impact on saltwater quality. Minor turbidity increase, and disturbance to benthic organisms will occur during the sea pens installation. These will be reversible and temporary.

One of the most, costly installation of the facility will be laying of the outfall pipe and pumps required for water circulation and air supply. Laying and anchoring pipes could damage corals and there is a significant risk for accidents, more so since the area is exposed to ocean waves.

The potential hazards during construction include fire, explosions, natural hazards (eg. flooding from heavy rain or wave, wind storms etc), hazardous materials spill or release, workplace violence, mechanical breakdown and supplier failure. The impacts of risks and accidents are usually casualties, works interruptions, financial loss and environmental pollution.

Overall construction of the facility is anticipated to have a positive impact on the local economy. However, based on the risk potential and impacts to the physical and biological environment, the construction of sea cucumber facility will have a moderate negative impact on the environment. The overall impact of the activity was calculated to -29 during construction phase.

**Mitigation Measures**

a. Work methodologies described in Section 2.18 shall be followed;
b. Building and grow out footprint areas shall be marked before the works begin;
c. Topsoil generated shall be set aside and used for landscaping purposes;
d. The outfall pipe shall be laid without trenching and installed using anchors as illustrated in Figure 14, to avoid sediment suspension and prevent damage to benthic ecosystem of the lagoon.;
e. Only the minimum number of workers shall be engaged in sea pens construction activities;
f. All wastes generated during sea-based activities shall be collected and brought to land for proper management;
g. Workers shall be informed of not to intentionally disturbed benthic organisms and to avoid trampling on them;
h. Sea pens should not protrude extensively above sea level to mitigate visual impacts and to allow easy access to the sea pens.
i. Only use skilled and qualified personnel when laying outfall pipe;
j. Monitor weather forecasts and pass the information to site supervisors; and
k. Conduct marine works during low tide.
9.2.1.6 Water Consumption (C6)

For construction activities water will be required and so will be for the workers toilet facility. Except for drinking water which will be bottled water all other construction related water will be obtained from the ground. The overall impact of the activity was calculated to -6 during construction phase. This activity is considered to have a minor negative impact on environmental receptors.

Mitigation Measures

a) Use pre-fab structures for the construction of the building over conventional method;
   b) Create awareness among workers on water use minimisation; and
   c) Initiate rainwater collection and storage as early as possible into the project construction.

9.2.1.7 Electricity consumption/generation (C7)

During the construction phase, on site generators (10-15 kW) will be used to provide electricity required for the operations of machineries and to light the project area. One generator will be used as a backup. Notable impacts of these include, increased air pollution, risk of spillage, impacts to health/wellbeing and accidents.

The primary pollutants that are already generated on the island due to power production from diesel based generator system including Nitrogen oxides (NO\textsubscript{x}), Sulphur dioxide (SO\textsubscript{2}), Carbon monoxide (CO), Hydrocarbons/ Polycyclic Aromatic Hydrocarbons (HC/PAH), Particles (PA) and Carbon dioxide (CO\textsubscript{2}) emission is expected to increase as a result of the construction activities although the exact amount is difficult to quantify.

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

Table 44 shows NO\textsubscript{x} and particles emission of burning a cubic meter of diesel by a generator.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Diesel generator mg/m\textsuperscript{3}</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>4000</td>
</tr>
<tr>
<td>Particles</td>
<td>100</td>
</tr>
</tbody>
</table>

The emission of nitrogen oxides is a serious problem and is often overseen. Nitrogen oxides are as seen in Table 44 responsible for a number of negative impacts on the environment. People living close to a generator will be affected by an elevated concentration of nitrogen oxides.

Nitrogen oxides contain different oxides of nitrogen, the most important being nitrogen monoxide (NO) and nitrogen dioxide (NO\textsubscript{2}). Nitrogen dioxide is a respiratory irritant and is responsible for a number of respiratory diseases. People with sensitive respiratory systems are especially affected. The overall impact of the activity was calculated to be -16 during construction phase. This activity is considered to have a minor negative impact on environmental receptors.
Mitigation Measures

a) Use well maintained, energy efficient equipment. Energy efficiency measures are of high importance for generators that operate for 24 hrs of each day both with regard to economy and the release of CO\textsubscript{2} and other pollutants. 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;
b) Reduce idle time of machineries and vehicles. Switch them off after use;
c) Utilize day time hours for the construction when plenty of light is available, and
d) Inform the utility provider regarding the planned works and amount of energy requirement.

9.2.1.8 Sewage Generation (C8)

A proper septic tank type sewage system will be installed as a very first step into the construction works at the project site. The amount of human waste generated per person is approximately 125 g/day, which means 1.8 kg will be produced daily if approximately 15 workers were active. Even though large volume of sewerage is not expected during the construction phase, it shall be managed properly to avoid heath and hygienic issues and polluting the environment. The overall impact of the activity was calculated to -25 during construction phase. This activity is considered to have a moderate negative impact on environmental receptors.

Mitigation Measures

- Open defecation whether it’s on land or on the beach shall be prohibited;
- Proper septic system shall be in place as the one of the very first activities of the construction works;
- Septic system shall be designed by a qualified sanitation engineer and the system shall be approved by EPA;
- Dual flush toilet shall be installed; and
- Water conservation devices shall be used.

9.3 OPERATIONAL PHASE IMPACTS

Leopold Matrix for the operational phase of the project is shown in Table 45. Figure 64 illustrates the impact magnitude of each activity and their relative importance. Figure 65 illustrates impact on the environmental receptors during the operational phase of the project. A summary of the major activities and their associated overall impact represented by colour codes are given in Table 46.
**Table 45: Impact matrix for the operational phase of the project**

<table>
<thead>
<tr>
<th>Envisaged impact factors</th>
<th>O1 Wastewater discharge (facility)</th>
<th>O2 Feeding sea cucumber</th>
<th>O3 Processing sea cucumber</th>
<th>O4 Sewage disposal</th>
<th>O5 Electricity generation/oil s saxage</th>
<th>O6 Use of pesticides</th>
<th>O7 Community aid</th>
<th>O8 General waste generation</th>
<th>O9 Habitat alteration</th>
<th>O10 Sea cucumber stocking</th>
<th>Total (Impact Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seawater</td>
<td>-8</td>
<td>-8</td>
<td>-4</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-2</td>
<td>-8</td>
<td>-5</td>
<td>-5</td>
<td>-41</td>
</tr>
<tr>
<td>Ground water</td>
<td>-6</td>
<td>-2</td>
<td>-5</td>
<td>-5</td>
<td>-2</td>
<td>-6</td>
<td>-3</td>
<td>-5</td>
<td>-3</td>
<td>-5</td>
<td>33</td>
</tr>
<tr>
<td>Air</td>
<td>-2</td>
<td>-2</td>
<td>-6</td>
<td>-7</td>
<td>-2</td>
<td>-4</td>
<td>-2</td>
<td>-3</td>
<td>-8</td>
<td>-2</td>
<td>18</td>
</tr>
<tr>
<td>Noise</td>
<td>-3</td>
<td>-2</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td>Coastal Zone</td>
<td>-4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Flora</td>
<td>-4</td>
<td>-3</td>
<td>-2</td>
<td>-2</td>
<td>-5</td>
<td>-15</td>
<td>5</td>
<td>-14</td>
<td>12</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Endangered species/protected areas</td>
<td>-9</td>
<td>-7</td>
<td>-6</td>
<td>-5</td>
<td>-4</td>
<td>-5</td>
<td>5</td>
<td>-4</td>
<td>-51</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Coral Reef</td>
<td>-5</td>
<td>-6</td>
<td>-5</td>
<td>-1</td>
<td>-8</td>
<td>-5</td>
<td>5</td>
<td>-5</td>
<td>-14</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Fauna</td>
<td>-5</td>
<td>-6</td>
<td>-5</td>
<td>-1</td>
<td>-8</td>
<td>-5</td>
<td>5</td>
<td>-5</td>
<td>-30</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>-5</td>
<td>-3</td>
<td>-2</td>
<td>-6</td>
<td>-3</td>
<td>-3</td>
<td>2</td>
<td>-3</td>
<td>-10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Accidents</td>
<td>-3</td>
<td>-5</td>
<td>-2</td>
<td>-6</td>
<td>-3</td>
<td>-15</td>
<td>9</td>
<td>-2</td>
<td>-7</td>
<td>19</td>
<td>14</td>
</tr>
<tr>
<td>Landscape</td>
<td>-3</td>
<td>-5</td>
<td>-2</td>
<td>-6</td>
<td>-3</td>
<td>-8</td>
<td>2</td>
<td>-7</td>
<td>10</td>
<td>42</td>
<td>8</td>
</tr>
<tr>
<td>Health/Well being</td>
<td>-6</td>
<td>-6</td>
<td>-5</td>
<td>-4</td>
<td>-3</td>
<td>-8</td>
<td>9</td>
<td>-6</td>
<td>8</td>
<td>58</td>
<td>58</td>
</tr>
<tr>
<td>Cultural heritage</td>
<td>-2</td>
<td>-4</td>
<td>-4</td>
<td>-6</td>
<td>-3</td>
<td>-15</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Local economy</td>
<td>-2</td>
<td>-4</td>
<td>-4</td>
<td>-6</td>
<td>9</td>
<td>4</td>
<td>3</td>
<td>-7</td>
<td>25</td>
<td>38</td>
<td>38</td>
</tr>
<tr>
<td><strong>Total (operational Phase Activity/Risk)</strong></td>
<td><strong>-41</strong></td>
<td><strong>-41</strong></td>
<td><strong>-26</strong></td>
<td><strong>-15</strong></td>
<td><strong>-18</strong></td>
<td><strong>-20</strong></td>
<td><strong>24</strong></td>
<td><strong>-16</strong></td>
<td><strong>-21</strong></td>
<td><strong>-27</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>
Figure 66: Impact magnitude and importance based on operational phase activities.
**Figure 67: Impact magnitude on environmental receptors during operational phase**

<table>
<thead>
<tr>
<th>Receptors</th>
<th>Seawater</th>
<th>Groundwater</th>
<th>Air</th>
<th>Noise</th>
<th>Coastal Zone</th>
<th>Flora</th>
<th>Protected areas</th>
<th>Coral Reef</th>
<th>Fauna</th>
<th>Aesthetics</th>
<th>Accidents</th>
<th>Landscape</th>
<th>Health/Well being</th>
<th>Cultural heritage</th>
<th>Local economy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-41</td>
<td>-34</td>
<td>-23</td>
<td>-8</td>
<td>3</td>
<td>-14</td>
<td>0</td>
<td>-31</td>
<td>-30</td>
<td>-10</td>
<td>-19</td>
<td>10</td>
<td>-29</td>
<td>0</td>
<td>25</td>
</tr>
</tbody>
</table>
Table 46: Summary of impact magnitude for operational phase activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>O1 Wastewater discharge</td>
<td></td>
</tr>
<tr>
<td>O2 Feeding sea cucumber</td>
<td></td>
</tr>
<tr>
<td>O3 Processing sea cucumber</td>
<td></td>
</tr>
<tr>
<td>O4 Sewage disposal</td>
<td></td>
</tr>
<tr>
<td>O5 Electricity generation/oil storage</td>
<td></td>
</tr>
<tr>
<td>O6 Use of pesticides</td>
<td></td>
</tr>
<tr>
<td>O7 Community aid</td>
<td></td>
</tr>
<tr>
<td>O8 General waste generation</td>
<td></td>
</tr>
<tr>
<td>O9 Permanent Land Use Change</td>
<td></td>
</tr>
<tr>
<td>O10 Impact of stocking in sea pens</td>
<td></td>
</tr>
</tbody>
</table>

9.3.1.1 Wastewater Discharge (O1)

The proposed project will discharge wastewater from the hatchery and wastewater from cooking and processing sea cucumber through a deep water outfall laid as per the aquaculture regulation. Since wastewater from the facility contains numerous chemicals that could affect coral reef ecosystem it is considered as an operational phase activity with significant impacts. In order to understand this, it is important to look into potential sources, types and fate chemicals that may be discharged from the facility.

**Endocrine-disrupting compounds**

The facility will use a lot of plastic including PVC pipes, plastic tubes and plastic mesh nets during its operation. Many of these products contain PCB’s (polychlorinated biphenyls). Even though these compounds are bonded they may get into the bio ecosystem, when plastics are scratched and as they wear out or through mechanical damage. Many of the plastics contain considerable quantities of PCB’s as plasticisers (such as biphenyl A, phthalates). These plasticiser materials may be lost into the surrounding seawater during. Plastics can become incorporated into marine algae and animals. Once ingested, these compounds can leach out in the organism and have endocrine disruption effects (Champeau & Boustead, 2013).

Inputs can be intentional or unintentional. Intentional inputs come from treatment for bacterial infection and infestations of parasites. Unintentional inputs include constituents of food, litter, fuel, leaching and oil.

The hydrology of sites will greatly affect the concentration and impacts of chemicals. For example, high flow sites have higher dilution rates than low flow sites. In seawater, the bond of chemicals to solids and organic matter is less important than in freshwater due to the high concentration of competing ions.
**Therapeutants**

Antibiotics and therapeutants can affect aquatic organisms in a number of ways. For example, aquatic ecosystems are largely controlled by, and are dependent on, microbial organisms for crucial processes (e.g., denitrification), associations (e.g., nitrogen fixation) and services (e.g., organic breakdown). Accumulation of antibiotics in sediments may interfere with bacterial communities and affect the rate and mechanism for mineralisation of organic wastes. (Champeau & Boustead, 2013). Plankton community composition can be affected by antibiotics, with toxicity varying widely depending on application rates and natural factors.

Although sea cucumber is not effected by many diseases it is susceptible parasites which causes skin ulceration. Skin ulceration is a fatal disease mostly effecting juveniles, and can have a huge impact on sea cucumber stocks. (Lavitra, et al., 2009).

**Detergents and disinfectants**

Detergents (or surfactants) are complex mixtures containing a variety of ingredients, particularly surface-active agents (surfactants), builders, bleaches and additives, blended for specific performance characteristics. All of the compounds used are water soluble. Detergents can damage proteins, nucleotides, and fatty acids, leading to the death of cells, but not whole organisms.

Detergents will be used in hatcheries for cleaning and to treat diseases. Concentration and effects of detergents depends on how much is used and where it is discharged.

**Toxins**

Sea-cucumbers are immobile bottom dwellers. They produce chemicals which act as their natural defence against predators. Studies have shown that these saponin chemicals are found both in the body wall as well as in the viscera. These chemicals are water soluble suggesting that they will be present in the cooked wastewater which will be discharged. If 12 tons of sea cucumber are processed annually, approximately 3.4 kg of saponin will be produced and discharged into the environment.

Since the potential for environmental pollution is high for wastewater discharge it is considered as an activity which has major impact. However, the extent of its impact is based on the hydrology of the environment to which the wastewater is discharged.

Wastewater from hatchery will be discharged into deep sea through an outfall. This area is highly dynamic with high water circulation unlike the lagoon area which was stagnant. If discharged into the lagoon which is relatively calm this would not only pollute the seawater, it would also directly kill many organisms in the lagoon. Since the lagoon will be used to source seawater for the hatchery, accumulation of these chemicals it would potentially increase treatment costs. Without deep sea discharge there is the risk of project becoming unproductive and unviable during the long run as a result of water contamination. Hence, the most effective mitigation measures to reduce
impacts of wastewater is through deep sea discharge after proper dilution and treatment, which is also the preferred option based on the alternative analysis. To reduce the impacts of wastewater, following mitigation measures have been proposed. The overall impact of the activity was calculated to -41 during operational phase. This activity is considered to have a major negative impact on environmental receptors.

**Mitigation Measures**

a) Wastewater (sea cucumber cooking water as well as wastewater from the hatchery) shall be discharged as explained in Section 2.8.10;  
b) All discharged water shall be treated and effluent quality shall be maintained as prescribed in Section 2.8.9 and Table 8;  
c) Antibiotics shall not be used at the facility;  
d) Chemicals, feed used in the facility shall be those that are approved by the authorities and approved chemicals and feed shall be only be used in required amounts;  
e) Use plastic products that are biodegradable and those that contain less plasticisers;  
f) Ensure that water coming into the hatchery is sterilised;  
g) Minimise use of antifouling agents;  
h) Maintain good animal husbandry throughout the process; and  
i) Use diffusers at the end of outfall pipe to effectively diffuse waste water discharged.

### 9.3.1.2 Feeding Sea Cucumber (O2)

Feed will be required for their growth of juveniles until they are transferred to grow out pens in the lagoon. With low density culture of larvae (around 0.3 larvae/ml) as will be practiced in this project feed input can be maintained very low. However in order to produce feed some level of fertilisation will be required. In addition to control larval predators such as copepods chemical treatment will be required. Also to keep the tanks clean and free from algal growth cleaning with chlorine may be required. Therefore the wastewater coming from hatchery will consist of fertilisers, chemicals, dead organisms, excess feed and larvae waste products. Even though the concentration of the most chemicals can be expected to be very low and immediate negative impacts are not envisaged, in the long run these pose cumulative impacts especially if discharged into near shore. Accumulation of nutrients in the lagoon could trigger algal growth, deplete oxygen, affect aesthetic qualities of the lagoon and ultimately affect the growth and survival of sea cucumbers in the sea pens. The overall impact of the activity was calculated to -41 during operational phase. This activity is considered to have a major negative impact on environmental receptors.

**Mitigation Measures**

a) Monitor nitrogen, phosphorous and potassium levels continually and compare with baseline levels. Modify feeding regimen according to analysis;  
b) Use common feed that is approved by MRC;
c) Do not increase density of sea cucumbers in pens above the stocking density recommended in Section 2.8.12 as this might stress the individuals and inhibit feeding;
d) Avoid supplementary feeding in grow out cages;
e) Regularly monitor water quality at grow out cages; and
f) Regular monitoring of sea cucumber for any disease outbreak.

9.3.1.3 Processing of Sea Cucumbers (O3)

Steps involved in processing sea cucumber are explained in Section 2.8.15 of the report. Multiple steps involved in the processing of sea cucumbers would require resources as well as generation of various types of wastes. Wastes generated could pollute the environment and create conditions that are not favourable for culture of sea cucumbers. Furthermore, improper sea cucumber waste handling could invite pests and diseases to the site, create odour and can the environment could become unsightly. The process will require significant amounts of amounts of gasoline for the cooking and fuel wood for smoking. Experience from small island countries have shown that demand for fuel wood causing extensive damage to forests and mangroves with resulting habitat degradation. Burning of cooking gas would also emit GHG into the atmosphere. The overall impact of the activity was calculated to -26 during operational phase. This activity is considered to have a moderate negative impact on environmental receptors.

Mitigation Measures

a) Develop a proper waste management plan and protocols for the facility before the processing begins;
b) Educate workers on the such protocols and ensure it is fully adhered to;
c) Adapt sun drying as much as possible to minimise use of other forms of energy;
d) Innovate processing technologies and explore new markets where apparently worthless by-products could be converted into valuable products. As such sea cucumber gut is consumed as a delicacy in some countries;
e) Conserve resource use such as avoiding over salting, over cooking and over drying;
f) Products that can be produced with least resource use shall be explored such canning boiled sea cucumbers and where feasible should be applied;
g) Intergrade renewable energy as much as possible in the processing;
h) Logging should not be carried out for obtaining fuel wood;
i) Use protective gear when cooking sea cucumber and conduct training sessions to brief employees with regard to best practice of handling and cooking and sea cucumbers;
j) Clearly label or distinguish wastewater. Waste water shall be discarded through designated gutter system which connects to the hatchery outfall;
k) Collect gutting’s in suitable bins and shall be kept covered until buried in the designated area;
l) Large pit not reaching the groundwater lens could be dug to bury the gutting waste, and shall be covered with a layer of soil that is sufficient to cover the waste layer and prevent flies and other pests getting attracted to it; and
m) Mitigation measures prescribed for boiled water in Section 9.3.1.3 shall be implemented.

9.3.1.4 Sewage Disposal (O4)

Poor sewerage management has the potential to create a negative perception of the facility created to produce premium quality bêche – de – mer for human consumption. Poor sewerage management can pollute surrounding environment and can also be cause of serious health hazards for the workers. Domestic sewage contains a wide variety of dissolved and suspended impurities. It amounts to a very small fraction of the sewage by weight, but it is large by volume and contains contaminants such as organic materials and plant nutrients that tend to rot. Most detergents and washing powders that are used for cleaning contain phosphates which are used to soften the water, among other things. These and other chemicals contained in washing powders affect the health of all forms of life in the water. There is also the possibility of groundwater contamination through possible leakage from pipes, joints, fittings and improper design. Open defecation could be a cause for disease and attracts pests to the site. Given the small number of permanent staff expected to reside at the facility the volume of sewerage generated at the facility is expected to be small. The overall impact of the activity was calculated to -15 during operational phase. This activity is considered to have a minor negative impact on environmental receptors.

Mitigation Measures

a) The septic system shall be properly designed by a qualified engineer and approved by EPA;
b) Regular maintenance of the septic system shall be ensured; and
c) Monitor groundwater quality routinely.

9.3.1.5 Electricity Generation/Oil Storage (O5)

At the start two diesel generators will provide the required electricity for the facility and in order to meet the fuel need oil will be stored at the facility. Once arrangements have been made, electricity will be sourced for the islands grid which is managed by FENAKA. The two generators will then be kept as a backup.

The proposed fuel reception at the resort involves buying fuel in barrels from a local supplier and transporting the barrels in a pickup to the site where it will be stored safely. Considering the facilities need, volume of fuel required for a month will be kept. Spillage during to the transport to the facility is expected to be negligible Fuel storage will be kept separate from the powerhouse.

Fuel spillage during storage and transfer could pose a serious risk as it could contaminate soil and groundwater. The likelihood of a major fuel spill is small legible since volume required will be relatively small.

The primary pollutants that are expected to be generated due to power production from diesel based generator system including Nitrogen oxides (NOX), Sulphur dioxide (SO2), Carbon
monoxide (CO), Hydrocarbons/ Polycyclic Aromatic Hydrocarbons (HC/PAH), Particles (PA) and Carbon dioxide (CO2). The visible pollution generated by burning diesel contains elemental carbon. The typical odour comes from polycyclic aromatic hydrocarbons, which also are cancer causing components. Table 47 shows NOx and particles emission of burning a cubic meter of diesel by a generator.

Table 47: Emission from a typical diesel generator

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Diesel generator mg/m3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>4000</td>
</tr>
<tr>
<td>Particles</td>
<td>100</td>
</tr>
</tbody>
</table>

The emission of nitrogen oxides is a serious problem and is often overseen. Nitrogen oxides are as seen in Table 47 responsible for a number of negative impacts on the environment.

Nitrogen oxides contain different oxides of nitrogen, the most important being nitrogen monoxide (NO) and nitrogen dioxide (NO2). Nitrogen dioxide is a respiratory irritant and is responsible for a number of respiratory diseases. People with sensitive respiratory systems are especially affected. The multi criteria impact magnitude for the activity was -18 which meant the activity will have a minor to moderate negative impact on the environmental receptors. The following mitigation measures are aimed at further reducing the expected impacts.

Mitigation Measures

a) The powerhouse design including the stack height shall meet the requirements of the MEA as such If the height of the powerhouse is 14 feet, the stack height will be 24 feet and if the height of the powerhouse is more than 14 feet, stack height will be 4 feet above the roof;
b) Generator house shall be located away from the hatchery, processing area and accommodation units;
c) The generator house will be soundproofed Sound level at 1 meter from the generator shall not be higher than 70 dB (A));
d) Cooling air released from the generator will not be faster than 5 meter per second;
e) Service and maintenance are very important as to have a generator to run efficiently and with least possible environmental impact when needed. Poorly maintained generators use up to 20% too much fuel, and may fail completely, leading to early replacement and additional cost. In areas with poor fuel quality, poor maintenance may reduce operating life by 80%.
f) Fuel storage area will be constructed in such a way it will not be in contact with the ground and any spillage will be contained. The storage tanks will be kept protected from rain. The bund wall around the fuel storage tanks will ensure fuel storage handling and safety regulations are enforced;
g) Waste oil and waste contaminated materials including soil, cleaning clothes, broken parts, shall be placed in containers, treated as hazardous waste and sealed for disposal at Thilafushi;
h) Energy efficiency measures, such as led lights, renewable energy sources and green labelled equipment shall be used;
   i) Explore feasibility of installing solar PV system on the rooftop of the buildings; and
   j) Firefighting equipments shall be installed to meet the requirement of the Ministry of Defense and National Security.

9.3.1.6 Pest Control (O6)

Mosquitoes, rats, crows, houseflies and cats are believed to be the pests that may become potential nuisances. In particular mosquito nuisance have been observed during the field visit as a major problem. Hence use of pesticides to control certain pests can become necessary especially given that unmanaged thick vegetation surrounds the project area. When pesticides are used in appropriately, people may be exposed through direct contact with sprays, by touching plants or other objects in the treated area, or by inhaling small amounts of pesticide remaining in the air. Assessment of human health and environmental risks of the pesticides most commonly used in show they last only short periods in the environment, so long-term exposure to humans is not expected. Based on its assessment, using toxicity data and exposure estimates, risks of concern to humans are not expected when these chemicals are used in outdoor residential systems according to labelling specific for use in these systems. However, excessive use or accidents may pose risks.

Chemicals such as pyrethrins and permethrin are toxic to all insects, they may kill beneficial insects such as butterflies, bees and other non-target species. In addition, permethrin is very highly toxic to fish. No pesticide should be regarded as 100% risk free hence appropriate mitigation measures will have to be put in place.

Other pests that can be of concern to the project include crabs and isopods. In the hatchery, copepods and ciliates are the most active predators. In the natural environment different species of fishes and crabs can prey on juvenile sea cucumbers (Lavitra, et al., 2009).

Based on these impacts/risks the multi criteria impact magnitude was -20 which meant the activity will have a moderate negative impact on the environmental receptors.

Mitigation Measures

a) The site and surrounding shall be kept clean and tidy at all times, littering and open disposal of food waste shall be prohibited;
b) Residues resulting from cleaning sea cucumbers shall be carefully removed and managed in the waste stream;
c) Minimal risk pesticides that is approved by a concerned authority shall be used and even when such chemicals are used manufacturer’s instructions shall be carefully followed;
d) Empty containers of pesticides shall not be discarded into the environment rather they should be treated as hazardous waste and removed from the island for transfer to Thilafushi;
e) Pesticides and other chemicals used in the facility shall be carefully stored in a separate area with labels and only authorosied personnel shall have access to such chemicals;
f) PPE shall be used by the operators of fogging machines and proper training shall be given to them before allowing them to operate it;

g) No antibiotics shall be used to kill or control pests, in the case of controlling copepods in the hatchery only approved chemicals with right concentration shall be used;

h) Ensure that seawater/equipment used in the hatchery is sterilised and cleaned;

i) Make sure handlers wear gloves to prevent transmission of pathogens;

j) Ensure that cages are monitored daily for predators; and

k) Sea pens shall be regularly checked for repair.

9.3.1.7 Community Benefits (O7)

No significant socio-economic impact of the project on the community emerged as a significant issue during the EIA study. Consultations with the community and island authorities have not identified any special use of the area by the community such as for fishing or picnicking. The site allocation would not deprive the community of any service or way of life. It does not involve relocating people or compensation issues. However, during the consultation process, EPA has indicated that lagoon area has been approved as a potential sand mining for the local construction activities. Field observation did not identify any such use of the area and in addition, the much of the sediment composition in the lagoon area that is free from sea grass revealed that it was mainly clayey and therefore may not be suitable for construction purposes. Nevertheless, once the development phase begins the site cannot be used for any such purposes. Loss of sand mining option from the site could become an issue only if a better alternative is not available. Field visit also confirmed large scale sand mining within the lagoon on the northern end of the island bordering the island’s coastline (see Figure 68). Mining sand from island beach is prohibited in the Maldives although sand can be obtained from approved locations within the lagoon. Lagoon area shown in Figure 68 could be an alternative site once it’s approved by the council in consultation with EPA. Discussion of this matter with Island Council revealed that although the lagoon space given for sea cucumber farming had been marked as potential site for sand mining people have not used the site as such and the council would soon identify additional sites for the mining sand for locals. Hence the issue not regarded as significant negative impact.
Since the grow out area will be set up in the open lagoon poaching and illegal activities may take place. Recognising the likely negative social impacts of the project, from the beginning the island community and local authorities have been involved and their views have been sought during the planning process. In addition, the project have been planned to have numerous benefits to the community. It involves a community farming component which will be in effect once the hatchery is operational and facility has been functioning for at least one year. The facility will not only provide new job opportunities; it will also teach locals of L. Gan valuable knowledge with regard to sea cucumber culture. As the facility develops, it will provide the locals with juveniles for value addition following which they could seek new markets. The overall impact of the activity was calculated to 24 during operational phase. This activity is considered to have a moderate positive impact on environmental receptors notably the economy and health/wellbeing of local community.

Enhancement Measures

a) Ensure that an alternative sand mining site is identified and approved by the island council before the project activities begin;

b) Proper surveillance of the grow out area and other facilities to prevent people from getting involved in thefts and vandalism;
c) Provide updates on the community component progress to the members of the public and the island council;
d) Recruit locals as far as possible during the operational stage of the facility;
e) Provide open days for locals who are interested in the field;
f) Assist and facilitate the community farming component of the project and have arrangements to create a market for their products;
g) Share knowledge by arranging seminars and workshop for the local community on sea cucumber farming.

9.3.1.8 Solid Waste Generation (O8)

Waste generated during the operation of the facility includes food waste, packaged waste, cardboard, paper, glass, empty containers, office waste including used cartridges, industrial waste such as PVC pipes, metals and hazardous waste such as chemicals, antifouling agents, waste oil and detergents. The increase in waste will put a burden on the islands inefficient waste management system. The overall impact of the activity was calculated to -16 during operational phase. This activity is considered to have a minor negative impact on environmental receptors.

Mitigation Measures

a) Waste management strategies given in Section 2.11 shall be implemented;

9.3.1.9 Habitat Alteration (O9)

For the proposed sea cucumber farming 500,000 ft$^2$ of lagoon environment and 30,000 ft$^2$ from land will be used. Once the farm begins its operations with the full set up in place a total of 530,000 ft$^2$ of area would undergo habitat changes. However, at the island level even considering the worst case scenario modification of the total area provided for the project seems relatively insignificant given that land allocated for the project is merely 0.005% of the land area of Gan while lagoon space provided for the project comes to 0.1% of the house reef area of Gan. Nevertheless, at the project level removal of trees for building purposes will result in loss of habitat for roosting birds, bats and other fauna in the environment. Installation of sea pens in the area will cause some level of visual impacts and alter the existing habitat to some extent especially in the long run. Physical habitat alteration for setting up of sea pens and semi enclosures, removal of trees for buildings and facilities is unavoidable for the project to proceed. Although this being the case, the existing environment cannot be considered pristine due to the level of waste dumping and pollution that taken place. The extensive changes that had taken place both on the terrestrial environment such closing up of the channel that existed between Maandhoo and Gan, clearing of vegetation for coconut plantations and changes to the seagrass extent in the area over the years lends evidence to significant alterations that had taken place.

While the aquaculture activities result in habitat alteration, sea cucumber’s ecological role in the environment can be considered a positive aspect of the project. Sea cucumbers are deposit feeders in the tropical coastal ecosystems, where they improve the sediment habitat and facilitate benthic
nutrient cycling through feeding and digestion of organic material (Uthicke 2001). In addition, their burrowing activity is known is oxygenate and improve the benthic ecosystem. These positive effects however, may be lost due to high, stocking densities and intense feeding, negatively affecting the benthic ecosystem (Eriksson et al, 2011) since sea cucumbers feed on large quantities of sediments and convert organic detritus into animal tissue and nitrogenous wastes, large scale sea cucumber farming could have an impact the physical and chemical composition of benthic sediment composition and benthic community structure. Sediment studies conducted by (Plotieau, et al., 2013) on a H. scabra farm that had been operational for two years showed that:

- The proportion of the finest grain size class (< 250 μm) decreased from 5 to 14%;
- Carbonate abundance decreased by 5%;
- Total organic matter did not vary significantly inside or outside sea pens;
- The number of bacteria decreased by up to 50%, and
- The concentration of photosynthetic microorganisms fell by up to 22% within sea pens.

The study implies that intensive sea cucumber farming can modify sediment composition and particle size in which fine sediment particles and its carbonate proportion gets reduced (Plotieau, et al., 2013). The study further confirms that photosynthetic microorganisms decreased significantly in sea cucumber pens after 2 years of farming (Plotieau, et al., 2013).

Risk from predators such as crabs have been noted as a challenge for sea cucumber aquaculture using pens (Lavitra et al. 2009) prompting the use of a range of predator control techniques including exterminating crabs before stocking and deploying baited traps around pens (Pascal & Robinson, 2011). Such activities, particularly as farming area increases, may potentially impact the benthic faunal structure in and around the grow out area.

In the case of the proposed project activities such as sediment ploughing is not considered as the existing conditions seem to be suitable for grow out of sea cucumbers. This would minimise the impact on the benthic environment. Further, targeted production level is seen to be another measure to minimise the impacts of habitat alteration. Furthermore, due to the degraded nature of the environment, the project itself will bring positive changes in that it would remove the accumulated waste both in the coastal areas and on the land. Coconut palms uprooted will be relocated or new trees will be replanted. These efforts are aimed at habitat restoration. As sea cucumbers are sensitive to changes to environmental quality maintaining a healthy environment is absolutely required to make the investment successful.

Habitat alteration and degradation can arise indirectly as a result of deforestation for having to obtain fuel wood for boiling and smoking sea cucumbers. It is estimated that 10 tonnes of firewood is needed to produce 1 tonne of bêche-de-mer (Preston, 1993). Intensifying sandfish farming may increase the use of firewood and lead to deforestation and associated erosion, particularly in atoll systems, where firewood is scarce (Eriksson, et al., 2012). Since it is not planned to obtain fuel wood from the island forest for cooking and smoking of sea cucumbers deforestation related impacts are not envisaged under the current project. The overall impact of the activity was
calculated to -21 during operational phase. This activity is considered to have a moderate negative impact on environmental receptors.

**Mitigation Measures**

- Planting of two trees for every mature tree removed;
- Keeping to bare minimum of the number of trees removed;
- Cutting of trees for obtaining fuel wood shall not be allowed, the requirement for fuel wood shall either be met using dried coconut husks, driftwood or trees removed legally for various reasons. Fuel wood could also be imported provided that it comes from a responsible logging project.
- Stocking density shall be maintained as prescribed in the Section 2.8.12 to prevent overcrowding;
- Use of feed materials should be avoided in grow out areas; and
- Avoid continuous use of sea pens rather they should be left to recover after a period of time for the microorganisms to regenerate and sediment composition to get back to normal. This could be achieved by constructing sea pens in half the area and using it for few years to grow out leaving the other half unseeded during the period. The fallowing system would ensure the nutrients needed for sea cucumbers are not exhausted as is the case in intensive farming system.

**9.3.1.10 Impact of Stocking in Sea Pens (O10)**

Stocking sea cucumbers in pens can contact diseases at various levels in their life – history (Eriksson, et al., 2011) in addition to affecting their growth. Research has also shown that the prevalence of pathogens and diseases in hatchery facilities with sandfish is known to frequently occur and is of particular concern as grow out farming takes place in high densities within the natural environment (Eeckhaunt, et al., 2004.). Diseases and parasites can also be introduced into the environment via imported organisms. Spread of diseases among the population of sea cucumbers can have a detrimental effect on the investment and if spreads in the environment it may even become difficult to control. The issue of outbreak of a disease is further exacerbated by the fact that certain treatments that are used to control the disease can also become an environmental and human health issue. Even though once it happens the impact can be considered negatively significant, it can be almost completely avoided by good animal husbandry and with required facilities established and keeping the facility fully prepared for such an incident. Considering the methodology to be adapted in the project and semi – intensive farming planned to be implemented the impact significance is considered to be low. The overall impact of the activity was calculated to -27 during operational phase. This activity is considered to have a moderate negative impact on environmental receptors.
Mitigation Measures

- Broodstock shall not be imported from abroad whereas local broodstock shall be considered for the farm;
- Proper quarantine facility shall be established and juveniles obtained shall be quarantined and checked for signs of diseases before releasing it to the sea pens;
- Protocols for disease control and management shall be developed before the work begins;
- Procedures to isolate potentially contaminated animals or equipment, minimizing exposure to disease vectors shall be in place before the work starts at the site;
- Systematic inspection of animals and equipment to detect early signs of pathogens or disease
- Stocking density shall be tightly controlled to avoid over stocking;
- In the event of an outbreak of a disease only approved drugs by WHO and national authorities shall be used and no antibiotics shall be used; and
- Records of all diseases and treatments shall be kept properly at the facility.
10. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

10.1 AIMS AND OBJECTIVES

In order to demonstrate the effectiveness of the proposed mitigation measures and to ensure unforeseen impacts arising out of project activities are controlled in a timely manner a robust environmental monitoring program is essential. Additionally, the monitoring program is also important to bring desired changes to the proposed mitigation measures as and when necessary and to enhance benefits of the Project. This chapter presents in detail the management and monitoring program put in place under the proposed project to evaluate the actual impacts and the effectiveness of the proposed mitigation measures and to ensure that the project is implemented responsibly ensuring that the project activities do not result in unacceptable changes to the environment. This Plan focusses on land based hatchery, marine based grow outs area and marine outfall location:

- a) Monitor and manage impacts of the project on the terrestrial and marine environment;
- b) Enhance positive impacts;
- c) Collect information that can be used for improving project performance and environment;
- d) Collect information that can be used for evaluating the effectiveness of implemented mitigation measures so it can provide information for better decision making and future improvement of environmental quality for similar projects;
- e) Ensure that the impacts are eliminated in a timely manner; and
- f) Provide evidence of compliance assurance to laws and regulations and requirements of enforcement agencies.

The detailed impact monitoring plan for the proposed for the project is given in Table 48. Indicative cost of the monitoring and environmental management is also given in the same Table. Proponent will ensure that the monitoring program is carried out in a timely manner. A commitment letter confirming compliance on mitigation measures and monitoring is given in Annex 3.

During the construction and operational phase, the project features and activities proposed to be monitored include:

- Changes to the terrestrial environment;
- Quality of the wastewater effluent;
- Health of the lagoon environment;
- Quality of the groundwater; and
- Status of health of corals on near shore house-reefs.

In addition, the project will also record all significant matters such as:

- Outbreak of diseases and invasive organisms;
- Use of chemicals and treatments;
- Use of feed and feed production information;
- Accidents, injuries and occupational illness; and
- Incidents and emergencies such as spills and other potentially dangerous incidents.
### Table 48: Environmental Monitoring and Management Plan

<table>
<thead>
<tr>
<th>Objective</th>
<th>Activity</th>
<th>Parameters to be monitored</th>
<th>Location</th>
<th>Method</th>
<th>Frequency</th>
<th>Responsible Agency</th>
<th>Verifiable indicator</th>
<th>Cost (MVR)</th>
<th>Phase¹²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimize vegetation removal</td>
<td>Tree survey &amp; set out survey</td>
<td>Vegetation falling within the footprint of buildings</td>
<td>At project site (land)</td>
<td>Close observation and Monitor if vegetation is removed from approved sites and specified type of vegetation</td>
<td>Once</td>
<td>Consultant, and the Proponent</td>
<td>Survey report</td>
<td>40,000</td>
<td>C</td>
</tr>
<tr>
<td>Ensuring that the project activities do not affect the quality of the groundwater</td>
<td>Establish baseline just before the construction begins and continue monitoring as stated. Establish two groundwater monitoring stations and geo-</td>
<td>Groundwater quality for electrical, conductivity, salinity, temperature, DO, BODs, COD, Nitrates, phosphates, Turbidity, pH, hydrocarbon, total coliform and faecal coliform</td>
<td>Project site (minimum 2 locations)</td>
<td>water quality testing potable equipment and or at the lab</td>
<td>Baseline data before the work begins and every three months thereafter</td>
<td>Proponent and environmental consultant</td>
<td>Lab report</td>
<td>15000/ monitoring</td>
<td>C &amp; O</td>
</tr>
</tbody>
</table>

¹² C = construction phase, O = Operational phase
| Waste generation at work site is audited and managed responsibly | Collect all construction related waste and manage it prescribed in this report. A proper waste audit conducted within the first year of operation to develop a waste management plan for the project | Waste generated estimated in a comprehensible way and records maintained. Records of waste sent to Thilafushi and managed on site maintained | Work site | Keep records in a log book, or data sheet | As required | Contractor and Proponent | Record sheets, photographs | Included in the project costs | C&O |
|---|---|---|---|---|---|---|---|---|---|---|
| House reef is not severely impacted as a result of outfall construction | Survey carefully the siting of the outfall and mark the most appropriate location for anchoring the outfall | In deciding the location, the lowest live coral cover shall be taken as the most important factor. Two potential sites shall be identified and location shall be decided after a LIT survey and | On the eastern house – reef of L. Gan facing the project site | Water quality testing potable equipments and or at the lab. | Baseline to be established before the work begins and soon after the construction works is complete and every 6 | Environment consultant and proponent | Field data, monitoring report | 15,000/survey | C&O |
photographs. LIT survey shall be used as the baseline for future monitoring. Fish count will have carried out in both locations as well. In addition the following parameters will have to be measured; Electrical conductivity, salinity, temperature, DO, BODs, COD, Nitrates, phosphates, Turbidity, pH, hydrocarbon, total coliform and faecal coliform

<p>| Lagoon environment is no polluted because of the project | Monitor the Water quality of the lagoon. Establish baseline before the project activities begin | Electrical conductivity, salinity, temperature, DO, BODs, COD, Nitrates, phosphates, Turbidity, pH, hydrocarbon, total coliform and faecal coliform, | In the lagoon area where sea pens are planned to be installed | Water quality testing potable equipments and or at the lab | Baseline to be established just before grow out activities begin and every 3 months thereafter | Environmental consultant and proponent | Field data, monitoring report | 15 – 20,000/survey | O |</p>
<table>
<thead>
<tr>
<th>Monitoring the long term variability in climatic conditions</th>
<th>Measuring physical characteristics of the lagoon</th>
<th>Daily weather information and tide</th>
<th>In the terrestrial environment and in the lagoon</th>
<th>Automatic weather station that can measure, wind, temperature, humidity etc over a long period of time. Install a rain gauge at the site. Installation of a tide gauge at the lagoon</th>
<th>Continuous monitoring of the weather and tide information</th>
<th>Environmental consultant and proponent</th>
<th>Field data, monitoring report</th>
<th>Approx. MVR 50,000</th>
<th>As soon as the construction work is complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managing pests and diseases from the project site</td>
<td>Monitoring of diseases and pathogens</td>
<td>As and when disease or pest issues are noticed</td>
<td>All project area</td>
<td>Visual inspections and laboratory investigations as may be needed</td>
<td>Continuous monitoring</td>
<td>Project staff</td>
<td>Record sheets</td>
<td>As part of staff mandates</td>
<td>O</td>
</tr>
<tr>
<td>Benefits to local economy is enhanced</td>
<td>Monitoring of beneficiaries of the project</td>
<td>No of locals obtaining juveniles and material from the site, their productivity income etc</td>
<td>L. Gan community</td>
<td>Data collection sheet</td>
<td>As the project progresses to the second phase</td>
<td>Proponent</td>
<td>Annual report</td>
<td>N/A</td>
<td>O</td>
</tr>
</tbody>
</table>
10.2 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 EIA 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 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.

10.3 MONITORING SCHEDULE

Monitoring frequency for various components given Table 48 shall be followed by all Parties. However initially during the early stages of the project monthly site visits is expected. Table 49 gives indicative timeline for the monitoring visits.

Table 49: Monitoring visit schedule

<table>
<thead>
<tr>
<th>Visit</th>
<th>Indicative timeline</th>
<th>Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit 1</td>
<td>During site preparation</td>
<td>Submit summary report 1 Proponent within 2 weeks</td>
</tr>
<tr>
<td>Visit 2</td>
<td>One month after work begins</td>
<td>Submit summary report 2 Proponent within 2 weeks</td>
</tr>
<tr>
<td>Visit 3</td>
<td>Halfway into the project construction</td>
<td>Submit summary report 3 Proponent within 2 weeks</td>
</tr>
<tr>
<td>Visit 4</td>
<td>Project is near completion</td>
<td>Submit summary report 4 Proponent within 2 weeks</td>
</tr>
<tr>
<td>Visit 5</td>
<td>Three month after completing the project</td>
<td>Submit first post-project monitoring report to Proponent</td>
</tr>
<tr>
<td>Follow up monitoring to continue</td>
<td>As stated in the monitoring section (see Table 48)</td>
<td>Submit report to Proponent within 2 weeks after each trip.</td>
</tr>
</tbody>
</table>

As indicated, during the course of the Project implementation summary reports following each trips is expected to be submitted by the Project’s environmental consultant. The first detailed monitoring report will be prepared after a month of completing the Project which will describe in detail the results of the environmental measures provided in the Project and will comment on their appropriateness, costs, adequacy, and administration as well as any problems that arose or changes that were made during the implementation of the project and the start-up of new operations. This audit 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 projects with similar impacts. The
consultant will prepare and submit the reports to Proponent and Proponent in turn will submit it to EPA.

The rest of the monitoring will continue on bi-annual basis for a period of 5 years. Long-term monitoring has been proposed due to the complex nature of coastal process that govern sediment dynamics at grow out and the impacts to marine environment at effluent disposal zone.

10.4 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.
10.4.1 Monitoring Report Format

The environmental monitoring report outlined in Table 50 below will be used in reporting environmental monitoring to be carried out as given in the monitoring plan.

Table 50: Monitoring report format

<table>
<thead>
<tr>
<th>Project Title:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the Island:</td>
</tr>
<tr>
<td>Monitoring Date:</td>
</tr>
<tr>
<td>Period Covered:</td>
</tr>
<tr>
<td>Prepared by:</td>
</tr>
<tr>
<td>Contributions:</td>
</tr>
</tbody>
</table>

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. Marine water quality
      Parameters given in the monitoring plan need to be assessed
   c. Marine reef assessment at outfall locations
      Reef areas assessed in the baseline surveys need to be assessed for coral cover and its health

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
   If specific recommendation is noted during the monitoring phase, specify it in the report

G. Conclusions

Reference

Appendix
11. CONCLUSIONS AND RECOMMENDATIONS

This EIA study was carried out by a multi-disciplinary team of experts, who considered the requirements set forth in the TOR for the study. The team took into account of available literature, views of the stakeholders, primary information collected from the project site and local experiences gained in sea cucumber farming in the Maldives in deciding the proposed and most preferred alternative to address the Project.

Information and data for the EIA was collected by making field visit made to the Project island and Project site on 23 September 2016 on during which baseline data was collected and stakeholder discussions of the project conducted. In addition, all available relevant literature and comparable studies were reviewed throughout the study.

In order to evaluate the proposed project with the most appropriate alternative detailed analysis has been carried out. All environmental and socio-cultural (positive and negative) impacts expected from the project have been identified for both terrestrial and marine environments. Cost effective, robust measures have been identified to address against adverse impacts and to enhance the positive impacts. Analysis of the environmental characteristics of the selected site proved to be suitable for undertaking aquaculture of sea cucumbers. The EIA revealed that the project will not result in loss of critical habitat or species or degradation of a habitat that has high ecological value nor does it involves forced re-settlement of inhabitants, loss of historical or cultural heritage and intervention into regular way of life of the people and that the predicted impacts are expected to be mitigated and residual impacts could be kept within generally acceptable levels. It has also been determined that the Project is being undertaken in state-owned land with no encroachment into private land involved.

Available information experience from projects of similar nature confirms that sea cucumber farming can be carried out in the Maldives at a commercial level. Due to the suitability of the site selected for the project and from available information it is considered that the proposed project is economically feasible. Furthermore, analysis of the likely environmental impacts it became rather clear that all foreseeable impacts can be mitigated through appropriate actions and commitment of the proponent and therefore the project can also be considered environmental viable.

Based on the findings, the EIA concludes that the project should be allowed to proceed with the proposed mitigation and enhancement measures during the construction and operational phases of the project as the benefits of the Project far outweighs its imposition on the environment or the people.

The project does conform to the development policies, priorities and aspirations of people of L Gan. Additionally, the EIA team also found that the project can be completed in full compliance with the relevant laws and regulations of the Maldives.

The following recommendations have been formulated in order to further enhance sustainability of the project:
• It is strongly recommended that the proposed mitigation measures in the report along with the monitoring plan be implemented to the fullest by the project proponent. Proper monitoring and mitigation of impacts is critical to ensure the project benefits are reaped while minimising the negative effects on the environment. In this regard, adequate budget and resources shall be allocated from the project funds for environmental monitoring and auditing. An independent third party shall be appointed for the monitoring works.

• Experience from similar projects indicate the success of aquaculture projects carried in semi controlled environment such as the one proposed depend on the good management practices and good animal husbandry applied, in this regard, it is imperative that all necessary operational protocols and resources to implement the protocols are in place prior to the work begins;

• Since the project is being undertaken in an inhabited island, the success of the project would largely depend on the community acceptability of the project which in the long run would depend on how community benefits from the project. In this regard the community component of the project shall be given a special attention and efforts shall be made to implement the component successfully and as planned;

• Due to the open nature of the project area proper security and surveillance is recommended to make the area uninviting for illegal activities such as theft and vandalism;

• From this assessment report it is evident that much of the environmental effects related to the aquaculture project stems from intensive farming methods which have proven to be disastrous not only from an ecological point of view but also from a financial perspective. Hence intensive farming shall be avoided in order to avoid diseases, ecological impacts, social issues and unnecessary loss of financial resources. Extensive farming shall be the only way as explained in the report shall be the only approach applied to ensure project sustainability and prosperity.
REFERENCES


Marisol, B. et al., 2014. Co-culture of sea cucumber Holothuria scabra and red seaweed Kappaphycus striatum.


MMS, 2016. Maldives Meteological Service. [Online]
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[Accessed 24 January 2017].


Steven, W., Jacques, P. & Nicolas , F., 2006. Experimental evaluation of co-culture of juvenile sea cucumbers, Holothuria scabra (Jaeger), with juvenile blue shrimp, Litopenaeus stylirostris.

Steven, W., Jacques, P. & Nicolas, F., 2006. Experimental evaluation of co-culture of juvenile sea cucumbers, Holothuria scabra (jaeger), with juvenile blue shrimp, Litopenaeus stylirostris.


12. ANNEX 1: TERMS OF REFERENCE

Terms of Reference for Environmental Impact Assessment for the Proposed Sea-cucumber Facility at Gan, Laamu Atoll

The following is the Terms of Reference (TOR) following the scoping meeting held on 28/4/2016 for undertaking the EIA for the proposed Sea-cucumber Facility at L. Gan. The proponent of this project is SS Farming Private Limited.

While every attempt has been made to ensure that this TOR addresses all of the major issues associated with the development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction to the project** – Describe the purpose of the project and, if applicable, the background of the project/activity and the tasks already completed. Clearly identify the rationale and objectives of the development. Define the arrangements required for the environmental assessment and if relevant, including how work carried out under this contract is linked and sequenced with other projects executed by other consultants, and how coordination between other consultants, contractors and government institutions will be carried out. List the donors and the institutions the consultant will be coordinating with and the methodologies used.

2. **Study area** – Submit an A3 size scaled plan with indications of all the proposed on land and marine infrastructures. Specify the boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent and nearby environmentally important areas (e.g. coral reef, mangroves, sea grass beds, marine protected areas). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including preparation, construction and decommissioning phases.

   **Task 1. Description of the proposed project** – Provide a full description and justification of the relevant parts of the agricultural works, using maps at appropriate scales where necessary. Describe the type of crops that would be cultivated. The following should be provided including all inputs and outputs related to the proposed activities shall be justified.

   **Type of Culture**
   - Identify species to be cultured, brood stock source (wild caught, hatchery produced), water quality requirements, waste generation, time required for optimum growth, monsoon season (if specific).
   - Identify and describe stages of brood stock maintenance, larval rearing/culture and grow-out phase of the seeds of fingerlings.
   - Type of feed, quantity, fertilizers required, costs.
   - Volume of culture and time required to grow full sized product

   **Land based hatchery and larval rearing facility**
   - Total land area required
   - Description of culturing process
   - Description of tanks, construction method equipment’s and wastewater disposal systems
   - Water supply for culturing process
   - Water intake pipeline, locations, justifications, storm water drainage and power sources.
   - Culture process
For sea bottom ranching:
- Details and justifications of total area of lagoon required, cage locations, number of cages, materials and installation methods of cages.
- Justification of distance to shore, water depth required, anchoring systems.
- Water pumping systems, sanitations and solid waste removal
- Access to cages from shore and transportation method.

Storage facilities/other infrastructure:
- Storage and packaging facility construction, size, method, machinery required (freezers, fish processing equipment), imported materials if required.
- Power supply plan, including power generation, fuel storage and transportation
- Land clearance activities and accessibility
- Operational plan including transport, pest control, water quality monitoring
- Emergency plan in case of spills (oils etc.) during construction phase.
- Emergency supply, description of quarantine facilities.
- Sewage Management details for construction and operational phase
- Water usage

Waste management plan:
- Waste disposal mechanisms

Task 2. Descriptions of the environment – Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction and from at least two benchmarks.

All data must be collected as per the requirements of the EPA Data Collection Guidelines (published on www.epa.gov.mv). The report should outline detailed methodology of data collection utilized.

All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects, vegetation transects and manta tours sites for posterior data comparison. Information should be divided into the categories shown below:

Physical parameters:
- Temperature, rainfall, wind waves
- Tidal range
- Risk of hurricanes and storm surges
- Waves dynamics
- Wind induced seasonal currents
- Bathymetry
- Beach profiles
EIA for Sea Cucumber Culture in L Gan, Maldives

- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction
- Sea water quality measuring: temperature, pH, salinity, turbidity, phosphate, nitrate, BOD and COD, total and faecal coliforms.
- Shoreline and vegetation near the project site of the island
- Ground water quality at 5 locations measuring: pH, salinity, turbidity, phosphate, nitrate, BOD and COD, total and faecal coliforms

Biological parameters
- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vectors.
- Benthic and fish community monitoring at proposed grow out sites.
- Details of the vegetation on the island and land clearance details including estimated types and number of vegetation to be cleared

Socio-economic environment
- Accessibility of commuting workers;
- If in inhabited island, demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
- Economic activities of both men and woman (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Seasonal changes in activities if observed;
- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Identify sites with historical or cultural interest at project site or impact area.

Hazard vulnerability:
- Vulnerability of area to flooding and storm surge

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. Legal requirements:
- Approval from the Ministry of Fisheries and Agriculture including type of work approved to be carried out on the island
- Regulations and guidelines of Maldives Food and Drug Authority
- Land Approval from Council

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:
Task 4a. Impacts to natural Environment

a) Impacts to configuration/coastal morphology resulting from sedimentation changes or changes in flow direction.
b) Impacts on vegetation, landscape integrity and scenery.
c) Loss of marine biota, both in the borrow area as well as in the reclamation site, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity and its density.
d) Sediment dispersion in water column (turbidity at the dredging sites), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.
e) Impacts of noise, vibration and disturbance.
f) Impacts on unique or threatened habitats or species (coral reefs, sea turtles, MPA etc.), and
g) In hatchery water runoff impacts from pesticides and fertilizers on marine environment
h) Assess impacts from increased nutrients in the surrounding waters (eutrophication)

Task 4b. Impacts on the socio-economic environment

a) Impacts of the works in fishing activities (disturbance);
b) Impacts of the harbour development and channel deepening works to nearby islands or sites, if any (e.g. resorts and dive sites);
c) Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
d) Employment and economic opportunities and diversification;

Task 4c. Construction related hazards and risks

a) Pollution of the natural environment during construction and operation (e.g. oil spills, discharge of untreated wastewater and solid waste, including construction waste);
b) Risk of accidents and pollution on workers and local population, and

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.

Task 5. Alternatives to proposed project – Describe alternatives including the “No Project Option” should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the “no action alternative”. This should include but not limited to alternative irrigation methods, alternative crops and alternative locations for buildings and infrastructure, alternative access options and alternative coastal protection methods for the island. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These should include both environmental and socio-economic mitigation measures with particular attention paid to toxin control. Measures for construction and operation phase shall be identified. Mitigation measures to avoid, minimize or compensate habitat destruction need to be considered. Give cost of the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An environmental management plan (EMP) for the proposed project, identifying
responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental impacts shall be given.

**Task 7. Development of monitoring plan** – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for sea water quality as well as marine ecosystem due to increased nutrients.

The baseline study of task 2 of the document shall be used to determine baseline and threshold conditions.

Give details of the monitoring program including the physical and biological parameters for monitoring, cost of monitoring and commitment letter from responsible person to conduct monitoring, reporting format and schedule. The monitoring report shall cover if required and shall not be limited to:

- a) Sea water quality: that includes EC, Turbidity, pH, DO, BOD and nitrates
- b) Effluent water quality
- c) Assessment of nearby marine sensitive ecosystems
- d) Re-colonization of the benthic organisms.

**Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation** – Identify appropriate mechanisms for providing information on the agricultural project to relevant stakeholders, government authorities such as government agencies, development managers, staff and members of the general public. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes.

- Consultations need to be made with Ministry of Fisheries and Agriculture and
- Marine Research Centre.
- Island Council regarding community farming, project location details
- Ministry of Housing and Infrastructure
- EPA: water section and Environment Research and Conservation Section.
- FENAKA
- Public consultation regarding community farming

**Presentation** – The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012 and the relevant Amendments.

**Timeframe for submitting the EIA report** – The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.

2 May 2016
EIA for Sea Cucumber Culture in L Gan, Maldives

Environmental Protection Agency

203-EIARES/PRIV/2016/230

1438 H 08
2016 H 08

Environmental Protection Agency
Green Building, 3rd Floor, Handicolor Avenue
Male', Rep. of Maldives, 20300
Tel: (+960) 331 5545 (+960) 331 5544
Fax: (+960) 331 5950

1 of 1
Website: www.epa.gov.mv

MEECO
13. ANNEX 2: DECLARATION OF PROPOINENT

31st January 2017

Mr. Ibrahim Naeem,  
Director General,  
Environmental Protection Agency,  
Ministry of Environment and Energy,  
Ameenee Magu,  
Male-20392’, Maldives.

Dear Sir,  

Sub: Declaration of Proponent

As the proponent of the project, we guarantee that we have read the report and that to the best of our knowledge all non-technical information provided are accurate and complete.

Yours Faithfully,

[Signature]

[Name]

[Title]
31st January 2017

Mr. Ibrahim Naeem,
Director General,
Environmental Protection Agency,
Ministry of Environment and Energy,
Ameenoo Magu,
Male-20392’, Maldives.

Dear Sir,

Sub: Development of Sea Cucumber aquaculture facilities in L Gan

As the developer of the captioned Project, we confirm and give commitment to bear the financial cost of undertaking mitigation and environmental monitoring as specified in the EIA report and implement all environmental impact mitigation measures and environmental monitoring proposed during construction and operation phase of the project.

Thanking you.

Yours sincerely,

Ismail Faeezeh
Director
15. **ANNEX 4: LETTER FROM ISLAND COUNCIL**

[Image of the letter from the Island Council]
16. **ANNEX 5: LIST OF PARTICIPANTS (STAKEHOLDER CONSULTATIONS)**

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<td>Hussain Abubakar</td>
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<td>555994</td>
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<tr>
<td>Ali Hameed</td>
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<td><a href="mailto:ali.hameed@meeco.com.mv">ali.hameed@meeco.com.mv</a></td>
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<tr>
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### Meeting Details

**Meeting With:** NRC

**Date:** 3/1/2017

**Time:** 11:00

**Venue:** NRC

**Subject:** Re: STAKEHOLDER CONSULTATION

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<td>Shajika Niaee</td>
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<td><a href="mailto:niaeed02@gmail.com">niaeed02@gmail.com</a></td>
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<td>Hussain Ahmed</td>
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*EIA for Sea Cucumber Culture in L Gan, Maldives*
EIA for Sea Cucumber Culture in L Gan, Maldives

Meeting With: PUBLIC
Date: 28/4/2016
Time: 9:00 AM
Venue: COUNCIL OFFICE MEETING ROOM
Subject: Re: PUBLIC CONSULTATION

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### EIA for Sea Cucumber Culture in L Gan, Maldives

#### Meeting Details

- **Meeting With:** Public Consultation
- **Date:** 29/07/2016
- **Time:** 9:00 AM
- **Venue:** Council Meetings Room
- **Subject:** Re: Public Consultation

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<td>Usman Mulla</td>
<td>Council Office, L Gan</td>
<td>9959955</td>
<td><a href="mailto:usmanmulla@hotmail.com">usmanmulla@hotmail.com</a></td>
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</tr>
<tr>
<td>Mohamed Hussain</td>
<td>Tamarind, L Gan</td>
<td>7710601</td>
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<td>Ahmed Hussain</td>
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<tr>
<td>Ahmed Forzeef</td>
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### EIA for Sea Cucumber Culture in L Gan, Maldives

#### Meeting Details
- **Meeting With:** COUNCIL
- **Date:** 22/09/2016
- **Time:** 10:30
- **Venue:** COUNCIL OFFICE
- **Subject:** Re: EIA Consultation

#### Attendees

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<td>ALI HAMADI</td>
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Stakeholder consultation for construction of a Sea cucumber hatchery facility at Gan, Laamu.

**Stakeholder:** Ministry of Housing and Infrastructure

**Date & Time:** 29th November 2016 / 1000am

**Place:** Meeting Room / MHI

**Participants**

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<tr>
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<th>Designation</th>
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<tr>
<td>Anoosha Hashim</td>
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<td>Hussain Rasheed</td>
<td>Director</td>
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Date: 2016-01-09

info@meeco-corn-mv
301 0844

MEECO
17. ANNEX 6: APPROVED LAND
EIA for Sea Cucumber Culture in L Gan, Maldives
EIA for Sea Cucumber Culture in L Gan, Maldives
18. ANNEX 7: CVs

1. **Position:** Assistant Team Leader

2. **Name of Firm:** Maldives Energy and Environmental Company (MEECO)

3. **Name of Staff:** Ali Hammadh

4. **Date of Birth:** 5th April 1991  
   **Nationality:** Maldivian

5. **Education:**

<table>
<thead>
<tr>
<th>Institution</th>
<th>Macquarie University, Australia</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date:</strong></td>
<td>January 2012 – February 2015</td>
</tr>
<tr>
<td><strong>Degree(s) or Diploma(s) obtained:</strong></td>
<td>Bachelor of Environment</td>
</tr>
<tr>
<td></td>
<td>Majors: Chemistry &amp; Environmental Management</td>
</tr>
</tbody>
</table>

6. **Membership of Professional Associations:**

   - Registered Temporary EIA Consultant (2015 – Present)
   - MQ University Alumni

7. **Other Training:**

8. **Countries of Work Experience:**

   - Maldives.
   - Australia

Management and Organisational experience

**Ongoing Projects**

1. Regional Solid Waste Management Feasibility Study (Northern Region), Project Coordination, Client: MEE

**Environmental Assessment Experience (Conducting surveys, studies and writing of the following EIA reports):**

1. Gn.Fuvahmulah Shore Protection Project, Coordination, Client: DHVRoyalHaskoning
2. Development of Maldives Energy Act, Project Coordination and assistance, Client: MEE
3. Islandway Iru Tourish Hotel Development Preliminary studies and EIA, Project Leader, Client: Islandway Hospitality Group.
4. L.Gan Seacucumber Facility Development, Preliminary studies and EIA, Project Leader, Client

9. Languages:

<table>
<thead>
<tr>
<th>Language</th>
<th>Reading</th>
<th>Speaking</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>English</td>
<td>V.Good</td>
<td>V.Good</td>
<td>V.Good</td>
</tr>
<tr>
<td>Dhivehi</td>
<td>Mother tongue</td>
<td>Mother tongue</td>
<td>Mother tongue</td>
</tr>
</tbody>
</table>

10. Employment Record:

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
<th>Employer</th>
<th>Positions held</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Present</td>
<td>Maldives Energy and Environmental Company (MEECO), Maldives</td>
<td>Assistant Director, Assessments.</td>
</tr>
<tr>
<td>February 2014</td>
<td>December 2014</td>
<td>Townsville Atmospherically deposited Dust Metal Study by MQ University</td>
<td>Data Analyst</td>
</tr>
<tr>
<td>June 2014</td>
<td>December 2014</td>
<td>MQ University</td>
<td>Laboratory Demonstrator</td>
</tr>
<tr>
<td>February 2013</td>
<td>September 2013</td>
<td>MQ University</td>
<td>Note Taker for the special needs student.</td>
</tr>
<tr>
<td>February 2012</td>
<td>March 2013</td>
<td>RMC College</td>
<td>Waste Collector</td>
</tr>
<tr>
<td>February 2011</td>
<td>March 2011</td>
<td>Ministry Of Tourism</td>
<td>Assistant Planning Officer</td>
</tr>
</tbody>
</table>
19. **ANNEX 8: WATER QUALITY**

---

**WATER QUALITY TEST REPORT**

**Sample Description / Location:** LGan-SW-001 L.Gan (seawater) 29/09/2016

**Sample No.:** 100004

**Date of Analysis:** 27/09/2016

**Test Report No.:** 10162016

**Customer Information:**
- **Name:** Meeco
- **Address:** G. Azhekegege-1, 2nd Floor,
  Male' City,
  Maldives

**Analysis Result:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analysis Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Appearance</td>
<td>Clear</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>0</td>
</tr>
<tr>
<td>Faecal Coliforms</td>
<td>0</td>
</tr>
</tbody>
</table>

**Notes:**
- Sampling Authority: Sampling was not done by MWSC Laboratory.
- This report shall not be reproduced except in full, without written permission.
- This test report is only for the samples tested.
- Information supplied by the customer.

**Checked by:**
- **Ahsan Farooq**
  Laboratory Executive

**Approved by:**
- **Mohamed Eymen**
  Senior Technical Officer

---

**END OF THE REPORT**
**WATER QUALITY TEST REPORT**

Test Report No: 301032/2016/17

**Customer Information:**
Meeco,
G. Akeelaage-1, 2nd Floor,
Hulhumale Island,
Repub. of Maldives

---

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analysis Result</th>
<th>TEST METHOD</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate</td>
<td>3.3</td>
<td>Method BS 71 (Adapted from IACH D5500 Spectrophotometer procedure Manual)</td>
<td>mg/l</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.16</td>
<td>Method 8246 (Adapted from IACH D5500 Spectrophotometer procedure Manual)</td>
<td>mg/l</td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Appearance</td>
<td>Clear with no turbidity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Checked by:**

Afman Farooq
Laboratory Executive

**Approved by:**

Dhany
Senior Technical Officer

---

**Notes:**
- Sampling Authority: Sampling was not done by MVISC Laboratory
- This report shall not be reproduced except in full, without written
- This test report is ONLY FOR THE SAMPLES TESTED.
- * Information Supplied by the customer

---

**END OF THE REPORT**

---

MEECO
## WATER QUALITY TEST REPORT

**Test Report No:** 301032/2016/18

### Customer Information:

Male',
G. Aakakaseh,-1, 2nd Floor,
Alilgeeselehlu Magu,
Male',
Rep. of Maldives

### Sample Description / Location:

- **Sample Description:** L.Gan SW-002 lagoon Water
- **Date:** 05/10/2016

### Test Method

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Analysis Result</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Appearance</td>
<td>Visual</td>
<td></td>
</tr>
<tr>
<td>Biological Oxygen Demand (BOD)</td>
<td>&lt; 1 (LaQ) mg/L</td>
<td>mg/L</td>
</tr>
</tbody>
</table>

### Notes:

- **Units:** mg/L: Milligrams per litre
- **Limit of Quantification:** LoQ
- **Sampling Authority:** Sampling was not done by MWSC Laboratory
- **This report shall not be reproduced except in full, without written permission.**

### Checked by: Afnan Farooq
Laboratory Executive

### Approved by: Mohamed Eyman
Senior Technical Officer

---

**END OF THE REPORT**
**WATER QUALITY TEST REPORT**

**Customer Information:**
Meeo,
1st Fl., Male' City, Maldives

**Sample Description/Location**
- L. Gan-GW-001: Ground Water
- L. Gan-GW-002: Ground Water
- L. Gan-GW-003: Ground Water

**Sample Type:** Ground Water

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>L. Gan-GW-001</th>
<th>L. Gan-GW-002</th>
<th>L. Gan-GW-003</th>
</tr>
</thead>
<tbody>
<tr>
<td>L. Gan-GW-001</td>
<td>826651</td>
<td>826649</td>
<td>826651</td>
</tr>
<tr>
<td>L. Gan-GW-002</td>
<td>826647</td>
<td>826649</td>
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</tr>
<tr>
<td>L. Gan-GW-003</td>
<td>826651</td>
<td>826651</td>
<td>826651</td>
</tr>
</tbody>
</table>

**Date of Analysis:** 29/09/2010

**Test Method:**
- Method 6371 (Adapted from APHA 1st Edition: Standard Methods for the Examination of Water and Wastewater)
- Method 4500 (Adapted from APHA 1st Edition: Standard Methods for the Examination of Water and Wastewater)

**Analysis Result:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>L. Gan-GW-001</th>
<th>L. Gan-GW-002</th>
<th>L. Gan-GW-003</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD4</td>
<td>0.92</td>
<td>0.80</td>
<td>0.92</td>
</tr>
<tr>
<td>Phosphates</td>
<td>0.12</td>
<td>0.25</td>
<td>0.50</td>
</tr>
<tr>
<td>Chl.a</td>
<td>0.16</td>
<td>0.20</td>
<td>0.16</td>
</tr>
<tr>
<td>N, Total</td>
<td>6.1</td>
<td>6.2</td>
<td>5.9</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>&gt;2410</td>
<td>117</td>
<td>647</td>
</tr>
<tr>
<td>Fecal Coliforms</td>
<td>&gt;2410</td>
<td>44</td>
<td>4</td>
</tr>
</tbody>
</table>

**Checked by:**
Afnan Farooq
Laboratory Executive

**Approved by:**
Mohamed Eyman
Senior Technical Officer

---
**Notes:**
- Sampling Authority: Sampling was not done by MWWC Laboratory
- This report shall not be reproduced except in full, without written approval of MWWC Laboratory
- This test report is only for the samples tested
- Information supplied by the customer

*END OF THE REPORT*
20. **ANNEX 9: APPROVED SITE DRAWING**
## 21. ANNEX 10: DECLARATION OF AUTHORS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page Number</th>
<th>Names of Contributors</th>
<th>Consultant Number</th>
<th>Signature</th>
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<tbody>
<tr>
<td>1. Introduction</td>
<td>1</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ali Hammadh</td>
<td>EIA T12/15</td>
<td></td>
</tr>
<tr>
<td>2. Project Description</td>
<td>20</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ali Hammadh</td>
<td>EIA T12/15</td>
<td></td>
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<tr>
<td>3. Legislative/Project Setting</td>
<td>23</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
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<tr>
<td>4. Existing Environment</td>
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<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
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<td>Ali Hammadh</td>
<td>EIA T12/15</td>
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<tr>
<td>5. Impact and Mitigation</td>
<td>249</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
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<td></td>
<td>Ali Hammadh</td>
<td>EIA T12/15</td>
<td></td>
</tr>
<tr>
<td>6. Stakeholder consultation</td>
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<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
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<td></td>
<td>Ali Hammadh</td>
<td>EIA T12/15</td>
<td></td>
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<tr>
<td>7. Monitoring and Management Plan</td>
<td>239</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
<td></td>
</tr>
<tr>
<td>8. Recommendation and conclusion</td>
<td>287</td>
<td>Ahmed Saleem</td>
<td>EIA 03/13</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ali Hammadh</td>
<td>EIA T12/15</td>
<td></td>
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</tbody>
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