ENVIRONMENTAL IMPACT ASSESSMENT

Proposed Sea cucumber Aquaculture Project

Boduhaikondi, Raa Atoll

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Sandcays

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Consultants Declaration

This EIA has been prepared according to the EIA Regulations 2012. We certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of our knowledge and abilities.

Hussain Fizah

Registration No. EIA01/2014

Ahmed Zahid

Registration No. EIA08/2007

Proponent's Declaration

As the Proponent of the proposed development I guarantee that I have read the report thoroughly and that to the best of my knowledge all information provided here regarding the project is accurate and complete.

Ali Aroosh Ibrahim

Proponent

Executive Summary

This report addresses the environmental concerns of the proposed mariculture project for the farming of sea cucumber in the lagoon of Boduhaikondi, Raa Atoll. Sea cucumber juveniles and grouper fingerlings will be bought from local hatcheries such as the sea cucumber hatchery at Nalandhoo until the proposed hatchery has been established. Sea cucumber juveniles (over four months old) will be put in the lagoon to grow out in its natural habitat to the adult size. The sea cucumber will grow to adult size in a year. The Project is proposed by Ali Ahroosh Ibrahim, M. Meadows.

Boduhaiykondi is a small island towards the middle of Raa Atoll close to Dhuvaafaru. It has been leased for agricultural/fishery purposes by the Ministry of Fisheries and Agriculture. With the potential for mariculture with a sizeable lagoon with a small deep lagoon, acting as a natural habitat for sea cucumber, the proposed aquaculture or mariculture project has been considered as a potential investment. Sea cucumber production using fingerlings from Nalandhoo will form the initial component of the proposed project. A hatchery will be later established on the island for improved productivity.

Sea cucumbers will be fed with food that will be imported to some extent but locally available seagrass and other food sources will be given priority. Sea cumber will be at the right size in 9 to 10 months following which they will be harvested, processed, packed and exported. A processing facility will be established on site.

In addition to staff accommodation, power house, fuel storage, water supply and sewerage, telecommunication services, jetty and channel, the following investments directly targeted at sea cucumber production will be established.

- Sea cage fish farm in the lagoon
- Sea cucumber boiling and processing facility
- Ice making facility
- Storage facility for processed sea cucumbers

Environmental concerns from the proposed project include:

- Sedimentation of some degree during channel dredging and jetty installation. The channel being about 3m on average, it will require only the removal of rock outcrops in the channel. Therefore, impact will be small.

- The impact of disease transmissions on wild populations. This impact is considered to be minor negative and depends on stocking densities and feeding. Environmental controls shall be established from the very onset of the project to mitigate disease prevalence and ensure a healthy environment.
- The impact cages may have on wild fish populations. Although this impact is not considered to be significant, this impact has to be studied in detail during the implementation stage.
- The genetic or competitive effect escapees may have on wild stock. Since juveniles that are not able to escape are used and exotic species would not be imported, this impact is unlikely to occur.
- In the case of cage culture using locally found species, genetic pollution will not be a concern even in case of escapees and new diseases will not be introduced to the wild stock. However, an incubation of local diseases present in the wild stock may be a potential cause for concern in case of high stocking densities. Therefore, stocking densities shall be kept to an optimum at all times. The likelihood for habitat modification could occur in case of imported broodstock causing stress and related disease prevalence. However, this is a minor impact not considered to be significant.

The proposed project is expected to be managed in conformity with local and international regulations and standards of relevance, especially environmental regulations and standards. Therefore, environmental impacts will be well managed, minimized and mitigated. The overall environmental impacts of the project have been assessed using appropriate matrices and the results indicated that the proposed project had net positive impact. That is, the project has no major adverse impacts on the environment as far as current knowledge is concerned.

Given that the project has moderate level of socio-economic benefits and possible environmental benefits, it is recommended to allow the project to proceed as proposed. However, due to the project being among a few of its kind in the country, it is important to consider uncertainties and continue to monitor the project impacts and undertake appropriate mitigation measures in consultation with the EPA and other relevant government agencies.

ސާރާ ހުލާސާ

މި ރިޕޯޓަކީ ރ. ބޮޑުހައިކޮނޑޫގައި ހިންގުމަށް ރޭވިފައިވާ ހުއިފިލަސޭގެ އެކުއާކަލްޗަރ/މެރިކަލްޗަރ މަޝްރޫއުގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރުމުގެ ގޮތުން ތައްޔާރުކުރެވިފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫއުގައި ހިމެނޭ ޢަމަލުތައް ތަފްސީލުކޮށް ދިނުމާއި ބައިނަލްއަޤުވާމީ ކޮމާޝަލް ބާޒާރުގައި "ސީކިއުކަމްބަރ" ނުވަތަ "ސޭންޑް ފިޝް" ބޮޑުހައިކޮނޑޫގެ ފަރުތަކުގައި އާލާކޮށް ވިޔަފާރީގެ އެކްސްޕޯޓް ކުރިއަށް ގެންދާގޮތަށް ހިންގާ މަޝްރޫއަކެވެ. މި މަޝްރޫއުގެ ހެދިޔާރަކީ ޢަލީ އަޙްރޫޝް އިބްރާހީމްއެވެ.

މި މަޝްރޫއު ހިންގާ ބޮޑުހައިކޮނޑޫއަކީ ރ. އަތޮޅު ދެކުނުގައި އިރުމަތީ ފަރާތަށް ވާ ގޮތަށް އެ އަތޮޅުގެ އޮންނަ ފަޅުން ގިނަ އޮންނަ ގިނަ މަސްވެރިން އާބާދީ އުޅުއްވުނު ދުވާފަރު ކައިރީގައި އޮންނަ ކުދި ރަށެކެވެ. ހުސްރަށްކަމުގައިވާ ފަރު ދެކުނުކޮޅުގައި މަޝްރޫއަކާ އެކަނިވެރިވާ ވަޅު ދުރު ސަރަހައްދެއް ދިމާވާ އަދި ދިރި ވިޔަފާރި ދިމާވާ ރަށެކެވެ. މިގޮތުން ހުސްރަށްގާފައިވާ މަޝްރޫއުގެ ބޭނުމަށް ބޭނުންކުރެވޭނެ މިފަދަ ހުސްރަށް އުމުރާވަމާގެ ވަރަށް ސާފު މިންވަރުކުރެވޭ. ހުއިފިލަސޭގެ އަދި ދުނިޔޭގައި ދިރިއުޅޭ ބަޔަކާ ދިމާވާ ގޮތަށް ބޭނުންކުރެވޭ ތަނެއްގައި ވަރަށް ބޮޑު ހިސާބެއްގައި ބޭނުންކުރެވޭނެ ގޮތަށް ފަރުތައް ބެލެހެއްޓުމަށް ބޭނުންވާ ކަންތައްތަކުގެ ތެރޭގައި އެކުލެވޭ ގޮތުން ފެނުމަށް މި މަޝްރޫއުގެ ފެށުމުން ތިމާވެއްޓަށް ގެއްލުމެއް ނުވާނެ ކަމަށް ބެލެވެއެވެ. އަދި ވަރަށް ސާފު ރާއްޖޭގެ ސިޔާސަތާ އެއްގޮތަށް ހިންގާ ކަމަށް ގަބޫލުކުރެވޭ ގޮތުން ބޭނުންވާ ހުއްދަތައް ހޯދާފައިވާ ކަމަށްވެއެވެ.

މަޝްރޫއުގެ ދަށުން ހުއިފިލަސް ބޮޑުކޮށް ބާޒާރަށް ނެރުމުގެ މަރުހަލާތައް ދެކޭ ގޮތް: ޖަމާ، ބިސް، ފުށި، ކަނޑަލާ، މަތިކަޅާ އަދި ފުރާ މިންވަރު ދެނެގަތުމަށް ފަސޭހަކޮށްދޭ ވަސީލަތްތަކާއި ހުރިހާ ކަމެއް ތައްޔާރުކުރެވެއެވެ. މިގޮތުން އެކަމާ ނުރައްކާ ބަރާބަރު ދުރުކުރުމުގެ ފިޔަވަޅު ލެވޭނެ ކަމަށް ކަނޑައެޅިފައި ސަރަހައްދު ބިން ޖަރީ ހަލާކުވުމާއި މެދު ހަރަކާތްތެރިވުމުގެ ސަބަބުން ނުރައްކާ، މަސައްކަތް ހިމެނޭ ރިސާލަތު ދުވަސްވަރުގެ ފަސް ދިރިއުޅުމުގެ ތެރެއިން، ހަލާކުވާ ނުރައްކާ ބޮޑުވެފައިވާ ހިސާބުން ބެލުމަށް ފޮނުވާލެވޭ ވަގުތު ވަރަށް ކުރިއަށްދާ ގޮތް ފަރުތަކުގައި އަދި ތިމާވެށްޓާ ބެހޭ ކަންތައްތަކާ ގުޅިގެން ރިސާލަތު ދެނެގަތުމާ އެއްގޮތަށް ކަމެވެ.

މަޝްރޫޢުގެ ސަބަބުން ކުރާނެ ކަމަށް ފާހަގަކުރެވޭ ނޭދެވޭ އަސަރުތަށް ވަރަށް ކުޑައެވެ. ހުއިފިލަނޑާއި އާދޭ ޗޮޕުގައި މިފަދަ މާހައުލުތަކުގައި އުޅޭ ބޮޑުވާ އެއްޗަކަށްވެފައި ކޯރުލިނަ ފަދަ ފަސާދައިން ދިފާއުން ހުރިހާ އެއްޗެއްސަށް އާދޭ ގާނޫނީ ވެރިންގެ، ބޮޑުން ގިނަ އިދާރާތަކުން ގާނާ ނުވެފައިވާ ކަރަންޓުތަކުގެ ވާހަކަތަކެވެ. އަދި ކަރަންޓުތަކާ ސަރަހައްދަށް ނިސްބަތްވާ ބޮޑު ސަރަހައްދުތަކުގައި ހުއިފިލަނޑު ސަރަހައްދުތަކުން މިންވަރު ކުޑަކަމުން މާބޮޑު ނޭދެވޭ އަސަރެއް ކުރާނެކަމަށް ނުފެނެއެވެ.

މި މަޝްރޫޢުގެ ސަބަބުން ވެށްޓަށް އަންނަމުންދާ ބަދަލުތައް ދެނެގަތުމުގެ ގޮތުން މަޝްވަރާ ގޮތްތަކަށް ބަލާނީ މަޝްރޫޢުގެ ސަބަބުން ކުރާނެ ކަމަށް ލަފާކުރާ އަދި ކުރާ އިޖާބީ އަސަރުތަކާއި، ފެނުގެ ކޮލިޓީ ބެލުމާއި ޓްރެކުރު ބެލުމުގެ އިތުރުން ހުއިފިލަނޑު ހިދުމަތް ފަހިކުރާ އާ ސިޔާސަތު އަންނަ ބަދަލުތަކެވެ. މި ދިރާސާތަކަށް ފަހު ވެށްޓަށް އަންނަމުންދާ ބަދަލުތައް ދެނެގަތުމަށް ބޭނުން ކުރާނީ އެންވަޔަރަންމަންޓަލް މޮނިޓަރިންގ ޕްލޭނެވެ. އަދި ހުރިހާ ކަމެއް ގެންދިޔުމަށް ފަރި ކަނޑައަޅައިފައެވެ.

މި ރިޕޯޓުގައި ހިމަނާފައިވާ ކަންކަމަކީ އެހެން ސަބަބުން ދިމާވެދާނެ ކުރާ ނޭދެވޭ އަސަރު ކުޑަ ނުވަތަ ނޭދެވޭ އަސަރުތަށް ކަމަށް ކަނޑައަޅާފައި ދެކޮންޓްރޯލްކުރެވޭ ކަންކަމުގައި މަޝްރޫޢުގެ ސަބަބުން މުއައްސަސާގައި ލިބޭ އިޖާބީ އަދި އިޤްތިޞާދީ ފައިދާ ބޮޑުކަމަށް ފެންނާތީ، ކަމާއި ބެހޭ އުސޫލުތަކަށް ހުރުމަތްތެރިވެ، މި މަޝްރޫޢު ހިންގާފައިވާ ގޮތަށް ކުރިއަށް ގެންދިއުން އެންމެ ރަގަޅު ކަމަށް ފެނެއެވެ.

1 Introduction

1.1 Introduction

This Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts of a sea cucumber culture/growout and processing facility proposed to be established in Boduhaikondi, Raa Atoll. This report will identify the potential impacts (both positive and negative) of the proposed project. The report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be evaluated. Measures to mitigate any negative impact on the environment would be suggested. Since these kinds of projects are becoming increasingly popular in the Maldives, a comprehensive monitoring programme would be outlined and taken into consideration in the design and implementation of the proposed project.

The findings of this report are based on qualitative and quantitative assessments undertaken during a site visit from 24 to 25 May 2016 as well as professional judgement. Data and information presented in the project proposal have been relied upon in order to understand and present the project. The impact assessment methodology has been restricted to field data collected, professional judgement and experience of similar settings and projects across the Maldives and elsewhere. Long term data relevant to this report on specific aspects such as meteorology and climate were gathered from secondary sources and published reports on the Maldives. Only few projects of this sort have been recently proposed or even fewer undertaken in the past, however, documents and experiences from these projects such as Kanduoiy Giri aquaculture project, sea cucumber project in Dhigelaabadhoo and proposed mariculture projects in ADh. Uthuru Athafaru and R. Fenfushi, seacucumber facility at Sh. Maroshi, mariculture project at B. Faress, and Sea cucumber project (experimental phase) at L. Fonadhoo have been reviewed and taken into consideration.

This EIA is prepared in accordance with the Terms of Reference (TOR) approved by the Environmental Protection Agency (EPA) on 05 May 2016. It is a legal requirement that new projects having potential for environmental impacts gain environmental clearance or approval prior to construction and operation of such projects.

1.2 Scope of the EIA and Approach

The main scope of this EIA report as per the approved TOR is to broadly assess, identify, predict and document potential environmental impacts from the proposed sea cucumber culture project in Boduhaikondi, Raa Atoll. Hence importance is given to document the whole project proposal in detail, identify the main environmental impacts that are associated with the proposed development and address the legal requirements that need to be taken into consideration while implementing this project. This document also addresses the existing environmental condition of the project site and foresees the ways in which potential environmental impacts will be managed, mitigated and reduced.

Hence the key aims of the report are to;

- Describe in detail the proposed project;
- Identify the need and justification for the proposed development;
- Describe the biophysical status of the existing environmental condition of the island based on the findings undertaken during the site visits;
- Assess, identify and predict potential environmental impacts of the proposed development;
- Evaluate the significance and magnitude of impacts that will be generated; and identify and predict ways in which these environmental impacts will be prevented or mitigated through appropriate environmental management and mitigation measures;
- Develop a mechanism to closely monitor and understand the long-term effects and changes of the proposed development on the environment with respect to the available baseline information, mostly collected from field assessments and site visits;
- Provide legal protection with regards to the proposed development activities; and
- Review the predictions and assessments made on environmental impacts that are associated with the proposed development activities.

In general, the EIA report has been based upon the following sources of information:

- Review of available project documentation (project proposal);
- Discussions with key stakeholders;
- Site visit to the island - baseline environmental assessments;

- Maldives Environmental Protection and Preservation Act, Law No. 4/93;
- Regulation on Environmental Impact Assessment of 2012
- Other Environmental Regulations
- Maldives National Development Framework
- Other EIAs for similar development projects that have been carried out in the Maldives.

1.3 Relevant Studies

In order to prepare this EIA, relevant EIA reports for aquaculture/mariculture projects involving sea cucumber or similar species have been studied, which includes;

- EIA for proposed sea cucumber aquaculture facility in L. Fonadhoo - experimental phase (Sandcays 2013)
- EIA for proposed seacucumber hatchery in Sh. Maroshi (Ali Shareef 2015)
- EIA for proposed mariculture project in R. Fenfushi (Naseem 2013)
- Environmental Impact Assessment (EIA) for the Development of an aquaculture facility in B. Fares (Zahid 2012).
- EIA for breeding, laval production and Culture of Sea Cucumbers at GDh, Dhigelaabadhoo (Ali 2012)
- EIA for proposed mariculture project in ADh. Uthuru Athafaru (Naseem 2012)
- EIA for Kanduoiy Giri aquaculture project (CDE 2010)

1.4 EIA Implementation and Methodologies

This study was based mainly on data collected during a field investigation mission from 24-25 May 2016 by a team from Sandcays Pvt. Ltd. and published literature on similar settings and projects including EIAs for L. Fonadhoo sea cucumber project (Sandcays 2013), mariculture/aquaculture project in B. Fares (Zahid 2012), GDh. Dhigelaabadhoo (Ali 2012), ADh. Uthuru Athafaru (Naseem 2012) and R. Fenfushi (Naseem 2013), seacucumber hatchery and growout in Sh Maroshi (Ali Shareef 2015), and Kanduoiy Giri (CDE 2010).

The EIA report was compiled by Ahmed Zahid, assisted by Hussain Fizah. Zameer Zubair, Mohamed Visham, Mohamed Riyaz and Mohamed Shifaf of Sandcays assisted in field work and in preparing maps and presentations required for the EIA report.

Established and widely accepted methods have been applied in this EIA study. Field studies have been undertaken using methods generally employed for EIA studies in the Maldives. The field assessment methodologies are briefly described in Section 5.2 of this report.

The methods used to identify, predict and assess impacts are based on matrices that have been established by the Consultants over a long period. In the matrix, the consultants assign a likert-scale number to represent the magnitude, significance, duration and spatial extent of the potential impact for each project activity against the key environmental and socio-economic components that the specific project activity may have an impact on. The product of the magnitude, significance, duration and spatial extent for each activity and component is summed up to measure the exact nature of the impacts by each activity and the overall impact of the proposed project is the sum of all activities.

The Terms of Reference (TOR) for this EIA has been attached as Appendix 1. This EIA has been prepared based on this term of reference.

2 Project Description

2.1 Introduction

The purpose of this section is to describe the project in terms of the need and justification of the project, location and boundaries of the project, project schedule, main inputs, project mobilization as well as project construction activities. In addition, this section presents materials and resources that will be used as well as the main output of the project.

2.2 Project Overview

The Proponent desires to capitalize on the growing global demand for beche-de-mer by developing a community-integrated operation targeted at the most populated islands of the Atoll in close proximity to the island. The scope of the proposed project involves the setup of sea cucumber facility with lagoon based sea pens or open cages for grow out in the lagoon (3,100m^2) and 2,563m^2 on land at Boduhaikondi, Raa Atoll. The facility will culture and grow the infamous sea cucumber species known as Holothuria Scabra (sand fish).

Sea cucumber juveniles will be bought from the sea cucumber hatchery at Nalandhoo. Sea cucumber juveniles will be put in large open cages to grow out in the natural habitat to the adult size. The sea cucumbers will be grown in the ocean lagoons for 18 months until they reach an optimal market size of 400 g. Specimens from among those juveniles will also be chosen to develop bloodstock for the spawning trials to be conducted in the hatchery that will be established at site. At full capacity the hatchery will produce 20,000 sea cucumber juveniles per month.

Broodstock and/or juveniles will be acquired from within the Maldives. Careful management oversight and ongoing training of staff will ensure that the highest levels of environmental and operational best practices are followed. Safety signs and indicators will be used throughout the project site. HACCP protocols will be followed when processing of sea cucumber.

2.3 Proponent

The project proponent is Ali Ahroosh Ibrahim of M. Meadows, Malé.

2.4 Project Location and Boundaries

Located at 275264m E, 620693m N (UTM coordinates), Boduhaikondi is a small island is found close to the middle of Raa Atoll, Maldives. It is strategically located close to the most inhabited island of Dhuvaafaru, the Regional and Atoll Capital island of Ungoofaaru and airport island of Ifuru at 8km, 9km and 12km respectively. Therefore, it has a strategic benefit in providing employment opportunities to the people of Raa Atoll.

The project boundaries are the entire reef system of Boduhaikondi including the lagoon and island of Boduhaikondi. The island has about 3.7hectares in area. The project components proposed at this stage takes only 7% of the land area of the island. The proposed sea cucumber growout facility takes only a fraction of the lagoon.

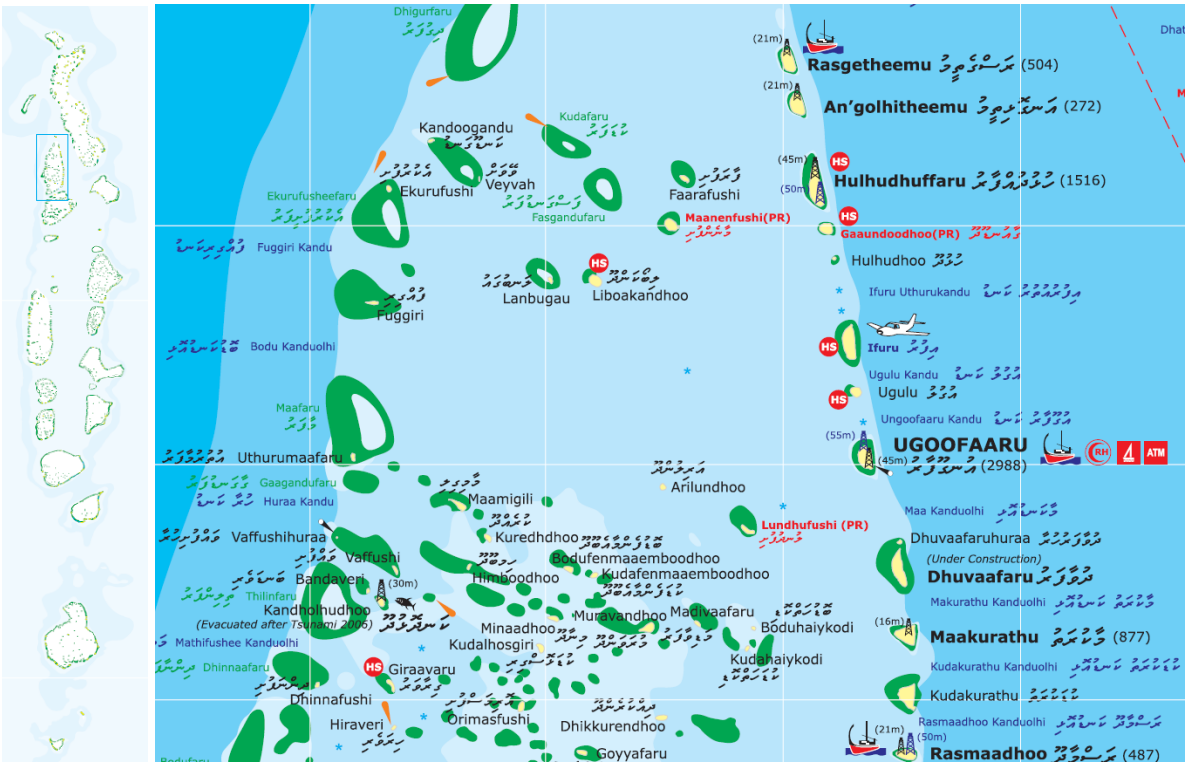


Figure 2-1: Location of Raa Atoll and Boduhaikondi in Raa Atoll

2.5 The Project

The project aims at the culture, grow-out and export of a commercially important sea cucumber species known as Holothuria Scabra. The hatchery (including any quarantine facility) will be developed at a later stage and an Addendum to this EIA will cover the details

of the hatchery. The proposed project will cover the grow-out pens or sea cage culture and processing facility. The island will have its own water and sewerage system, power/electricity and fuel and water storage. There will be two jetties, a harbour entrance and shore protection structures as per the proposed and approved concept.

2.5.1 Processing Unit

The processing unit (about 147m^2) will be located on land and will facilitate the drying and processing of sea cucumbers. The processing area will be a rain sheltered open air facility, with tables and processing materials all weather protected.

This processing area will be equipped with the following tools, machines and materials:

- Large, industrial quality containers and pots for boiling
- A wire mesh basket as well as wire scoop
- Sharp, industrial knives
- A smoke-drying hut with industry standard trays and drying racks
- Miscellaneous equipment and materials including but not limited to sacks, firewood, buckets, industrial cooking utensils
- Sea cucumber specific ovens created to cook and process with precision at global standards

Water required for sea cucumber use will be stored in freshwater tanks. All used water will be filtered through the water treatment plan described below. All unused sea cucumber product will be incinerated.

The packing of sea cucumbers will be done in a temperature and humidity controlled room (about 20m^2) to prevent dried sea cucumbers from reabsorbing moisture. The beche-de-mer will be packed in plastic lined cardboard boxes and stored in the same hall until dispatch. At peak capacity, the movement of product may require small trucks. Finished goods will be dispatched using owned/contracted dhonis and/or speed boats, as well as airfreight, and directly exported to buyers through Malé Port or Ibrahim Nasir International Airport.

2.5.2 Office, Laboratory and Security

A 180m^2 area has been allocated for office and laboratory. A small security hut will be located at the jetty to ensure that entry to the island is restricted.

2.5.3 Ranching Area

The sea cucumber ranching area is to be conducted in 3 farms covering a total of 3,100m2. It is located on the northwest lagoon. This ranching space is suitable for sea cucumber grow out since the lagoon area is clean. The area is also quite sheltered except during the southwest monsoon.

Details of the three enclosed farm areas are not available at this stage. It is believed that PVC coated wire mesh will be used for the enclosures, as it is strong, durable, and will not rust, making it ideal to withstand the strong currents/tides within the lagoon.

2.5.4 Waste Management

The sea cucumber only eats sand and does not harm the reefs in any way. The faecal droppings of a sea cucumber is mainly sand and, as such, does not pose a threat to the marine life or its environment.

Holothuria scabra are scavengers, feeding on debris in the ocean. Their diet consists of plankton and decaying organic matter found in the sea. They sift through the bottom sediments using their tentacles, serving a useful purpose in the marine ecosystem as they help recycle nutrients by breaking down detritus and other organic matter after which bacteria can continue the degradation process. Healthy sea cucumbers in a lagoon, even in high densities, are not known to have caused damage to fish or other marine fauna. In fact, evidence suggests that Holothuria scabra will provide a benefit to the oceanic environment when managed properly.

2.5.5 Culture Species and Characteristics

The focus of the project will be on sea cucumber culture, with the main species being Holothuria scabra, commonly known as sandfish. Various endemic species of sea cucumber including *Thelenota ananas* (*alanaasi* as locals call it) and the less favoured *Holothuria (Halodeima) atra*, locally known as *fulhi* or *holhi* that has been seen in the lagoon of

Boduhaikondi may also be used in the trials once the hatchery is established. Details will be provided in an Addendum to this report.

Though Holothuria scabra is not endemic to Maldives, it does fall within the distribution of Holothuria scabra worldwide. Known distribution of scabra are recorded from the coasts of east Africa, to the seas on the Arabian peninsula, in waters of Sri Lanka, off the coast of Sumatra in Indonesia, in the Philippines, and in South Pacific waters. They are generally found between the latitudes of 30 degrees N and 30 degrees S. Holothuria scabra is now present in the Maldives, having been cultured in Noonu atoll since the early 1990s and then distributed to nearby islands. Holothuria scabra has also recently been experimented in the lagoon of L. Fonadhoo by BluBridge Inc.

Holothuria scabra is an echinoderm of the holuthuroida class (has tube feet), in the aspidochirotida class (has tentacles), in the holuthuroida family (generally a circular body with single gonad), and of the Holothuria genus.

Holothuria scabra have the same general anatomy as other sea cucumbers. The gonads reside on one end of the sea cucumber and open through a single gonopore. The digestive system consists of a mouth, esophagus, stomach, intestine, cloaca and anus. The respiratory trees lie in the posterior of the body. The body wall of the scabra accounts for approximately 56% of total weight.

Holothuria scabra move by using their tube feet and through the use of their body wall. Scabra feed on sandy substrate and process the organic matter found in the substrate, only retaining 1% of that which they consume. They often burrow in the sediment (particularly in the heat of day). While growth rates vary significantly based on unique environmental conditions, we estimate an average monthly growth rate of 26 g per month in Maldives lagoons.

The scabra species live in tropical waters generally 1 to 10 m deep and rarely greater than 20 m deep. They prefer habitats with high levels of nutrients in the substrata and often in or near dense sea grass.

2.5.6 Growth Cycle and Procedures

Juveniles that have grown to over 5g in size will be brought from hatcheries and transferred to the lagoon ranching area and systematically assessed for growth and survival rates. While growth rates vary significantly based on unique environmental conditions, an average monthly growth rate of 26g per month is estimated for Maldivian lagoons.

2.5.7 Processing

Sea cucumbers can be processed anywhere between 200g to 1kg. The sea cucumbers must be kept alive in optimum condition until the time of processing. The procedure is as follows:

- Remove all coral and sand stuck to the exterior before removing from the ocean environment
- Gutting - if guts remain after harvest, make a small slit 2---3 cm on the underside of the sea cucumber near the anus and carefully remove all water and guts
- First boil - the initial boil is approximately 20 minutes but can range up to 2 hours
- Salt burying - bury the sea cucumber in rock salt to allow for the outer layer of body wall to decompose. Afterward, wash in seawater and rub vigorously to remove all hard spicules
- Second boil - boil with continuous stirring for 40-45 minutes
- Sun-dry and curing - arrange the sea cucumbers on proper drying racks allowing the air and heat to circulate evenly over the entire sea cucumber.

Typically, the wet-to-dry ratio is 10:1. The goal in processing is to create the highest quality product based on the following characteristics: large in size; regular in shape; having clean, straight and minimal cuts; completely dehydrated.

2.5.8 Stock Health

Experienced hatchery and grow out managers will monitor the health of our stock on a daily basis. Good water quality and controlled stocking density are the biggest factors to ensuring a healthy stock. In the hatchery, high water quality will be maintained by the use of a sand filter and a submicron filter AMF CUNO during the larvae culture stage. The number and biomass of H. scabra will be limited throughout the growth cycle to best practices within the industry to maintain high survival rates and maximize production. Estimated stocking density

in the grow-out lagoon will be 700 g per m^2 with feed added to ensure availability of nutrients for the specimens.

2.5.9 Work Plan

The proposed project will take about 1 year for completion. A tentative work plan is given in the Appendix.

2.6 Project Inputs and Outputs

The project has inputs in terms of human resources and natural resources such as water and fuel. The main output of the project is the successful culture and grow-out on a commercial scale of culture of Holothuria Scabra and endemic species such as *Thelenota ananas* (*alanaasi* as locals call it) or *Holothuria (Halodeima) atra* (locally known as *fulhi* or *holhi*). These inputs and outputs are summarised in Table 2-1 and Table 2-2.

Table 2-1: Main inputs of the proposed project

Input resource(s)	How to obtain resources
Workforce (human resource)	Constructional workers and employed staff during operation
Construction machinery and materials such as cement, pipes, etc.	Contractor's and/or imported or local purchase/rental
Food, water and other resources	Provided on site
Energy for construction and operation	Electricity from the island power grid and fuel for some machinery including trucks
Juveniles of sea cucumber	Bought from local suppliers/culture facilities
Sea cucumber feed	Use imported feed or seaweed from local lagoons

Table 2-2: Matrix of major outputs

Products and waste materials	Anticipated quantities	Method of disposal
Green waste from clearing for buildings	Minute quantity	Burnt on site or mulched for use in agriculture
Human waste	No. of staff x 95l/c/d	Septic tanks
Constructional waste	Small amount	Collected and disposed at designated landfill
Cultured/processed sea cucumber	N/A	Exported for sale/sold to local processors
Waste from sea-cages	Minute quantities	Dispersed by natural hydrodynamics in the area. If bottom gets stagnated, submersible pumps used to clean up and debris used as agricultural manure.
Waste water from processing	High amounts	Sewerage system of the island after pretreating

2.7 Need and Justification

With wild stocks under threat of over-fishing, aquaculture/mariculture ventures will minimize the need for wild capture fisheries supplies. In fact, the export of sea cucumbers has been on the rise for quite some time in the Maldives and this has put the wild fish stocks in danger of depletion. Such is the case of sea cucumber species, the fishery of which started in 1985 with harvest of nine species targeted exclusively for export. Due to its sedentary nature, sea cucumbers are easy to harvest with just a mask and snorkel. As a result, the resource was over-exploited starting with the most valuable endemic species (*Thelenota ananas*, or *alanaasi* as locals call it) to the less favoured *Holothuria (Halodeima) atra*, locally known as *fulhi* or *holhi*. This led to a ban on the use of SCUBA gear for harvesting sea cucumber in the mid-1990s, which was, however, not effectively implemented. Attempts to culture these endemic species are underway since 1995 with a project in Laamu Atoll (James 1996) but success has not been achieved so far. However, the imported alien species, Holothuria scabra is cultured quite effectively in Sh. Nalandhoo with millions of hatchery produced juveniles made available every year for grow-out production. Although this was an unregulated activity with no details of the hatchery available, the grow-out culture of this alien species has recently been introduced to a few islands in the neighbouring atolls. Environmental impacts have not been reported so far, except for concerns raised by local environmental NGO, Blue Peace, mainly due to lack of planning, organization and regulation. However, these trials are mainly in semi-enclosed bays or inland waters. Therefore, the grow-out on the lagoon floor would form an interesting study and may prove to contribute positively to the economy.

Sea cucumber is among the most exported fishery products in the country and over-harvesting has been identified as major direct threat to Baa Atoll ecosystem (Baa Atoll Conservation Programme, 5-year Strategy – 2009 to 2013). In that strategy paper, sea cucumber and grouper over fishing is listed among the medium-priority conservation issues to be addressed and among three specific priority issues apart including shark finning/overfishing listed as the only top priority issue to be addressed in terms of fish stock depletion. Therefore, commercial farming as proposed in this project will help to minimize depletion of wild fish stock of other endemic and locally important species of sea cucumber. The project will also help to increase the local production of seafood for export and to support national efforts for food security. The project will pave way for a profitable business

with several job opportunities while providing the know-how for further expansion of aquaculture activities in the country.

Aquaculture is making an increasingly significant contribution to the global seafood trade, as well as to domestic consumption, and will continue to grow due to stagnating wild capture fisheries supplies. The sedentary life of sea cucumbers makes them extremely easy to harvest, resulting in worldwide overexploitation and a global decline in stock levels. As supply decreases and demand increases the converging dynamics create high prices in the marketplace. “Sandfish” or Holothuria scabra, for example, range from USD100/kg to USD200/kg in processed form, creating a compelling opportunity for taking on the risk of aquaculture in this species.

The Indo-Pacific regions have harvested and traded sea cucumbers for over one thousand years, driven primarily by Chinese demand. Because sea cucumbers are a rich source of glucosamine and chondroitin, the animals are harvested for use in traditional Chinese medicine and cuisine. In Chinese cultures, sea cucumbers are a delicacy eaten on significant occasions throughout the year by the growing middle and upper classes. The ability to purchase processed sea cucumbers, also known as “Beche-de-mer” or “trepang”, is a status symbol for those able to afford the high retail prices found in local markets. Over the past decade the number of millionaires in China has grown 5X at the rate of 19% CAGR (BCG Wealth Market Sizing Database 2008). The increasing personal wealth in China, and other areas where sea cucumbers are consumed, will continue to drive long-term demand.

Figure 2-2: Proposed project concept

3 Project Alternatives

3.1 Introduction

This section looks at alternative ways of undertaking the proposed project. There are two basic options: (1) leave the problem as it is (no project option), or (2) take measures to resolve the problem (undertake the project options). If the project were to continue, it would be necessary to take economic, ecological and social aspects of the project into consideration and ensure that these concerns exist within a delicate balance. Neither the economic benefits nor the social and ecological concerns can be avoided. Therefore, it is important to consider all options and ensure that the best available option(s) is/are chosen to solve the issues/problems.

Not all the impacts of a project can be completely prevented, however, with the use of appropriate technology and management measures; the magnitude of most of these impacts can be either reduced or minimized. Nevertheless, the effectiveness of these technology and mitigation measures highly depends on the environmental condition and procedures in which they are applied in the field. On the other hand, there are complex and sophisticated procedures of minimizing environmental impacts by means of alternative methods to some of the activities. Often, alternate means are not economically competent with the extent of the project itself. However, to some of the activities where predicted impacts and its magnitudes on the environment are very adverse, alternate means must be applied considering long-term benefits from use of alternatives, as short-term environmental restorations can become very costly.

The following section describes and evaluates some alternatives in terms of locations and various project activities and methods of construction for the proposed project.

3.2 No project option

It should be noted that the “no project” option cannot be excluded without proper evaluation. In this report this alternative was considered as the baseline against which to evaluate the other options. The no project option takes the following arguments into consideration:

- Commercial scale developments may be difficult in the open water due to wave and tide.

- The details of the project are sketchy making it difficult to understand the project performance with reference to environmental and social factors.

The main advantages and disadvantages of the no-project option are given in Table 3-1.

Table 3-1: Advantages and disadvantages of the no project option

Strategy/option	Advantages	Disadvantages
Project is not undertaken at all	• The island will not undergo any modification. • Environmental impacts and costs related to proposed project may be avoided. • Island can be used for recreational purposes by locals and tourists	• Lost economic and social benefits due to the project including employment opportunities. • Lost opportunity for a medium scale commercial activity that may benefit the atoll and country. • Economic potential of the lagoon area may remain untapped for a long time. • Potential depletion of wild fish stock. • Potential government/public revenue lost

The no-project option also needs to be discussed in light of the proposed project. It is believed that some degree of environmental impacts will arise due to the proposed development of sea cucumber culture facility. Although there will be no negative social and environmental impacts if the proposed development does not go ahead, this will eliminate an important development that has direct linkages with the development of the socio-economic conditions around the project area.

The proposed project will bring numerous benefits to the communities of Ungoofaaru, Dhuvaafaru and other islands in the vicinity including job opportunities and direct and indirect revenue generating activities. In terms of socio-economic benefits, the proposed project will create job opportunities and various small business opportunities to the communities. This will bring more revenue to these communities. The proposed project will also contribute to GDP and state revenue. Hence, the proposed project is considered to be beneficial over the no-project option.

3.3 Alternative Uses

The island is an ideal size for a small tourist resort. Given that there are a few resorts in Raa Atoll and the bed capacity has only increased recently with the opening of Maamigili Resort

in 2014, the island is suitable for tourism development although there are several islands in Raa Atoll under development. However, since the island is under the jurisdiction of the Ministry of Fisheries and Agriculture and the decision to develop the island for fisheries activity has already been made, it is not worth considering the possibility of the development of the island for tourism purposes at this stage. However, if the proposed project were found to be unsuccessful, the possibility to undertake the more feasible tourism activity exists. However, the dependence on tourism alone is risky and it would be worthwhile to create successful fishery projects.

3.4 Alternative species

Sea cucumbers are among the most exported fishery products in the country and over-harvesting has been identified as major direct threat to Baa Atoll ecosystem (Baa Atoll Conservation Programme, 5-year Strategy – 2009 to 2013). In that strategy paper, sea cucumber over fishing is listed among the medium-priority conservation issues to be addressed and among three specific priority issues apart including shark finning/overfishing listed as the only top priority issue to be addressed in terms of fish stock depletion. Therefore, sea cucumbers have conservation value due to depletion of wild stock. However, the particular species of sea cucumber to be used, *Holothuria scabra*, is considered exotic or alien to the Maldivian waters so far although the broodstock is locally produced and made available in large quantities. Therefore, their introduction to the wild shall be carried out with great caution.

While the project is focused on H. Scabra culture, the endemic species such as *Holothuria fuscogovilla* may also be considered in later stages as a research and development species. However, H. fuscogovilla is hard to find due to over exploitation, although Laamu has been known as home for fuscogovilla and some research has been undertaken. Another species that is common locally is *Thelenota ananas* (known locally as *alanaasi*) and the less favoured *Holothuria (Halodeima) atra* (locally known as *fulhi* or *holhi*) have also been over-exploited. However, culture techniques have not been developed and broodstock is not available. These sea cucumbers are found in deep waters at about 30 to 40m (James 1996) and the culture of Holothuria fuscogovilla was initiated in 1995 with assistance from FAO, the results of which were never published and to date no culture techniques exist in the country for these species. Therefore, juveniles of such endemic species can only be used in the proposed project if and

when they become available or if appropriate culture techniques have been studied developed during the feasibility stage. It would be worthwhile trying to develop culture techniques for these species, given that they can be safely released into the wild to enhance natural stocks without the fear of competition in the wild (Ali 2012).

The option of grow out of different species in the same tropic level such as lobsters, giant clams, seaweed, oyster is considered feasible (CDE 2010). Cage culture for spiny lobsters, for instance, is also a well-developed industry in some countries such as India and Vietnam. This could be tried in the lagoon assuming the Fisheries Ministry will approve lobster hatchery and grow-out farming in the Maldives.

Grouper, snapper or prawns in upper trophic levels, may also be co-cultured, as has been discussed in CDE (2010).

3.5 Alternative materials and design

For the design of the sea pen barrier structure, the proposed design may be altered in consideration of possible escape of juveniles out of the barrier. However, this has already been taken into consideration in the proposed design, similar to the V-shaped loop at the top to guide the juveniles back into the cage as suggested by Reichenbach, *et al* (1998). Furthermore, a high profile cage may also be experimented, however, Reichenbach, *et al* (1998) suggests low profile cages, as proposed in this project, due to high currents.

3.6 Alternatives to Jetty and Shore Protection

The primary alternative to the proposed concept of 2 jetties would be a small harbor on the eastern side. This will suffice for the proposed operation. The harbor can be developed with a jetty extending from the northeast end of the island into the deep lagoon with a breakwater to keep the area calm during northeast winds. The alternative location for a harbor would be the location of the proposed growout cages and moving the grow-out cages to the opposite side. This will involve shorter channel but would require more dredging of the harbor area, therefore, it is not recommended. There will also be greater impacts on the reef than the northeast side.

There is no better alternative for the proposed location of jetties since the two jetties have been located in the best location in terms of being in the lee of the island during both monsoon, based on prevalent wind directions.

There are no feasible alternatives to the shore protection structures except the material to be used. Both geotextile containers and rock boulders are equally appropriate to the given design with preference to rock structure.

3.7 Preferred alternatives

It is recommended to start immediately with locally available broodstock of H. Scabra and continue to research into the culture techniques of endemic species such as H. Fuscogovilla. Strict control and monitoring measures shall be in place to ensure that the species do not escape into the wild. Although, introduction of H scabra in the wild under the proposed project is not considered to have adverse impacts, there are several uncertainties owing to which research (through regular monitoring) will help to identify the concerns and address them appropriately. This improves the management of the proposed aquaculture project and provides information that would help to replicate the project in other areas of the country.

The preferred alternative for jetties would be a small harbour on the northeast lagoon area. However, this alternative is not preferred over the proposed jetties, as the jetty option involves lesser degree of dredging and does not have a longterm change to the hydrodynamics around the island.

It is also recommended to try mixed farming in the deep lagoon area including finfish species, lobsters and shellfish culture such as pearl culture along with sea cucumber. Mixed farming is healthy for ecosystems at multi-trophic levels. In fact, some studies have indicated that excreta from shellfish stimulate the growth of phytoplankton species, which are important for healthy reef ecosystems while finfish excrete inhibit their growth (Arzul, G et al 2001).

4 Legislative and Regulatory Considerations

This section will 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. The proposed project is expected to conform to all of the policy and regulatory aspects outlined here. This section outlines and summarizes key policies, applicable laws and regulations and regulatory bodies regarding environmental protection, air transportation in the Maldives. Also, it outlines some international and regional obligations that the country has to meet in terms of sustainable development, environmental management and protection as well as safety of civil aviation and air transportation systems.

The proposed project will be subject to the key regulations including Environmental Protection and Preservation Act (No. 4/93) and Fisheries Act (No. 2/2001) of the Maldives. Thus, it must satisfy the EIA process and get approval as well as conform to the regulations under the Fisheries Act.

4.1 Policy Guidance

The policy guidance on the development of the proposed project is taken from a number of policy documents prepared by the Government of Maldives on sectoral developments. Key documents outlined in this EIA are currently being implemented towards sustainable development of the country.

4.1.1 National Framework for Development 2009-2013

Important environmental policy guidance is also given in the Strategic Action Plan (SAP) of the National Development Framework for 2009-2013. Due to the fragile nature of the country's environment, all the development activities must ensure that appropriate care is taken to protect the environment. Environmental sustainability is the basis for socio-economic development, hence, the SAP outlines the key environmental policies that will be implemented in the country for environmental protection and sustainability, while one of the key environmental goals of the country is to protect and preserve the natural environment to ensure prosperous economic development. The environmental policies outlined in the SAP include;

Policy 1: Strengthen EIA process with an emphasis on EIA monitoring.

Policy 2: Conserve and sustainably use biological diversity and ensure maximum ecosystem benefits.

Policy 3: Develop resilient communities addressing impacts of climate change, disaster mitigation and coastal protection.

Policy 4: Strengthen adaptation and mitigation responses for beach erosion and develop a system to assist communities where livelihood and property are affected by beach erosion.

Policy 5: Ensure management of solid waste to prevent impact on human health and environment through approaches that are economically viable and locally appropriate.

Policy 6: Ensure protection of people and the environment from hazardous waste and chemicals.

Policy 7: Improve air quality to safeguard human health.

Policy 8: Enable a fully functional decentralized environmental governance system.

Policy 9: Develop a low carbon economy to achieve Carbon Neutrality by 2019.

Policy 10: Inculcate environmental values in the society and enable environmentally friendly lifestyle.

The Ministry of Environment and Environmental Protection Agency takes the lead role in implementing the above national policies through various strategies and regulatory measures.

Food security and increasing exports in the fisheries sector is an important priority of the Government. In this regard one of the policies in relation to the fisheries sector development, which are of relevance to this project, have been identified SAP.

Policy 1: Expand the scope of the fisheries sector in the economy and diversify fish and marine products in a sustainable manner.

Policy 3: Facilitate business development, trade and export promotion in fisheries

Policy 5: Promote research in fisheries and introduce fish breeding and productivity.

As stated in Policy 1, sustainable development of the fisheries sector is the key and it would be important to undertake feasibility research and develop culture techniques and facilities based on continued research and monitoring.

One of the strategies under Policy 5 is to establish a Mariculture Development Corporation. Policy 5 also includes the strategy to identify and lease potential islands, lagoons and water bodies for mariculture development. It is under this policy that the government is keen to setup the proposed experimental mariculture facility in L. Fonadhoo lagoon.

4.1.2 Third National Environment Action Plan

NEAP 3 sets out the agenda for environmental protection and management in the Maldives for the five year period 2009-2013. This plan is targeted to achieve measurable environmental results that matter to the people of the Maldives.

The aim of developing NEAP 3 is to protect and preserve country's environment and properly manage natural resources for sustainable development of the country and encompasses ten principles, six strategic results with targeted goals to be achieved under each result.

The key principles of the NEAP 3 are:

Principle 1: Environmental protection is the responsibility of every individual

Principle 2: Achieve results

Principle 3: Promote and practice sustainable development

Principle 4: Ensure local democracy

Principle 5: Inter-sectoral co-ordination and co-operation

Principle 6: Informed decision making

Principle 7: Precaution first

Principle 8: Continuous learning and improvement

Principle 9: Right to information and participation

Principle 10: Environmental protection complements development

The six strategic results of NEAP3 are: resilient islands; rich ecosystems; healthy communities; safe water; environmental stewardship; and a carbon neutral nation with 30 result oriented environmental goals that will be achieved in the span of the NEAP 3.

4.1.3 Maldives National Strategy for Sustainable Development 2009-2013

The Maldives National Strategy for Sustainable Development (NSSD) outlines the key objectives, principles and goals that the country will embark toward achieving sustainable development. Hence, the overall direction of the NSSD is to build a nation which appreciates the true value of the natural environment, utilizes its natural resources in a sustainable manner for national development, conserves its limited natural resources, has built the capacity to learn about its natural environment and leaves a healthy natural environment for future generations.

The guiding principles outlined in the NSSD are:

Principle 1: Promotion and protection of fundamental human rights

Principle 2: Equity within and between generations

Principle 3: Democratic and open society

Principle 4: Full participation of businesses and civil society

Principle 5: Policy coherence and coordination

Principle 6: Use best available knowledge

Principle 7: Precaution first

Principle 8: Make polluters pay

While the country will be steered in accordance with the underlying principles of NSSD, the country aims to achieve very important environmental goals, including; adapting to climate change, protecting coral reefs, achieving carbon-neutrality in energy, ensuring food security,

establishing a carbon neutral transport system, protecting public health and achieving full employment and ensuring social security.

4.1.4 National Biodiversity Strategy and Action Plan

Maldives was one of the first nations to ratify the United Nations Convention on Biological Diversity (UNCBD). The objectives of the Convention 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".

Based on the requirements under this framework convention, the Maldives has developed the National Biodiversity Strategy and Action Plan (NBSAP) in 2002, which was recently revised. The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities due to care has to be given to ensure that the national biodiversity strategies are adhered to. The project is in line with the spirit of the UNCBD and NBSAP by helping to protect wild fish/marine resource stock.

4.1.5 Waste Management Policy

As waste management has been identified as a key environmental issue in the Maldives, a National Solid Waste Management for the Republic of Maldives was developed in 2007 as an important step towards mainstreaming waste management in the country. The key strategic principles outlined in the document include; establishing polluter pay principles, integrated solid waste management, best practice environmental option (BPEO), best available technology not entailing excessive costs (BATNEEC), proximity principle and private sector participation. It is an important priority of the Government of Maldives as identified in the policy document to setup regional waste management facilities and island waste management centres and decentralizing waste management administration. Hence, the key policies relevant to this project include;

Policy 1: Establish a governance structure for solid waste management which will distribute clearly delineated roles and responsibilities for solid waste management at island, regional and national levels

Policy 2: All waste producers have a duty to manage the waste they generate

Policy 3: Waste will be management and disposed as close as possible to the place of their generation

Policy 8: Private sector participation (PSP) will be facilitated where it is financially for both government and private sector.

Establishing a proper mechanism of waste management and disposal will be vital for the overall operation of the project and the waste management practices both during construction and operation of the project will closely adhere to the policies and principles taken as a priority of the government.

4.2 Regulatory Bodies

4.2.1 Ministry of Environment and Energy

The primary environmental institution in the Maldives is Ministry of Environment and Energy (MEE). It is mandated with formulating policies, strategies, laws and regulations concerning environmental management, protection, conservation and sustainable development. The Minister of Environment or a designate gives the environmental approval or clearance to EIA by an Environmental Decision Statement. Additionally, MEE is responsible for formulating relevant laws and regulations, policies and strategies concerning energy, water and sanitation, waste and infrastructure.

4.2.2 Environmental Protection Agency (EPA)

EPA is the key regulatory body on environment, which is an autonomous body formed under the umbrella of MHE. It is mandated with implementing the EIA process in the Maldives, implementing the Environment Act and subsequent regulations on behalf of MHE, regulating water and sanitation, biodiversity conservation, waste management and coastal zone management. Also, it is responsible for developing environmental standards and guidelines in the country.

4.2.3 Ministry of Fisheries and Agriculture

Ministry of Fisheries and Agriculture is the state institution responsible for regulating the fisheries and agriculture sectors for the sustainable management and development of fisheries and marine resources as well as agriculture. With that mandate, the Ministry approves fisheries and agriculture projects in the country, issues licenses for related research, culture and fish processing, leases uninhabited islands and monitors and regulates fisheries and agriculture projects.

The project has been awarded to the Proponent by the Ministry of Fisheries under a bidding process based on the outcome of the bid. The development concept has also been approved and the approved concept is included in the Appendix.

4.2.4 Atoll/City Councils and Island Councils

Under the Maldives Decentralization Law, elected Atoll Councils, City Councils and Island Councils have been formed as regulatory bodies dealing directly with atoll, cities and island issues. In this regard, some of the development projects are subject to approval of these councils through a public consultation process. This project does not require Council approvals as yet. However, for the proposed project, EPA requires that a copy of the final draft of the EIA report be submitted to Raa Atoll Council and receipt of communication provided to EPA or attached to the EIA report.

4.3 Laws and Regulations

There are a number of laws and regulations relating to environment in the country. Only relevant laws and regulations have been outlined in this section.

4.3.1 Environmental Protection and Preservation Act

The Environmental Protection and Preservation Act of the Maldives, EPPA (Law No. 4/93) provides the basic framework for environmental management including Environmental Impact Assessment (EIA) process in the Maldives, which is currently being implemented by EPA on behalf of MHE.

Clause 2 of the EPPA mandates the Ministry of Environment to formulate policies, rules and regulations regarding the environment.

Clause 5 of this Act specifically provides for environmental impact assessment (EIA), a tool implemented to attempt to integrate environmental issues into development decisions. According to the Clause, environmental impact assessments are a mandatory requirement for all economic development projects.

Clause 6 of the EPPA gives the Ministry of Environment the authority to terminate any project that has an undesirable impact on the environment.

Clause 7 of the EPPA refers to the disposal of oil, wastes and poisonous substances in to the Maldivian territory. According to this clause, any type of waste, oil, toxic gas or any substance that may have harmful effects on the environment should not be disposed within the Maldivian territory. If, however, the disposals of such substances become absolutely necessary, the clause states that they should be disposed only within the areas designated for that purpose and if incinerated, appropriate precautions should be taken to avoid harm to the health of the population.

Furthermore, clause 9 sets a fine between five and five hundred Rufiyaa for minor offenses in breach of this law and a fine of not more than one hundred million Rufiyaa for major offenses. The fine shall be levied by the Ministry of Environment or by other government authorities designated by that Ministry in case of minor offenses.

Finally, Clause 10 of EPPA gives the government of the Maldives the right to claim compensation for all damages caused by activities that are detrimental to the environment.

The Environmental Act or Law 4/93 is the single most important legal instrument with regards to environmental management and it gives very high prominence towards safeguarding the environment with regard to all the development activities. Under this Act, the Ministry of Environment have developed regulations and guidelines concerning the environmental protection through implementation of EIA procedures.

4.3.2 Environmental Impact Assessment Regulation 2012

This EIA is subjected to the EIA Regulations 2012. This EIA Regulation is currently only in Dhivehi and an official translation is awaited. The Regulation sets out the criteria to determine whether a development proposal is likely to significantly affect the environment and is therefore subject to an EIA. Schedule D of the EIA Regulations defines the type of

projects that would be subject to Environmental Impact Assessment. Aquaculture and mariculture are among those.

The main purpose of this Regulation is to provide step-by-step guidance for proponents, consultants, government agencies and general public on how to obtain approval in the form of an Environmental Decision Statement.

4.3.3 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was issued by the Ministry of Environment in 2006. Clause 5 (a) of the Regulation states that prior to the commencement of any project(s) that would require the indiscriminate removal and transplanting 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 an Environmental Impact Assessment report.

Article 8 (a) requires permission be obtained from Ministry of Environment, if more than 10 coconut palms that are of a six of 15ft (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 (now Island Council) (Article 8 (c)).

This regulation also provides particular protection to the following:

- coastal vegetation extending 15 meters into the island;
- all trees and palms growing in and within 15m around mangrove and wetland areas;
- all trees and palms growing in protected areas; and
- trees and palms that are unique in shape, structure or character

The proposed project does not involve indiscrete removal of trees at any of the land-based sites although a few shrubs and small trees may have to be cut or transplanted. If necessary only a few mature trees including coconut palms would need to be removed.

4.3.4 Regulation on Sand and Aggregate Mining

This regulation disallows sand mining from uninhabited islands that have been leased, sand mining from the coastal zone of other uninhabited islands and aggregate mining from uninhabited islands that have been leased and from the coastal zones of other uninhabited islands.

This regulation would not have any implication on the project since mined sand and aggregate will not be used in any of the project activities but cements and cement blocks as well as imported river sand and aggregates will be used.

4.3.5 Desalination Regulation

Desalination Plant Regulation (2002) states that all sea water desalination plants installed and intended to supply water to 200 or more people or large scale agricultural needs or tourism related activity need to be registered prior to the operation of the plant. Therefore, it would be necessary to consider the impacts of desalination plant in this EIA so that registration can be done without further environmental scrutiny. Desalination plant registration is required to be renewed every five years. Therefore, regular monitoring shall be undertaken in order to carry out and efficient renewal process.

4.3.6 Dredging and Reclamation Regulations

The Dredging and Reclamation Regulations was gazetted on 2 April 2013 as Regulation No. 2013/R-15. This regulation is currently in Dhivehi and an English translation is awaited. Clause 6 of the Regulation requires applying for approval under this Regulation by submitting the project details, land use plan, project justification and scaled maps of existing site plan and site plan with proposed project components. The EIA process can be commenced once EPA/Ministry of Tourism approves the application for coastal modification.

Clause 7 provides the conditions for dredging, clause 8 for reclamation and clause 9 for beach nourishment or beach enhancement. Clause 9 is of specific relevance to beach nourishment projects. Clause 9(a) states that beach nourishment shall be done up to 10m from the registered shoreline. Clause 9(b) identifies that sand for beach nourishment shall be taken from an area (borrow area) that is not prohibited under clause 13 of the Dredging and

Reclamation Regulation. Clause 13(c) states that borrowing material from the following areas are prohibited.

1. 100m shore-wards from the reef line
2. 500m seawards from the reef line
3. 50m from the vegetation line
4. Protected Area or Environmentally Sensitive Areas (ESA) identified under Law No. 4/93 (Environmental Protection and Preservation Act of the Maldives).

Clause 13(d) restricts to borrow material or dredge or reclaim within 200m of a Protected Area or ESA identified in 4 of Clause 13(c). Clause 13(e) states that those areas or islands where the reef extent (distance from shore to reef edge) is less than 300m, dredging and reclamation may be done in consultation with the EPA. Clause 13(f) gives the EPA the authority to restrict borrowing sand from those locations from which dredging or borrowing sand has been approved earlier, if the EPA finds that the area is environmentally significant or worthy of protection or preservation. Clause 14 identifies the options for disposal of dredge material which include land reclamation, construction, levelling of land, shore protection and other activities approved under the EIA process or EIA Regulations. Clause 14 also states that land levelling shall be done with minimal disturbance to wetland areas. Clauses 15 and 16 provide the details of area (size) that can be dredged and reclaimed respectively. Clause 17 requires that a scaled as-built drawing indicating the new shape and size of the island upon completion of reclamation shall be submitted to the EPA. Clause 18 gives the EPA the right to terminate a project that has been seen to cause significant environmental damage and to claim compensation under the Regulation on Environmental Liability (2011/R-9). Clause 19 further reinstates the compensation claims under the Regulation on Environmental Liability.

This regulation may have some relevance to the channel component of the proposed project. However, there will be no major dredging involved, therefore, approvals given by the Ministry of Fisheries is considered sufficient for the purpose. If required following EIA approvals, dredging application may be submitted to the EPA.

4.3.7 Regulation on Fuel Storage, Handling and Usage

The Regulation on Fuel Storage, Handling and Usage (2015/R-160) came into effect recently on 12 August 2015. The following clauses of the regulation may be of relevance to the proposed project.

Clause 4 deals with installation, registration and inspection of fuel storage facilities. The following sub-clauses in this clause are of relevance.

a. Fuel storage facilities shall be established according to the Regulations and shall have appropriate fire safety and protection systems.
b. All fuel storage facilities shall be registered with the Ministry of Defense and National Security as per the Regulations
c. The Ministry reserves the right to inspect the facilities prior to registration and every six months thereafter in the presence of the Developer or Developer's designate. In case of rectification

Clause 6 considers the requirements of petrol storage facilities. This may not be of relevance to the proposed project.

Clause 11 states the design requirements for fuel/petrol storage tanks/containers. The maximum capacity allowed for underground tanks is given as 40,000litres. The containers/tanks should be separate from other buildings such as convenience stores. Requirements for overhead tanks are also provided.

Clause 12 discusses about the requirements for petrol dispensers and filling points and Clause 13 prohibits keeping wet cells, acids and pressurized containers in petrol sheds or petrol storage areas.

Clause 14 to Clause 17 states the requirements for the installation of diesel and kerosene storage and handling facilities. These are similar to those for petrol sheds and handling facilities.

Clause 18 discusses the requirements for fuel delivery line. Fuel delivery lines are required to be kept underground and the pipes are required to conform to BS EN10025 and BS EN10296 or similar international standards. The delivery line is required to be buried at safe depth from ground within a trench that can contain the entire volume of the pipeline in case of breakage.

Clause 19 provides definitions and clause 20 penalties. The penalties vary from fines of MVR5000 to MVR25000 and withdrawal or cancellation of permits depending on the severity of the offense.

This regulation may be of relevance since fuel storage for powerhouse operation is required.

4.3.8 Electricity Regulations and Guidelines

The Maldives Energy Authority has formulated a General Electricity Regulation and also recently drafted a Service Providers Code for electricity service providers and Guidelines for the power system approvals and standby power generation have been issued. According to these Regulations and Guidelines, all power plants need to be registered and environmental clearance is required prior to registration. Therefore, this EIA will look at the environmental aspects of power generation for the proposed facility in order to assist the powerhouse registration process, when and where necessary.

4.3.9 Regulation on Environmental Damage Liabilities

Under the Environmental Protection and Preservation Act (No. 4/93), the Ministry of Environment formulated the Environmental Damage Liabilities Regulation in February 2011, which encompasses the basis to avoid environmental deterioration, extinction of biological resources, environmental degradation and avoid wastage of natural resources. The main purpose of this regulation is to stop unlawful activities on environment and adequately implement a fining procedure for violations as well as implement a compensation mechanism on environmental damages. Its Schedules form the basis for levying fines on various environmental components and activities. Hence, the proposed project will be subject to this Regulation for any activity outside of the EIA scope and Environmental decision Statement.

4.3.10 Waste Management Regulation

The Waste Management Regulation (Regulation No. 2013/R-58) came into effect in August 2013. The objective of Waste Management Regulation is to implement the National Waste Management Policy; through which it aims to protect the environment by minimizing the impact of waste on the environment, including the impact of waste on human health, establishing an integrated framework for minimizing and managing waste in a sustainable manner and establishing uniform measures to reduce the amount of waste generated. The

regulation also ensures waste is reused, recycled and recovered in an environmentally sound manner before being safely treated and disposed. The regulation covers the management of general, hazardous and special waste. Wastes arising from paints and chemical solvents are considered as special waste.

Clause 1.4 of this regulation is of relevance to the projects under consideration. This clause is for construction waste and it states that;

a. Building construction works shall be planned and organized in a manner that there is minimal waste

b. Measures shall be in place to minimize construction waste

c. Reusable or recyclable waste among demolition/construction waste shall be reused or recycled

d. Construction waste shall be kept at the demolition site until demolition is completed

e. Demolition of buildings shall be done with minimal disturbance due to dust and emissions to the environment and people living in the vicinity.

This regulation was effective from 6 January 2014 and EPA would be responsible for the implementation this regulation. The proposed project will follow the regulation.

4.3.11 Dewatering Regulation

Dewatering regulation (2013/R-1697) was published on 31 December 2013 and has become effective from 1 February 2014. The Regulation covers the following:

- Exceptions under the Regulation including dewatering for cleaning household wells and extraction for agricultural purposes.
- Application for dewatering permits including application form, information required such as size, water quality, work schedule, method of dewatering and disposal location.
- Fees for dewatering permits including MVR500.00 for administrative fees, MVR500 per day for the first 28 days, MVR1000 per day for first extension, MVR1500 per day for second extension and MVR 2000 per day for third extension.
- Water quality testing requirements including parameters that has to be tested

- Provision of information (in writing) regarding dewatering to entities within 30m from the dewatering location and ensuring that in case of difficulty in getting water from neighbouring wells, providing 250litres or RF30 as compensation for each household.
- Provisions for disposal of dewatering effluent.
- Reporting requirements.
- Procedures for termination of work and fines levied.

This regulation is not relevant to the project as the foundation for the buildings would be above the groundwater lens and, therefore, no dewatering would be required. Yet, due to the superficial nature of the water lens, if dewatering becomes necessary, appropriate approvals shall be sought and the dewatering regulation adhered to.

4.3.12 Fisheries Act and Regulations

The Fisheries Act (Law No. 5/87) is the umbrella law that governs the affairs of the fishing industry in the Maldives. Articles 3(a) of the Fisheries Act is of specific relevance, which states that the Fisheries Ministry shall formulate and administer regulations on matters relating to fisheries. However, there are no specific regulations on aquaculture or mariculture in the Maldives despite small scale practice and potential for large scale production. The Licensing Regulation (No. 01/2001), which specifically includes licensing for aquaculture, is the primary regulation of relevance to the proposed project. Clause 6 specifies the specific requirements for obtaining a license for aquaculture projects. These include:

- Documentary evidence that the Proponent has legal rights over the proposed land
- All required approvals under the Environmental Protection and Preservation Act
- Health Certificate issued by Maldives Food and Drug Authority
- Approvals from other government institutions, if required

Clause 6 (b), (c) and (d) states that the license is issued for a particular place and for particular species and the license cannot be used for other places and species than those defined by the License. Therefore, it is important that the Proponent takes this into consideration when applying for the License. This is to say that if the Proponent is desirous of mixed culture, such as both grouper and sea cucumber, they should ensure that the license is for both species. The regulation also states that the species that can be approved shall be determined by the Fisheries Ministry and so the Proponent shall have documentary evidence

to support that the Ministry has at least conditional approval for the growout of *Holothuria scabra* in a natural setting.

Live Animal Import Regulation may also be of relevance. This regulation defines the requirements for maintaining health standards and quarantine procedures while in transit and upon importation into the country.

4.3.13 Project Compliance

The proposed sea cucumber culture and grow out facility project was won by competitive bidding process conducted by Ministry of Fisheries and Agriculture. Copies of the relevant approvals/communications are included in the Appendix. The project will use Holothuria scabra for the culture. The project does not involve the use of chemicals including pesticides and chemical fertilizers.

The environmental clearance required for the project is one of the conditions of approval by the Ministry of Fisheries and Agriculture and is a core requirement for all such development projects in the Maldives. This EIA report fulfils that requirement and is expected to result in a Decision Statement to proceed with the project.

The species proposed to be cultured is *Holothuria scabra* that have been cultured in Sh. Nalandhoo. To increase the genetic diversity and improvement of brood stock additional sea cucumbers (Holothuria scabra) maybe bought from Nalandhoo. It is also possible to import Holothuria scabra from neighbouring countries to improve genetic diversity and to decrease the risk of disease.

4.4 International and Regional Context

The major global issue facing the Maldives is climate change, global warming and subsequent sea-level rise. The small size of the islands and their low elevation above MSL makes possible impacts of it very serious. Consequently, the country plays a prominent role in fore-fronting environmental issues faced by many other small islands developing states including the Maldives in the international arena. The Maldives is therefore, a party and signatory to various international conventions and declarations. These include;

- UN Convention on the Law of the Sea – UNCLOS (1982)

- International Convention for the Prevention of Pollution of the Sea by Oil (1982)
- Vienna Convention for the Protection of the Ozone Layer (1985)
- Montreal Protocol on Substances that Deplete the Ozone Layer (1987)
- Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (1989)
- The London Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1990)
- Agenda 21 and the Rio Declaration of the United Nations Conference on Environment and Development (1992)
- Convention on Biological Diversity (1992)
- United Nations Framework Convention on Climate Change (1992)
- The Copenhagen Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1992)
- The Montreal Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1997)
- The Beijing Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer (1999)
- Washington Declaration on Protection of the Marine Environment from Land-Based Activities
- Kyoto Protocol to the United Nations Framework Convention on Climate Change (1998)
- Cartagena Protocol on Biosafety (Maldives acceded on 2 September 2002)
- United Nation Convention to Combat Desertification (2002)

The Maldives is also a key player in formulating and adopting various regional plans and programmes to protect the environment by continuously participating in various activities organized by regional bodies such as SACEP, ESCAP and SAARC. As a result the Maldives is committed to the following;

- SAARC Environment Action Plan adopted in 1997 in Male'
- SAARC Study on Greenhouse Effect and its Impact on the Region
- South Asian Regional Seas Action Plan and Resolutions concerning its implementation (1994)
- SAARC Study on Causes and Consequences of Natural Disasters, and

- South Asian Seas Programme initiated by SACEP
- Male' Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia (1998)

4.4.1 Project Compliance

UN Convention on Biological Diversity is of relevance to the proposed project and to some extent the UNFCC and the Kyoto Protocol.

The proposed aquaculture project upholds the spirit of the UN Convention on Biological Diversity in that it helps to protect and conserve the wild fish stock in the farming as well as sourcing of fish seed from the local environment. The introduction of exotic species into the wild is the only concern and shall be addressed in the best possible manner to avoid genetic modifications and behavioural changes to the endemic population as well as to affect the biological diversity in the local environment.

The Maldives has been taking steps to address global climate change and the declaration by the President in 2009 to make the Maldives the world's first carbon neutral country by 2020 requires dramatic changes to the way we produce electricity or use energy. Hence, alternative energy sources shall be given priority in the implementation of the proposed project, especially during the commercial phase, for which a separate EIA will be documented..

4.5 Environmental Permits required for the Project

4.5.1 EIA Decision Statement

The only environmental permit to initiate proposed works would be a decision regarding this EIA from the Environmental Protection Agency (EPA). The EIA Decision Statement, as it is referred to, shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Statement may only be given to the Proponent after a review of this document following which the EPA may request for further information or provide a decision if further information is not required.

5 Existing Environment

5.1 Introduction

Conditions of the existing environment of the study area were analysed by using appropriate scientific methods. Field surveys were undertaken to get further understanding of the existing environment of the island. These surveys were carried out during field visit to the island from 28th and 29th March 2016 to collect baseline data. Before the trip was undertaken all existing information regarding the site was gathered.

The following components of the existing environment were assessed;

- Coastal environment including shoreline and currents using drogue
- Bathymetry of the project site
- Marine ecology of the proposed project areas
- Marine water quality
- Existing landuse and additional land requirements
- Socio-economic aspects

5.2 Methodologies

Conditions of the existing environment of the study area were analysed by using appropriate scientific methods. The environmental components of the study area were divided into marine, coastal and terrestrial resources. The marine environment of the island covered the lagoon, reef flat areas and seagrass beds in the project area. The coastal environment covered the beach, the beach rock formations and coastal processes including currents, tides and wave climate. The terrestrial environment covers the vegetation of the proposed coastal structures.

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

5.2.1 Location identification

The location of data collection sites have been marked using handheld GPS. Figure 5-16 shows the data collection and sampling locations.

5.2.2 Marine Water Quality

One of the main environmental components that would be affected by implementing the project would be marine water quality. Water quality was assessed in-situ for most of the parameters using a YSI handheld water quality logger and Hach portable turbidity and TSS meter. Water quality was assessed at different locations within the impact zone. Water testing was also undertaken for a marine location identified as control marine reef survey locations.

All water samples were taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. GPS coordinates of each water sampling location was taken. The samples were analysed for the following parameters as indicated in the environmental monitoring manual issued by the EPA recently.

Table 5-1: Water quality parameter optimum conditions

PARAMETER	OPTIMAL RANGE	REFERENCE
TEMPERATURE	18ºC and 32ºC Changes should not surpass 10C above the average long term maximum	GBRMPA, 2009
SALINITY	3.2% - 4.2%	GBRMPA, 2009
PH	8.0-8.3 Levels below 7.4 pH cause stress	
TURBIDITY	3-5 NTU >5 NTU causes stress	Cooper et al. 2008
SEDIMENTATION	Maximum mean annual rate 3mg/cm2/day Daily maximum of 15mg/cm2/day	GBRMPA, 2009
NITRATES	<5 mg l-1 NO3-N	UNESCO/WHO/UNEP, 1996
AMMONIA	Max. 2-3 mg l-1 N	UNESCO/WHO/UNEP, 1996
PHOSPHATE	0.005 - 0.020 mg l-1 PO4-P	UNESCO/WHO/UNEP, 1996
SULPHATE	2 mg l-1 and 80 mg l-1	UNESCO/WHO/UNEP, 1996
BOD	< 2 mg l-1 O3	UNESCO/WHO/UNEP, 1996
COD	< 20 mg l-1 O2	UNESCO/WHO/UNEP, 1996

Samples that were brought for laboratory testing were taken to the MWSC laboratory for testing for those parameters that have not been tested in-situ.

5.2.3 Coastal processes

Beach profiles have not been taken as the project does not involve major coastal modification. Therefore, only shorelines have been taken using GPS.

A purpose built drogue integrated with Trimble Juno GPS was released at selected locations around the project site, especially the main impact areas to understand general longshore currents around the island. Several drogues were done. Repetitive long term measurements at

the same locations would help to understand the general current patterns that will be used in assessing impacts as well as designing structures in the future.

5.2.4 Bathmetry

Bathymetry at the project location was done using GPS integrated echosounder. The results are given in Figure 5-17.

5.2.5 Marine Ecology

Marine environmental surveys were conducted to collect data on key environmental components (i.e. the coral reef system) that will be impacted due to the development. Purposes of the surveys are to define and establish marine environmental baseline conditions for impact evaluation during and after the proposed project implementation. Surveys were based on standard marine environmental survey techniques (English, *et al* 2007) so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities as well as operation of the facility. These surveys should be continually repeated to assess the short-term and long-term impacts on the marine environment.

5.2.6 Socio-economic conditions

Socio-economic condition was assessed through secondary data sources.

5.3 Overview of Project Site

As described earlier, Boduhaikondi is a small island surrounded by crystal clear water with a shallow lagoon and a patch of deeper lagoon on the southeast of the island. The island is surrounded by a beautiful housereef with an abundance of corals and fish. The housereef has a naturally deep area on the east, which is used for entrance. However, there may be a need to clear the channel due to the presence of rock outcrops in the path.

5.4 Current status of Sea Cucumbers

Approximately 20 species of sea cucumbers have been recorded from the Maldives, of which nine species were commercially exploited (Adam 2006), which are generally dried and exported to Singapore, Hong Kong and Taiwan. Harvesting of holothurians started in 1985 resulting in rapid expansion leading to overexploitation especially the high valued but less abundant species like *alanaasi* (*Thelenota ananas*) and *batu* (*Microthele nobilis*) as well as the less favoured *Holothuria (Halodeima) atra*, locally known as *fulhi* or *holhi*. Therefore, in 1993, harvesting sea cucumbers using SCUBA was prohibited, however, this prohibition was not adequately enforced and illegal diving for holothurians is still conducted in 2005 in the northern part of Baa Atoll (Bers 2005).

Attempts to culture endemic species of holothurians are underway but the alien species, *Holothuria scabra* is cultured quite effectively in Nalandhoo with millions of hatchery produced juveniles made available every year for grow-out production (Adam 2006). While this is an unregulated activity with no details of the hatchery available, the grow-out culture of this alien species has recently been introduced to a few islands in the neighbouring atolls.

Table 5-2: Sea cucumber exports from 1995-2005 (Adam 2006)

Year	Qty (Mt)	Value (Rf)	Value US$	FOB ($/kg)
1995	93.81	8,316,827	706,612	7.53
1996	145.33	7,600,524	645,754	4.44
1997	318.03	8,559,723	727,249	2.29
1998	85.0113	4,067,649	345,595	4.07
1999	53.841	4,795,478	407,432	7.57
2000	205.245	28,524,834	2,423,520	11.81
2001	225.852	34,330,925	2,682,104	11.88
2002	190.795	38,044,294	2,972,210	15.58
2003	293.335	43,147,093	3,370,867	11.49
2004	182.057	31,049,007	2,425,704	13.32
2005	117.397	23,223,586	1,814,343	15.45

5.5 Climate

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25^{o}C to 30^{o}C and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. There is some variation of climate between northern and southern atolls. The Table below provides a summary of key

meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 5-3: Key meteorological information (Maldives)

Parameter	Data
Average Rainfall	9.1mm/day in May, November 1.1mm/day in February
Maximum Rainfall	184.5 mm/day in October 1994
Average air temperature	30.0 C in November 1973 31.7 C in April
Extreme Air Temperature	34.1 C in April 1973 17.2 C in April 1978
Average wind speed	3.7 m/s in March 5.7 m/s in January, June
Maximum wind speed	W 31.9 m/s in November 1978
Average air pressure	1012 mb in December 1010 mb in April

5.5.1 Monsoons

Maldives is in the Monsoonal Belt in the North Indian Ocean. Therefore, climate in the Maldives is dominated by south-west (Hulhangu) and north-east (Iruvai) monsoons. The southwest monsoon is the rainy season which lasts from May to September and the north-east monsoon is the dry season that occurs from December to February. The transition period of the south-west monsoon occurs between March and April while that of the northeast monsoon occurs from October to November. These monsoons are relatively mild due to the country's location on the equator and strong winds and gales are infrequent in the Maldives. However, storms and line squalls can occur, typically in the period May to July. The winds usually get stronger in the south west monsoon especially during June and July. During storms the impact is greater on the northern atolls than the southern atolls.

Table 5-4: Summary of Monsoons in Maldives

Season	Months
North East-Monsoon (Iruvai)	December to February
Transition Period - 1 (HulhanguHalha)	March to April
South West Monsoon (Hulhangu)	May to September
Transition Period - 2 (IruvaiHalha)	October to November

5.5.2 Temperature

The temperature of Maldives varies little throughout the year with a mean daily maximum temperature of about 32°C and mean low of 26°C and are rarely below 25°C or above 33°C. The highest temperature ever recorded in the Maldives was 36.8°C, recorded on 19 May 1991 at Kadhdhoo Meteorological Office. Likewise, the minimum temperature ever recorded in the Maldives was 17.2°C, recorded at the National Meteorological Centre on 11th April 1978. The highest recorded temperature for Male' was 34.1°C on 16th and 28th of April 1973. The hottest month of the year is usually April reaching a peak around 24 April.

The figure below represents daily average low (blue) and high (red) temperature with percentile bands: inner band from 25th to 75th percentile and outer band from 10th to 90th percentile (source: weatherspark.com) based on the historical records from 1998 to 2012 at Hulhulé weather station.

The hottest day of the last 12 months was January 5, with a high temperature of 38°C. For reference, on that day the average high temperature is 30°C and the high temperature exceeds 31°C only one day in ten. The hottest month of the last 12 months was April with an average daily high temperature of 32°C.

The longest warm spell was from January 9 to January 30, constituting 22 consecutive days with warmer than average high temperatures. The month of June had the largest fraction of warmer than average days with 93% days with higher than average high temperatures.

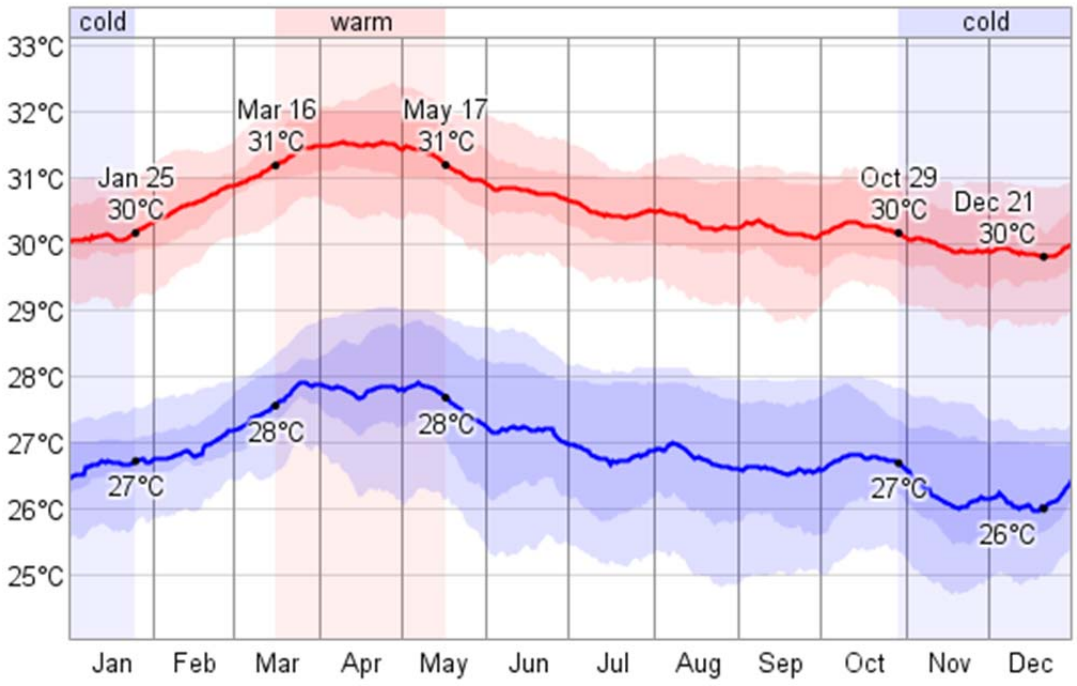


Figure 5-1: Daily average temperature for Central Maldives with percentile bands

The coldest day of the last 12 months was July 9, with a low temperature of 24°C. For reference, on that day the average low temperature is 27°C and the low temperature drops below 25°C only one day in ten. The coldest month of the last 12 months was November with an average daily low temperature of 27°C.

The longest cold spell was from February 24 to March 5, constituting 10 consecutive days with cooler than average low temperatures. The month of December had the largest fraction of cooler than average days with 48% days with lower than average low temperatures.

5.5.3 Rainfall

Annual average rainfall in the Maldives is about 1900mm. There is a marked variation in rainfall across Maldives with an increasing trend towards south. The annual average rainfall in north is 1977mm and for south is 2470mm. The southwest monsoon is known as the wet season with monthly average rainfall ranging from 125-250mm. The northeast monsoon is known as the dry season with average monthly rainfall of 50-75mm.

The following figure illustrates the likelihood that precipitation may occur at some point in the day on a given day, based on the historical records from 1981 to 2012 at Hulhulé weather station (weatherspark.com).

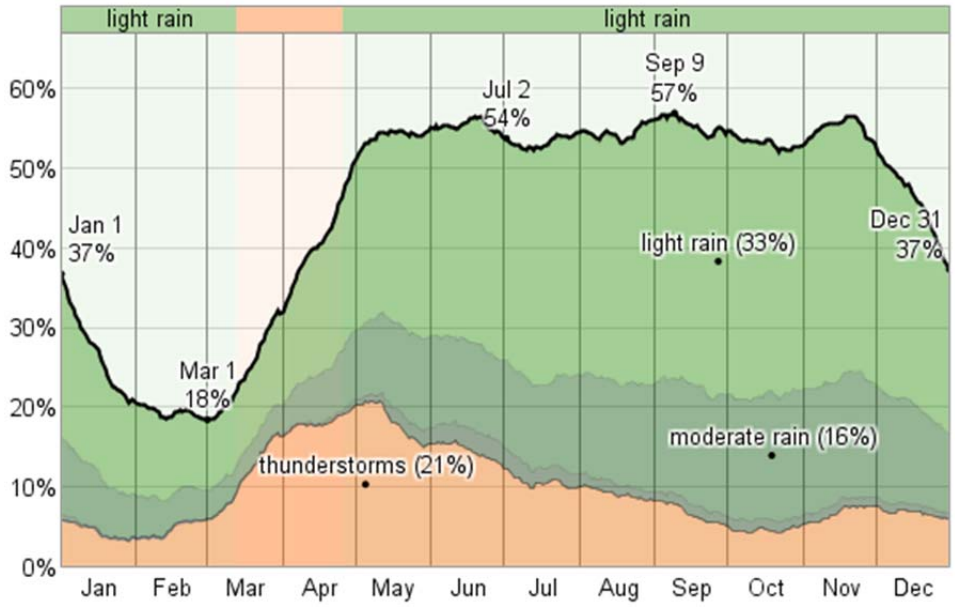


Figure 5-2: Probability of precipitation at some point in the day for Hulhulé, Maldives

5.5.4 Wind

Wind has been shown to be an important indirect process affecting formation development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore, winds are important here, as being the dominant influence on the sediment transportation process (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too. These aspects have ramification on the seasonal sediment movement pattern on the islands and also the delivery/removal of sediments from the reef platform/island.

The two monsoon seasons have a dominant influence on winds experienced across the Maldives. These monsoons are relatively mild due to the country's location close to the equator and strong winds and gales are infrequent. However, storms and line squalls can occur, usually in the period May to July; gusts of up to 60 knots have been recorded at Male' during such storms.

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer 2003). Wind speed is usually higher in central region of the Maldives during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975

to 2001. Maximum wind speed recorded in the south was 17.5 m/s during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind speed was in general lower and more uniform throughout the year in the southern region. Wind analysis indicated that the monsoon was considerably weaker in the south (Naseer, 2003). During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

Figure 5-3 summarizes the wind conditions in the region throughout the year and Figure 5-4 provides the wind-rose diagram typical to the atoll (windfinder.com). This analysis represents wind data from Hulhule Airport taken between 07/2002 and 04/2016 from 0700 to 1900hrs local time.

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant wind direction	➤	➤	➤	➤	➤	➤	➤	➤	➤	➤	➤	➤	➤
Wind probability >= 4 Beaufort (%)	57	40	15	16	48	44	33	32	34	38	24	40	35
Average Wind speed (kts)	11	10	8	7	11	10	9	9	10	10	8	10	9
Average air temp. (°C)	30	30	31	31	31	30	30	30	30	30	29	29	30

Figure 5-3: Summary of general wind conditions in Malé region

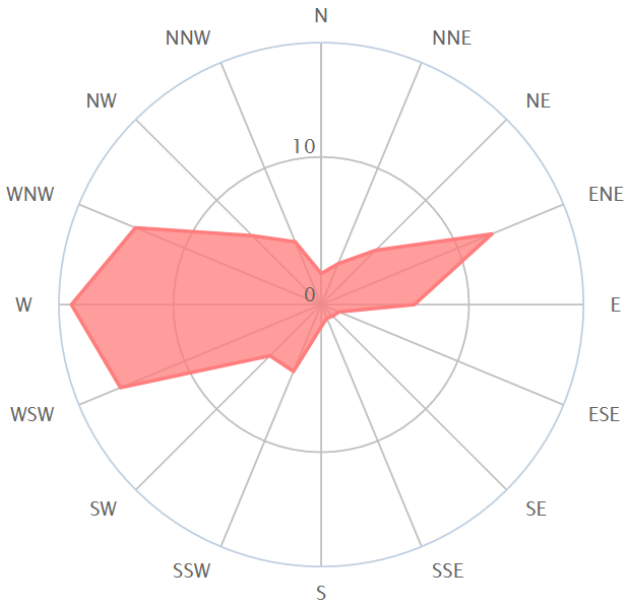


Figure 5-4: Windrose diagram based on data from Ibrahim Nasir International Airport

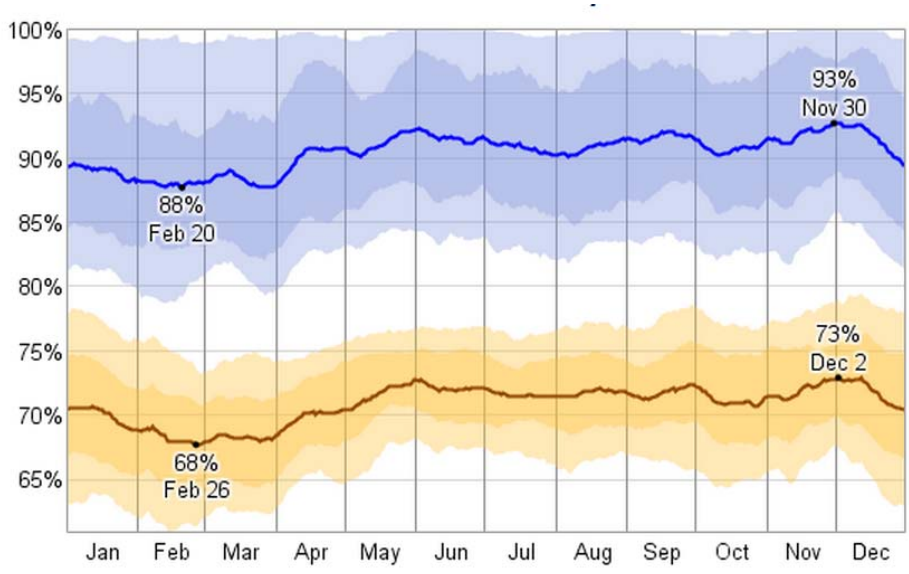
5.5.5 Humidity and Evaporation Rates

Based on data obtained from Hulhulé weather station over a period of 14 years from 1998 to 2012 given in Figure 5-5 (weatherspark.com), the relative humidity typically ranges from 68% (mildly humid) to 93% (very humid) over the course of a year, rarely dropping below 61% (mildly humid) and reaching as high as 100% (very humid).

The air is *driest* around February 26, at which time the relative humidity drops below 71% (humid) three days out of four; it is *most humid* around November 30, exceeding 89% (very humid) three days out of four.

Over the course of a year, the dew point typically varies from 23°C to 27°C and is rarely below 21°C or above 28°C.

Open water evaporation and transpiration from vegetation are very high. The high rates of evaporation and transpiration, especially owing to global warming, may be considered to add further to the evaporation rate and cause sea levels to fall in the future (Morner *et al* 2004). Evaporation rates are influence by wind, temperature and humidity and level of particulates in the air, studies of pan evaporation rates may yield misleading results as pan evaporation rates are influenced by the amount of sunlight hitting the pan, rather than other meteorological factors (Dawson and Spannagle 2009).



The average daily high (blue) and low (brown) relative humidity with percentile bands (inner bands from 25th to 75th percentile, outer bands from 10th to 90th percentile).

Figure 5-5: Relative humidity over a period of 1 year

5.5.6 Waves

Wave energy is important for sediment movement and settlement, and it is also a crucial factor controlling coral growth and reef development. Waves have been attributed to the diversity and the abundance of coral and algal species. These aspects have implications for the type and perhaps the supply of sediments to the island.

Studies by Lanka Hydraulics (1988 & 1989) on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Wave data reported in DHI (1999) shows that the highest waves reaching the southern Atolls of Maldives are from the west direction. Waves with height 2.75m and wave periods of 8s and 9s have been recorded from the west direction. Swell waves with wave periods greater than 9s prevails from south and southwest directions. Over 80% of the waves from south and southwest directions are long period swell waves.

Boduhaikondi is at the middle of a large lagoon with deep waters surrounding it from the other small sandcays. Therefore, it is quite protected from oceanic swells as well as wind-generated waves. Therefore, there is beach around the island. The island is formed close to the western reef while it grows to the north with a long, wide sand spit at the northern end. The western side is generally exposed to wind-generated waves during the SW monsoon while the SE of the island is exposed to wind-generated waves during the NE monsoon.

Table 5-5: Summary of wave conditions around Fonadhoo

Monsoon	Total waves	Long period waves	Short period waves
NE Monsoon (Dec-Feb)	Predominantly from N-E. High Waves from E	From NE-E	Mainly E-NE
Transition Period 1 (Mar-Apr)	Mainly from SE-E	From E to SE	Mainly from NE-SE
SW Monsoon (May-Sep)	From SE-SW. Mainly from S. High waves also from W	From E	Mainly from SE-NW. High waves from W
Transition Period 2 (Oct-Nov)	As SW monsoon but mainly NW to N	From NE-E	From NE-NW. Higher waves from NE

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system of west coast of Australia, had significant wave heights in the order of 3 metres. On 15th May, and for four subsequent days, powerful swells hit many islands throughout the Maldives. According to the Department of Meteorology, the swells were generated by waves between 10 - 15 feet from a dissipated polar storm 3,500 miles south west of Maldives (near 50S, off the coast of South Africa). After generation, the waves travelled northeast for a few thousands kilometres and for a few days (the longest wavelengths travel the fastest) across the Indian Ocean. Five islands in Huvadhoo Atoll were among the most severely affected. It has been reported that this type of tidal surges occur annually around May but unusual high tides occurred in 2007 (NDMC 2007).

In addition, Maldives has recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than one occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Choi *et al* 2003). Gan was not affected by the recent tsunami of 26 December 2004.

5.5.7 Evaporation Rates and Relative Humidity

Open water evaporation and transpiration from vegetation are very high. The high rates of evaporation and transpiration, especially owing to global warming, may be considered to add further to the evaporation rate and cause sea levels to fall in the future (Morner *et al* 2004). Evaporation rates are influence by wind, temperature and humidity and level of particulates in the air, studies of pan evaporation rates may yield misleading results as pan evaporation rates are influenced by the amount of sunlight hitting the pan, rather than other meteorological factors (Dawson and Spannagle 2009).

The figure below represents daily high (blue) and low (brown) relative humidity with percentile bands: inner band from 25th to 75th percentile and outer band from 10th to 90th percentile (source: weatherspark.com) based on the historical records from 1981 to 2011 at Hulhulé weather station.

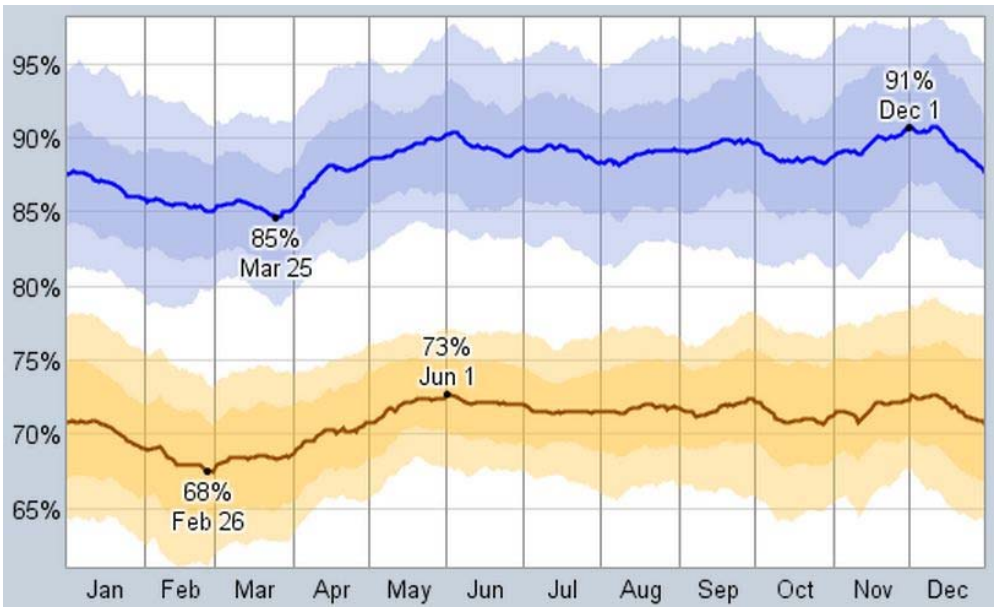


Figure 5-6: Average daily relative humidity with percentile bands

5.6 Hydrography

5.6.1 Tides

Tides affect wave conditions, wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives, where the tidal range is small (1m), tides may have significantly important influence on the formation, development, and sediment movement process around the island. Tides also may play an important role in lagoon flushing, water circulation within the reef and water residence time within an enclosed reef highly depends on tidal fluctuations.

5.6.2 Currents

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

Generally, current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly 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.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef platforms, which are capable of transporting sediments on them. Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoon ward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the back reef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

Data on current speed and direction in the project area was measured on the day of the field visit. These are given in Figure 5-16. However, spot data taken on a single day would not yield sufficient data to understand coastal dynamics. Therefore, long term monitoring of data will be recommended in the monitoring programme proposed for the development.

Aspects relating to currents have a direct impact on the project, especially in understanding the movement of sediments and the design of the cages. Therefore, longterm monitoring of currents is important.

These findings about longshore currents in the area indicate that the proposed project location is quite protected. However, there may be a need to protect the cages from waves during the southwest monsoon. This can be addressed at a later stage, if required.

5.6.3 Bathymetry

Bathymetry of relevant areas of the site is given in Figure 5-16. Bathymetry indicates that the lagoon is deeper than what it appears to be from the Google image. The average depth of the shallow area of the lagoon varies from 1.6 to 2.2m while the deep lagoon has about 5 to 8m.

5.7 Geology and geomorphology

The island of Boduhaikondi lies on its own reef close to the western reef flat and at a considerable distance from the eastern reef. This formation indicates that the island is more protected on the western side due to the presence of several reefs on the western side while it is slightly less protected on the eastern side due to the effect of swells from the channels on the eastern rim of the atoll. For this reason, the proposed location of the farming cages may be considered quite suitable.

Due to the fact that the island is quite protected, no signs of major erosion were seen except on the northwest and southwest corners, which is mainly due to strong currents passing around those corners.

The island formation theories suggest that Maldives was formed around prehistoric volcanoes in Indian Ocean which has gone extinct. As the ocean floor subsided with the volcano, corals began to populate and grow around it forming a fringed reef. As ages passed the reef slowly became a barrier reef enclosing a shallow lagoon inside. The volcanoes disappeared and the coral continued to grow. Slowly as material eroded from the reefs they got collected on the shallower reefs and the sand banks became tiny islands. According to the geological formation, the island of Boduhaikondi appears to have been formed due to material deposition from the eastern rim reef as well as western reef. The effect of swells from the eastern atoll rim occur towards the middle of the existing island mainly because the reef flat at this location is deeper than the rest of the western side.

A further cause of long-term shoreline retreat is the rise in mean sea level relative to the land. In the future, the consequences of atmospheric pollution, and hence global warming, may include an acceleration of the increase in mean sea levels around the world. As a consequence, large parts of the coast of Maldives may begin to experience a net increase in sea levels. However, there are also theories that support that a reduction in sea level may occur around equatorial zones as a result of global warming and subsequent increases in sea surface evaporation (Mörner, etal 2004).

In recent centuries, Maldives may have slightly suffered from the increase in global sea levels, which has been averaging about 1mm to 1.5mm/year. This is because all islands of the

Maldives are about a metre or two above mean sea level. As sea level rises relative to a beach, there is an inevitable tendency for the shoreline to move inland.

A proper lagoon can be seen on all sides of Boduhaikondi with the lagoon and reef extent on the western side being the shortest. The western side also rubble on the seabed along with muddy substrate on the nearshore areas. The project lagoon is quite shallow with deeper areas near the causeway. The project area consists of medium-fine size sandy floor, and scattered coral colonies mainly porites. The depth of the shallow lagoon areas ranges between 1.3 to 2.2m at mean sea level. That would provide appropriate depth for mariculture activities, as it is neither too shallow nor deep.

Seasonal sand movement is seen to be restricted due to the long length of the islands. Erosion is a major problem facing the islands of Maldives. However in Boduhaikondi, no major signs of erosion were observed except on the north and south ends where erosion is due to longshore currents, especially on the western side on the day of the field visit.

5.8 Water quality

5.8.1 Marine water quality

Marine water quality has been measured from two locations of the project site. The water quality results (in-situ) are given in Table 5-6.

Table 5-6: Marine water quality results

	Units	Site 2	Site 4
GPS coordinates	UTM	275738.50m E 620664.32m N	274748.47m E 620754.96m N
Temperature	°C	30.12	29.27
E. Conductivity	uS/cm	54320	55100
Total Dissolved Solids	mg/l	34950	35120
Salinity	ppt	35.1	35.1
Dissolved Oxygen	mg/l	6.75	6.94
pH		8.23	8.17
Turbidity	NTU	0.88	0.50
Total Suspended Solids	mg/l	0	0
Phosphate	mg/l		
Ammonia	mg/l		
BOD	mg/l		
COD	mg/l		
Nitrate	mg/l		

5.8.2 Ground water Quality

Marine water quality has been measured from representative locations around the project site. The water quality results are given in table 5.6

Table 5-7: Ground water quality results

	Units	GW1	GW2
Geographic coordinates	WGS	275053.64m E 620549.63m N	275157.33m E 620460.35m N
Temperature	^{o}C	27.62	28.10
E. Conductivity	µS/cm	1100	1210
Total Dissolved Solids	mg/l	622	653
Dissolved Oxygen	mg/l	2.95	2.66
pH		7.51	7.95
Turbidity	NTU	2.86	3.01
Total Suspended Solids	mg/l	2	3
Phosphate	mg/l		
Ammonia	mg/l		
BOD	mg/l		
COD	mg/l		
Nitrate	mg/l		

5.9 Ecology

5.9.1 Marine Protected Areas and sensitive sites

As per the requirements of the TOR, Marine Protected Areas (MPAs) and ecologically important or sensitive sites such as breeding or nursery grounds for protected or endangered species have been considered. There are no MPAs in the vicinity of the project site. There are several other ESAs on the south of Raa Atoll, most of which are small vegetated sandcays which have been identified mainly as bird roosting sites. Mangroves in some larger islands including the landfill island, Vandhoo has been declared as ESAs. The only Marine Protected Area (MPA) identified so far in Raa Atoll is Villingillee Thila at the southern periphery of Raa Atoll at about 20km south of Boduhaikondi.

Figure 5-7: ESAs within project vicinity

5.9.2 Floral Landscape

Boduhaikondi is a small vegetated sandcay with vegetated area covering about 1 hectare although grass has grown on the newly growing northeast *thundi* end. The vegetation is dominated by young to medium-sized palms with mainly sea lettuce (*magoo*) growing with tassel pant (halaveli) on the coast.

Figure 5-8: Trees on either side of cleared access/walkways

Sea hibiscus (*dhiggaa*), sea trumpet (kaani), tulip tree (hirundhu) and country almond (midhili) were also quite common with some nit pitcha (uni) inside the island and close to the coast. Beach heliotrope (boashi) was also seen in some coastal areas. The vegetation is typical of young islands in the Maldives.

Tree surveys have been done along three cleared walkways and the results have been given in Figure 5-18.

5.9.3 Terrestrial Fauna

During the field visit to the island, a few black naped terns (*Sterna sunmatrana*) and a crested tern was seen at the northeast thundi area. According to the island caretakers, several migrating birds visit the northeast thundi. They also reported occasional turtle nesting on the island. However, at the time of the field visit, no turtle nests have been observed. There was not much fauna on the island. Some small shore crabs were seen on the shore.

The island has previously been used for agricultural purpose and some foundations of structures and about 30 chickens were observed.

5.9.4 Marine Ecological Survey

The island's reef is one of the emerged areas of a deep reef system in the area. The housereef surrounding the island is a normal reef with a variety of corals with an abundance and diversity of fish sheltering in the housereef. The reef has been extensively bleached during the prolonged bleaching event of 2016. Signs of recovery are rarely observed at some spots.

Figure 5-9 shows results of the benthic substrate assessment using photo quadrates near the project site. Photo quadrates were conducted at these sites recorded the following attributes.

- Live Coral
- Bleached Coral
- Rubble
- Sand

The following sub-sections provide results of the quantitative assessment of the marine environment of Boduhaikondi, including coral reef and the lagoon area in terms of percentage benthic cover, fish count and general status of the reef.

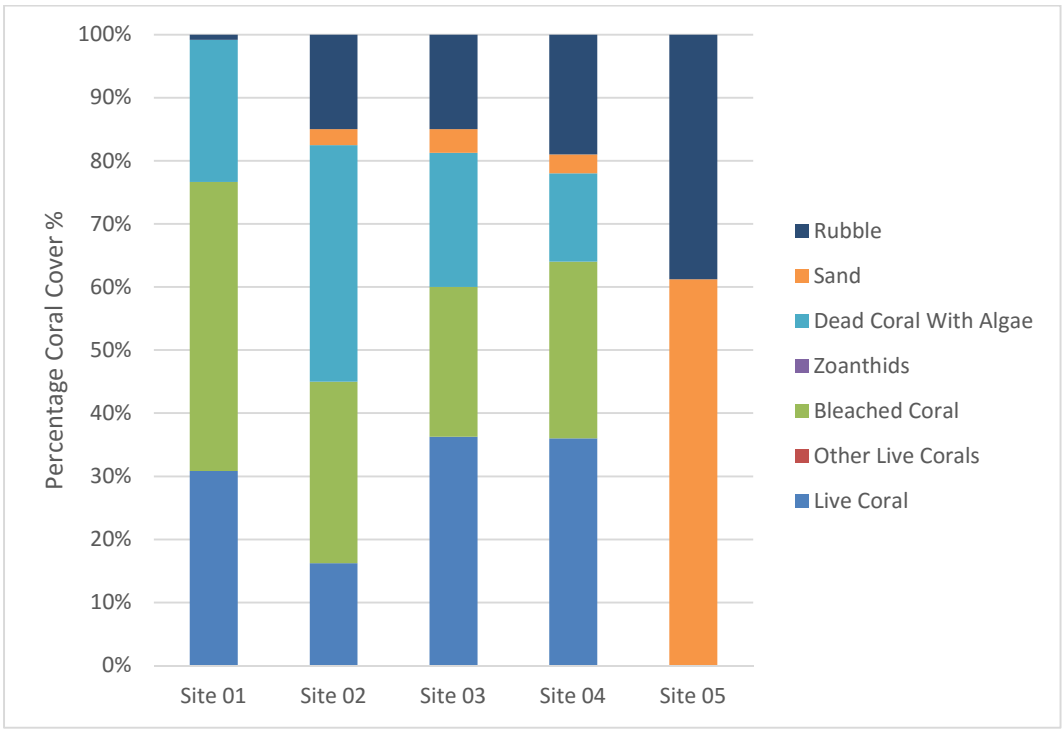


Figure 5-9: Attributes of marine environment

5.9.4.1 Site 1

Site 1 is located on the northeastern side of the island. Coral bleaching dominated the site with almost 45% of the total corals being bleached. Live species were dominated by *Acropora Clathrata* (10%) and *Dead Coral with algae* (22.5%).

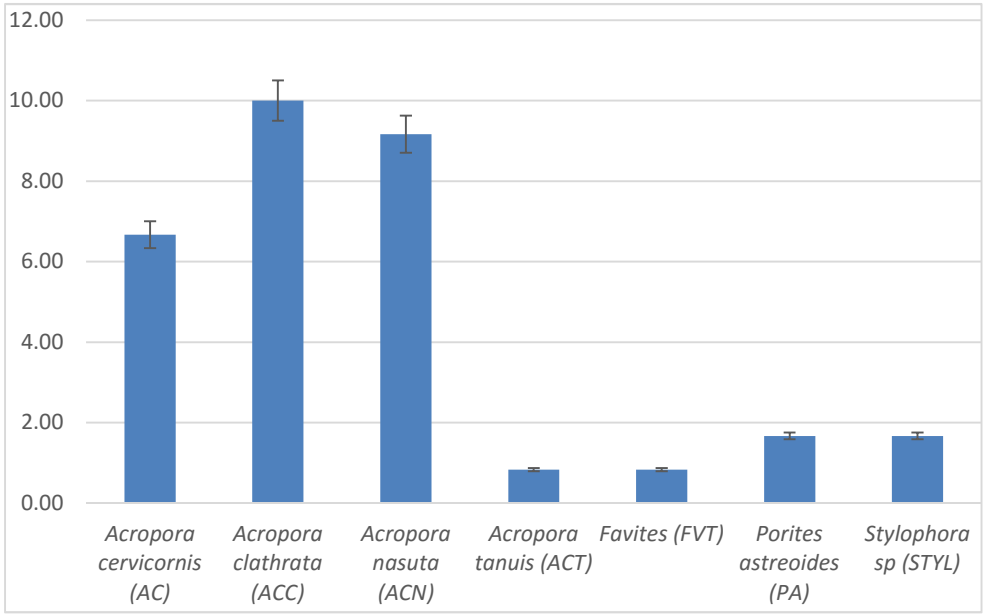


Figure 5-10: Benthic Cover at Site 1

Table 5-8: Fish count at Site 1

Common name	Scientific name	Abundance
Swallow tail puller	*Chromis ternatensis*	10
Jewel damsel fish	*Plectroglyphidodon lacrymatus*	9
Surge Damselfish	*Chrysiptera brownriggii*	6
Six-bar wrasse	*Thalassoma hardwicke*	5
Five strip wrasse	*Thalassoma quinquevittatum*	5
Zigzag wrasse	*Halichoeres scapularis*	5
Fusilier Damselfish	*Lepidozygous tapeinosoma*	5
Schooling banner fish	*Sacarus scaber*	4
Powder blue surgeonfish	*Acanthurus leucosternon*	3
Whitetip reef shark	*Triaenodon obesus*	2

5.9.4.2 Site 2

Site 2 is located on the east slightly south east of the island. Dead corals were mainly observed in the site with a percentage of 37.5%. Live corals were dominated by *Favites* (7.5%). Other species such as *Acropora cervicornis* (1.25%) and *Porites astreoides* (2.50%). Coral bleaching was high at this site too.

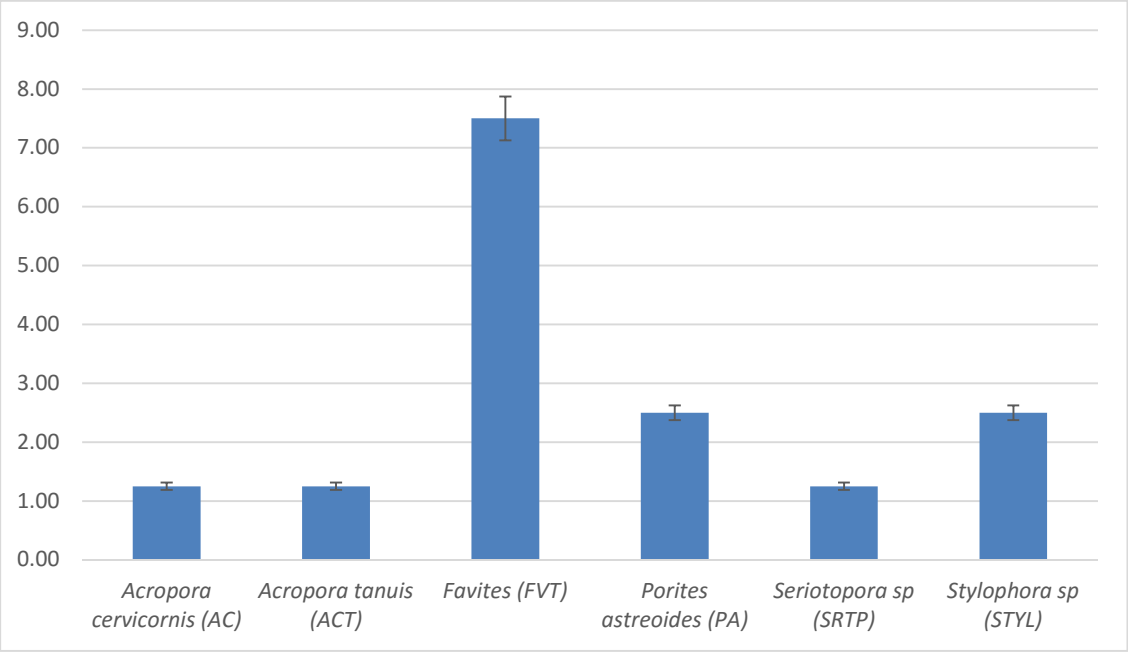


Figure 5-11: Benthic Cover at Site 2

Table 5-9: Fish count at Site 2

Common name	Scientific name	Abundance
Green puller	*chromis viridis*	40
Humbug Dascyllus	*Dascyllus aruanus*	35
Fusilier Damselfish	*Lepidozygous tapeinosoma*	12
Surge Damselfish	*chrysiptera brownriggi*	10
White tail damsel fish	*Pomacentrus chrysurus*	8
Convict surgeon fish	*Acanthurus triostegus*	7
Bluebarred parrotfish	*Sacarus ghobban*	5
Powder blue surgeonfish	*Acanthurus leucosternon*	4

5.9.4.3 Site 3

Site 3 is located at the end of the reef flat on the southern side of Boduhaikondi island approximately 450m from the shoreline. Unlike site 2 or 1, Site 3 was dominated by live corals with Acropora cervicornis (21.25%) being abundant of all corals. Other live corals such as Acropora clathara (2.5%) and Acropora tenuis (5%) were also observed. The species richness as well as the biodiversity is noticeably higher in Site 3 than any other site investigated.

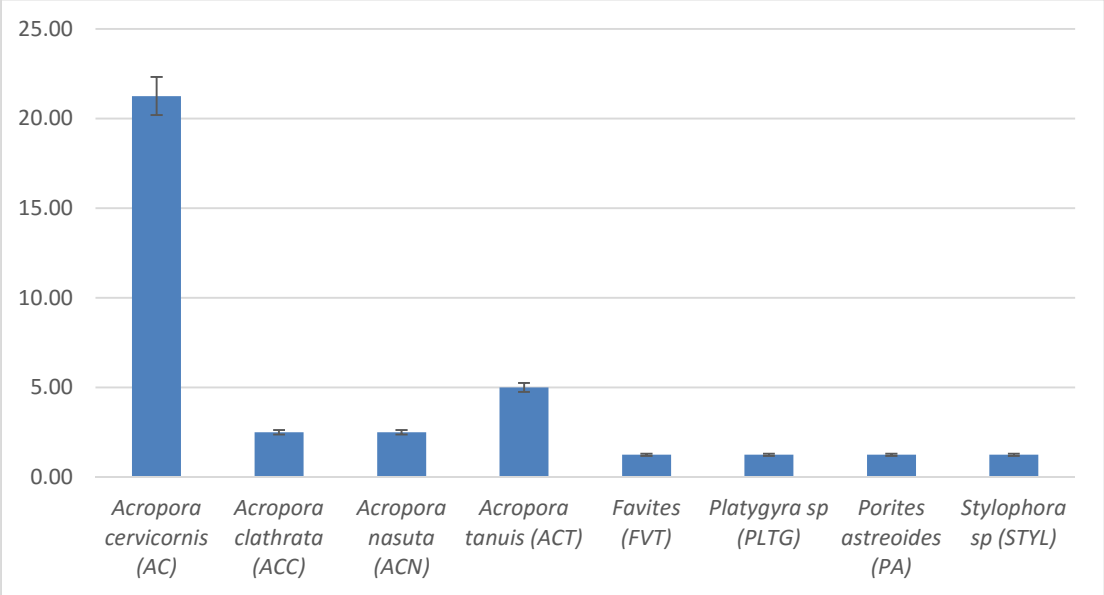


Figure 5-12: Benthic Cover at Site 3

Table 5-10: Fish count at Site 3

Common name	Scientific name	Abundance
White tail damsel fish	*Pomacentrus chrysurus*	20
Surge Damselfish	*chrysiptera brownriggi*	18

Five strip wrasse	*Thalassoma quinquevittatum*	5
Oval butterfly fish	*Chaetodon trifasciatus*	4
Jansens wrasse	*Thalassoma janseni*	3
Powder blue surgeonfish	*Acanthurus leucosternon*	3
Checkerboard Wrasse	*Halichoeres hortulanus*	2
Honeycomb grouper	*Epinephelus merra*	2
Lunar-tailed grouper	*Variola louti*	1

5.9.4.4 Site 4

Site 4 is located on the western side of the island, approximately 50m from the reef edge. Like Site 3, Site 4 was also dominated by live corals. *Acropora Cervicornis* (20%) dominated the coral species. Other live species such as *Favites* (4%) and *Stylophora sp* (1%) were observed during the survey.

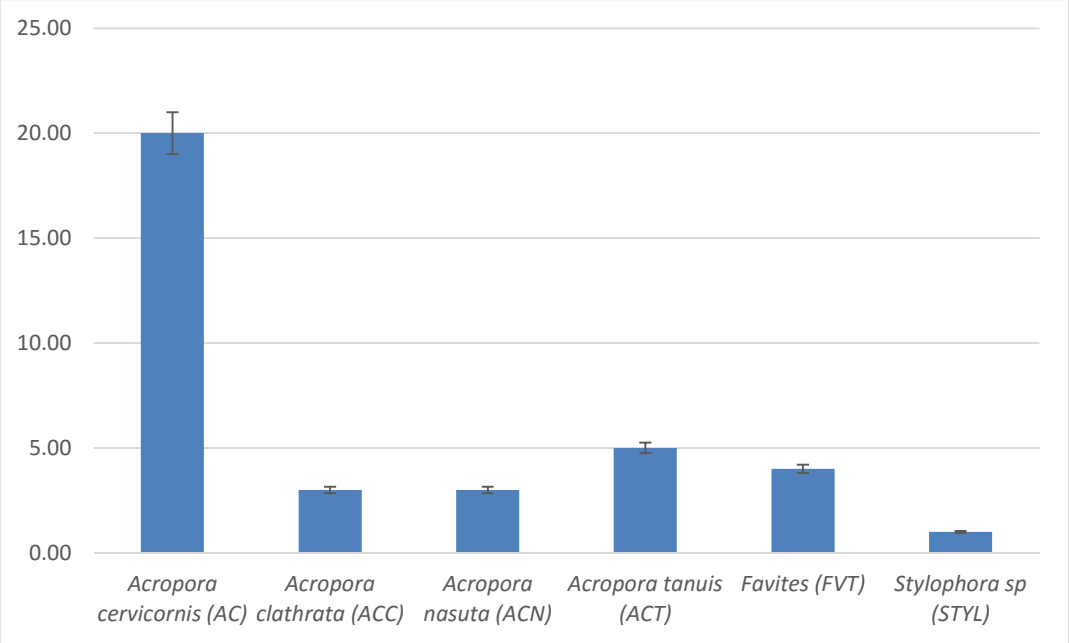


Figure 5-13: Benthic Cover at Site 4

Table 5-11: Fish count at Site 4

Common name	Scientific name	Abundance
Checkerboard Wrasse	*Halichoeres hortulanus*	3
Orange stripe Spinecheek	*Scolopsis auratus*	2
Jewel damsel fish	*Plectroglyphidodon lacrymatus*	8
Bluebarred parrotfish	*Sacarus ghobban*	2
Powder blue surgeonfish	*Acanthurus leucosternon*	1
Five strip wrasse	*Thalassoma quinquevittatum*	2

Common name	Scientific name	Abundance
Fusilier Damselfish	*Lepidozygous tapeinosoma*	3
Surge Damselfish	*chrysiptera brownriggi*	6
White tail damsel fish	*Pomacentrus chrysurus*	8
Lemon Meringue Wrasse	*Biochoeres leucoxanthus*	3

5.9.4.5 Site 5

Site 5 was located on the eastern side of the island near the deep lagoon area. Site 5 consisted of *sand and rubble*. No live corals were observed on site. Fish count was not done at this site.

5.10 Socio-economic environment

Raa Atoll has a population of 14,862 and 957 foreigners working in the islands (Census 2014). Raa Atoll is one of the most populated atolls in the Maldives. There are a total of 14 inhabited islands in the atoll; Dhuvaafaru has been recently created for the settlement of people of Kandholhudhoo, who were displaced to different islands in the atoll following the tsunami of December 2004. Kandholhudhoo used to be a congested island with the largest population in the atoll, therefore, Dhuvaafaru is now the largest in Raa Atoll.

Table 5-12: Island level Demographic statistics of Raa Atoll (Census 2014)

	Total			Maldivians			Foreigners		
	Both sexes	Male	Female	Both sexes	Male	Female	Both sexes	Male	Female
Alifushi	1,804	939	865	1,571	726	845	233	213	20
Vaadhoo	398	190	208	375	177	198	23	13	10
Rasgetheemu	509	237	272	484	221	263	25	16	9
Agolhitheemu	403	201	202	373	180	193	30	21	9
Ugoofaaru	1,501	729	772	1,384	659	725	117	70	47
Maakurathu	798	393	405	765	372	393	33	21	12
Rasmaadhoo	516	266	250	494	248	246	22	18	4
Innamaadhoo	577	324	253	504	257	247	73	67	6
Maduvvari	1,449	744	705	1,390	696	694	59	48	11
Inguraidhoo	1,209	586	623	1,123	508	615	86	78	8
Fainu	318	158	160	304	149	155	14	9	5
Meedhoo	1,726	857	869	1,664	805	859	62	52	10
Kinolhas	464	231	233	432	206	226	32	25	7
Hulhudhuffaaru	1,131	520	611	1,079	493	586	52	27	25
Dhuvaafaru	3,016	1,448	1,568	2,920	1,372	1,548	96	76	20
TOTAL	**15,819**	**7,823**	**7,996**	**14,862**	**7,069**	**7,793**	**957**	**754**	**203**

There are two operational resorts in the Atoll following the opening of Maamigili island on the northwest of Kudahaikondi in 2014. Until then there was only Meedhupparu for the past 14 years. The statistics for these two resorts are provided in the table below. Currently, several new resort developments are underway. In the recent years, there has been a rapid growth in the guest house industry in inhabited islands of the Maldives but the growth of this sector in Raa Atoll has been restricted until the recent opening of Ifuru Airport. Accurate statistics for this sector is unavailable.

Table 5-13: Bed capacity changes over the years in resorts in R. Atoll

	Year established	**Initial**	**2010**	**2011**	**2012**	**2013**	**2014**
Adhaaran Select Meedhupparu	2000	430	470	470	470	470	470
Loama Maamigili	2014	40					186
Total		**470**	**470**	**470**	**470**	**470**	**656**

5.11 Natural hazard vulnerability

Boduhaikondi is of an average height above MSL of about 1.2m. The newly grown sandspit area may be slightly low. However, this area also keeps growing and due to the location of the island, it is less susceptible to tidal waves and extreme tides and related flooding than low lying islands.

The island is in the middle of the atoll and sheltered on the west by several reefs and by a large extent of shallow and deep lagoon on the eastern side, the island may be considered safe from waves. However, the island lacks wide beach on the western side due to the closeness of the island to the reef. Therefore, harsh southwest weather tends to cause large scale retreat of the beach with movement of the sand to the northeast sandspit area.

The reef flat has also not had any anthropogenic impacts. Therefore, the reef provides good protection to the island beaches. However, on the eastern side, where the reef flat is deep and connects to the deep lagoon, there is stronger wave action on the beach. As a result, the eastern side has seen severe erosion especially over the prolonged seasonal transition period (*halha*) during the early months of 2016. However, given the small scale of the project, structural protection to maintain beaches would not be necessary.

Apart from the low elevation and subsequent risks related to tidal surges, there are no serious natural hazard concerns. A general account of the vulnerability of the islands of Maldives to natural hazards is considered below based on a study by UNDP (2006).

An island's natural vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island and location of the island with respect to the country, the formation of the island, location of the island respect to the atoll, orientation of the island, region of the country where island is located, level of protection to the island from the reefs and other islands; area of the inland lake found on the island, width of the island's house reef, coastal defense structures on the island, shape of the island and the area of the island. Although Maldives is generally considered to have moderate risk to natural hazards or disasters, islands across Maldives experience varying degree and magnitude of natural disasters.

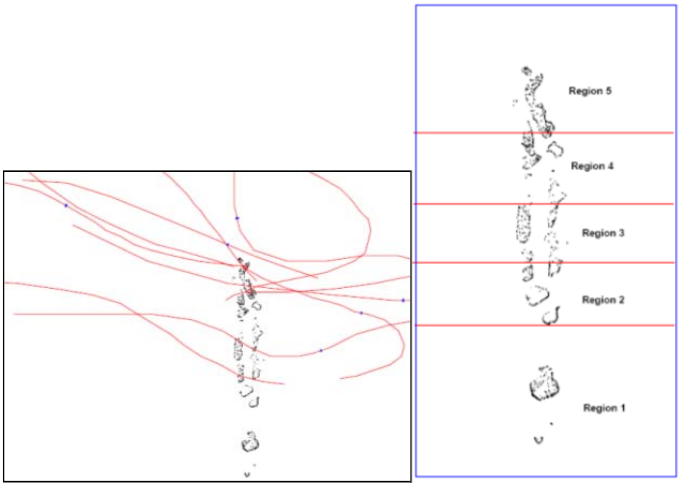
The stormy weathers around the world are affecting coral reef systems directly and indirectly due to global climatic changes. Intense storms can wipe out the natural coral "recruitment" process (Daily Science, April 29, 2008) as a direct effect of climatic change. Healthy coral reef systems are vital assets to many economies around the world on which large numbers of island communities, including the Maldives, depend on a range of fisheries activities. In the Maldives, for instance, according to NAPA (2006), local demand on reef fishery has increased in recent years. Therefore, the concerns due to natural hazard vulnerability of coral reefs in the Maldives are very high, which needs a solution through local and global effort.

Besides heavy rains and strong winds during monsoons, hazardous weather events which regularly affect Maldives are tropical storms or 'tropical cyclones', and severe local storms. At times, tropical cyclones hitting Maldives are destructive due to associated strong winds that exceed a speed of 150 kilometres per hour, rainfall of above 30 to 40cm in 24 hours and storm tides that often exceed four to five meters (UNDP 2006).

Cyclonic winds sometimes can cause a sudden rise in sea-level along the coast, leading to a storm surge. The combined effect of surge and tide is known as 'storm tide'. Storm tides can cause catastrophe in low-lying areas, flat coasts and islands such as Maldives.

Referring to Suffir-Simpson Scale given in Figure 5-14, Boduhaikondi is considered to be in a moderately high vulnerable zone when cyclonic winds and storm surges over the Maldives are concerned and also low risk when tsunamis and earthquakes are concerned. The island

falls under hazard zone 3 at Suffir-Simpson Scale 1, the maximum probable wind speed expected to be at 69.6knots as shown in the following figure.



Hazard Zone	Probable Maximum Wind Speed (knots)	Saffir-Simpson Scale
1	0.0	0
2	55.9	0
3	69.6	1
4	84.2	2
5	96.8	3

Figure 5-14: Cyclonic wind hazard zones (adapted from RMSI/UNDP 2006)

Figure 5-15 show that Maldives faces tsunami threat largely from the east and relatively low threat from the north and south. So, islands along the eastern fringe are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe experience a relatively low tsunami hazard. This map is produced based on the experience of the tsunami in 2004 and also occurrence of historic tsunami events in the greater region where most of the events have identified to have occurred from the Sumatra Region.

Maldives is also affected by severe local storms- thunder storms/ thunder squalls. Hazards associated with thunder storms are strong winds, often exceeding a speed of 100 kilometres per hour, heavy rainfall, lightning and hail; they also give rise to tornadoes in some regions. In general, thunderstorms are more frequent in the equatorial region than elsewhere, and land areas are more frequently hit by thunderstorms as compared to open oceans. However, thunder storms close to the equator are less violent when compared with those in the tropical regions and beyond. Maldives being close to the equator, thunder storms are quite frequent but less violent here. Strong winds generated by severe local storms generate large wind-driven waves which are hazardous for Maldives.

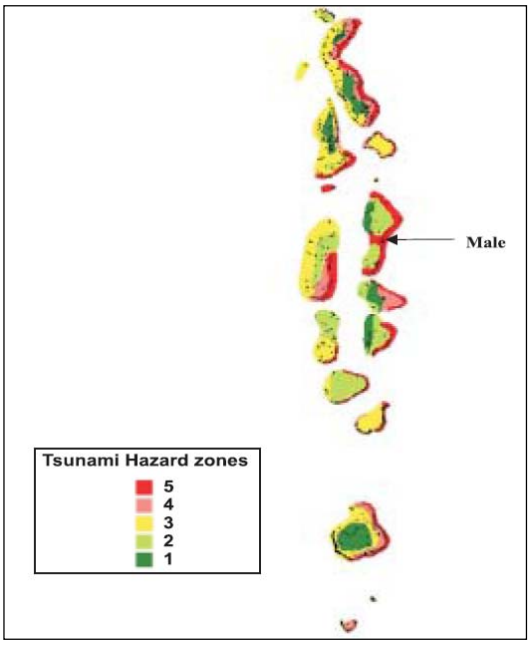


Figure 5-15: Tsunami hazard zones

Vulnerability of the islands of the Maldives to flooding and storm surges and possibly complete inundation is considered to be high due to increasing vulnerability to the effects of global warming such as melting of polar ice caps. As a result, sea level rise due to climate change has uniform hazard throughout the country. However, there are theories that support that high rates of evaporation in the tropical Indian Ocean may cause water levels to go down although pan evaporation studies may indicate of only evaporation due to sunlight falling on the pan excluding other meteorological factors.

Rainfall in the Maldives is such that regular flooding caused by heavy rainfall is a somewhat annual occurrence especially for those islands with low lying areas towards the middle of the island. For Boduhaikondi, such flooding is not considered to be a cause for concern as the island is narrow and small and does not cup towards the middle of the island.

Figure 5-16: Survey locations

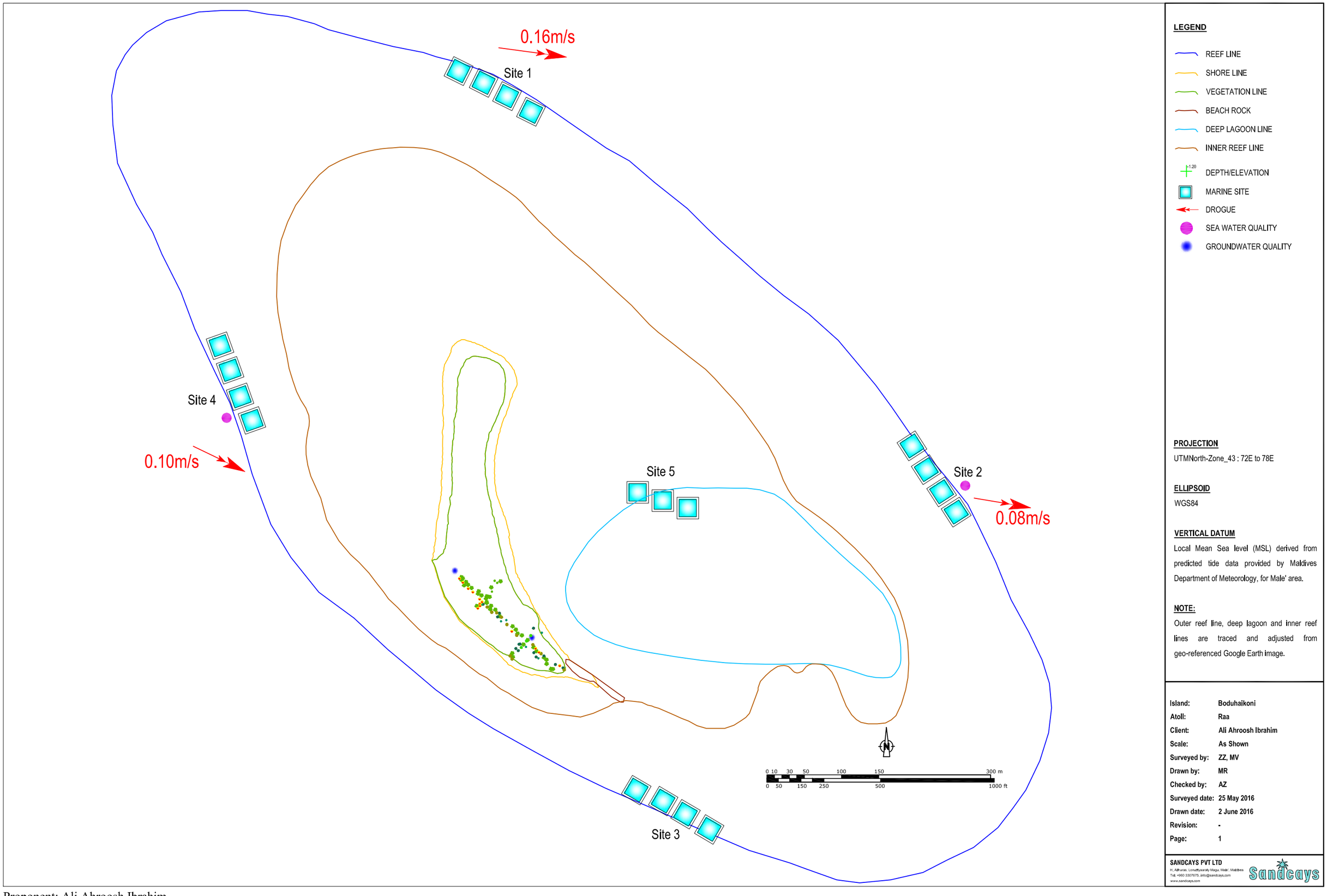


Figure 5-17: Bathymetry

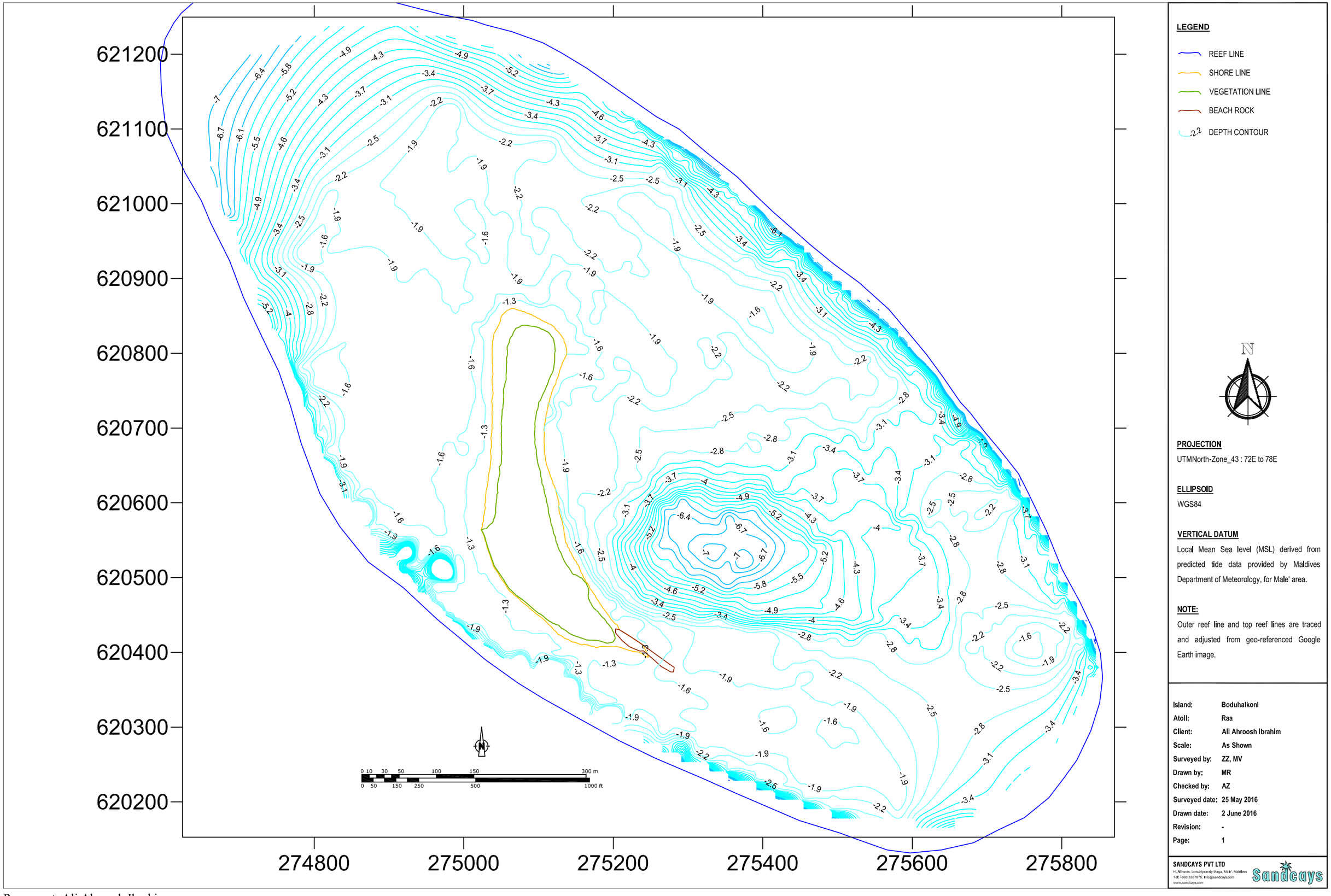


Figure 5-18: Tree survey results

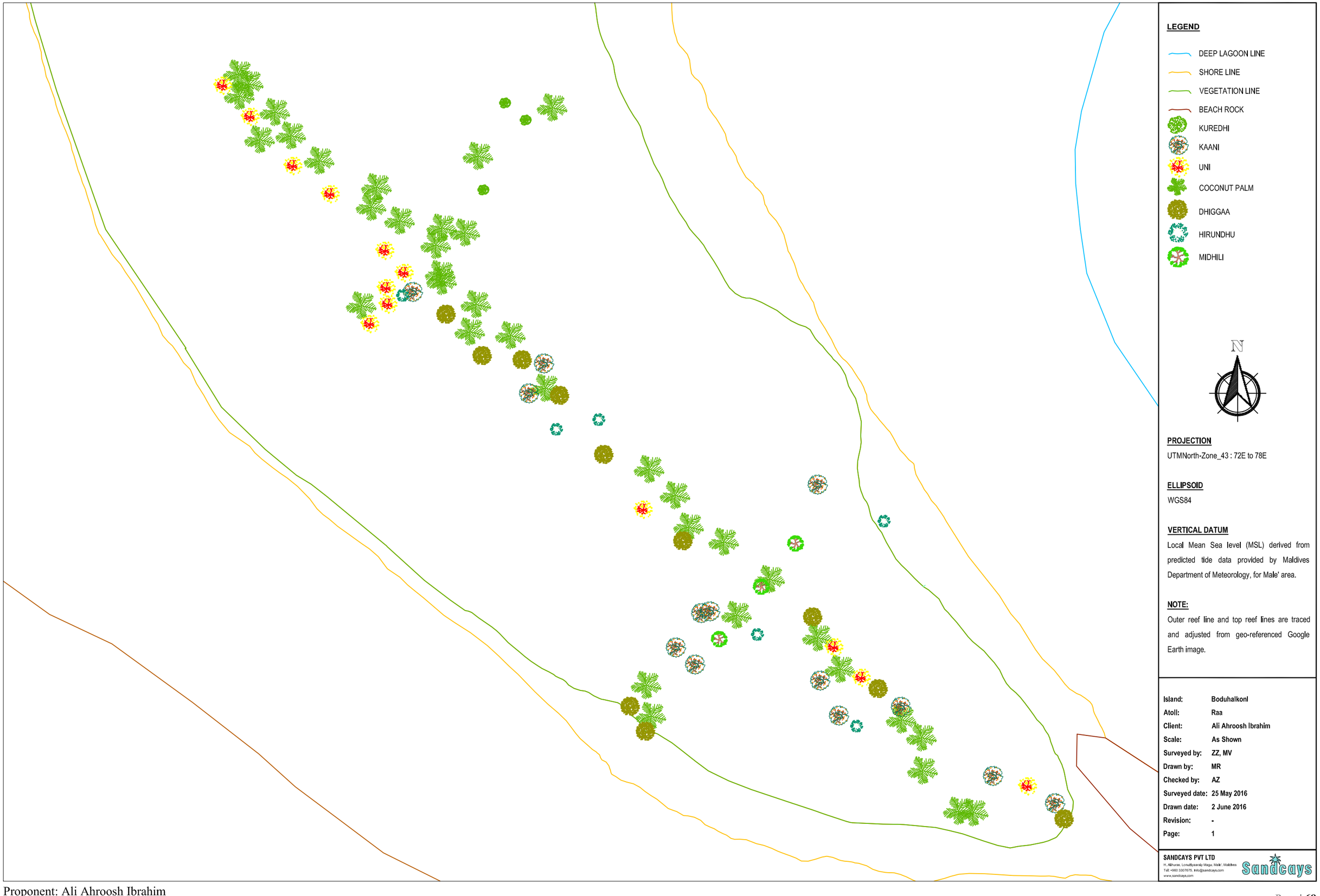


Figure 5-19: Photographic summary of conditions of the coastal environment

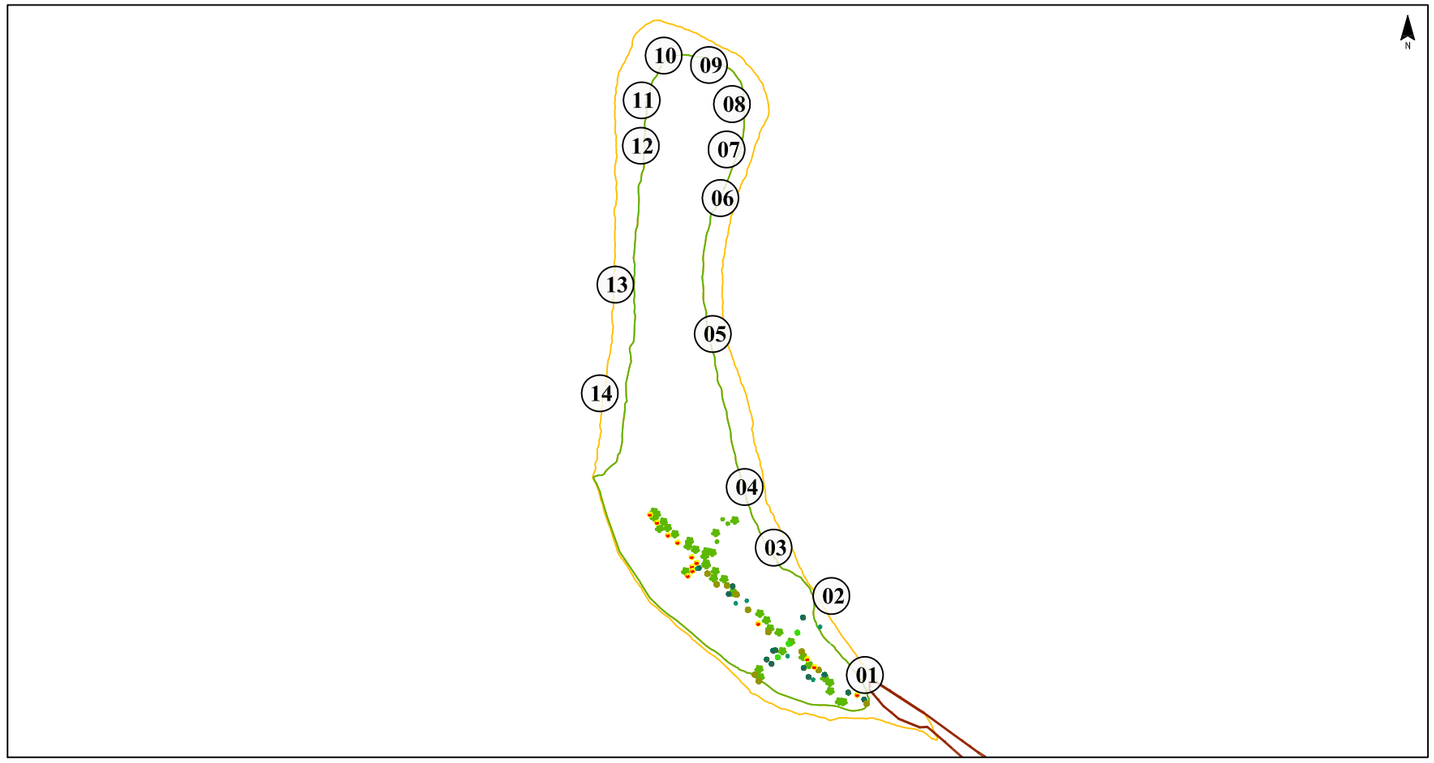


Figure 5-20: Photographic summary of conditions of the marine sites 1-2

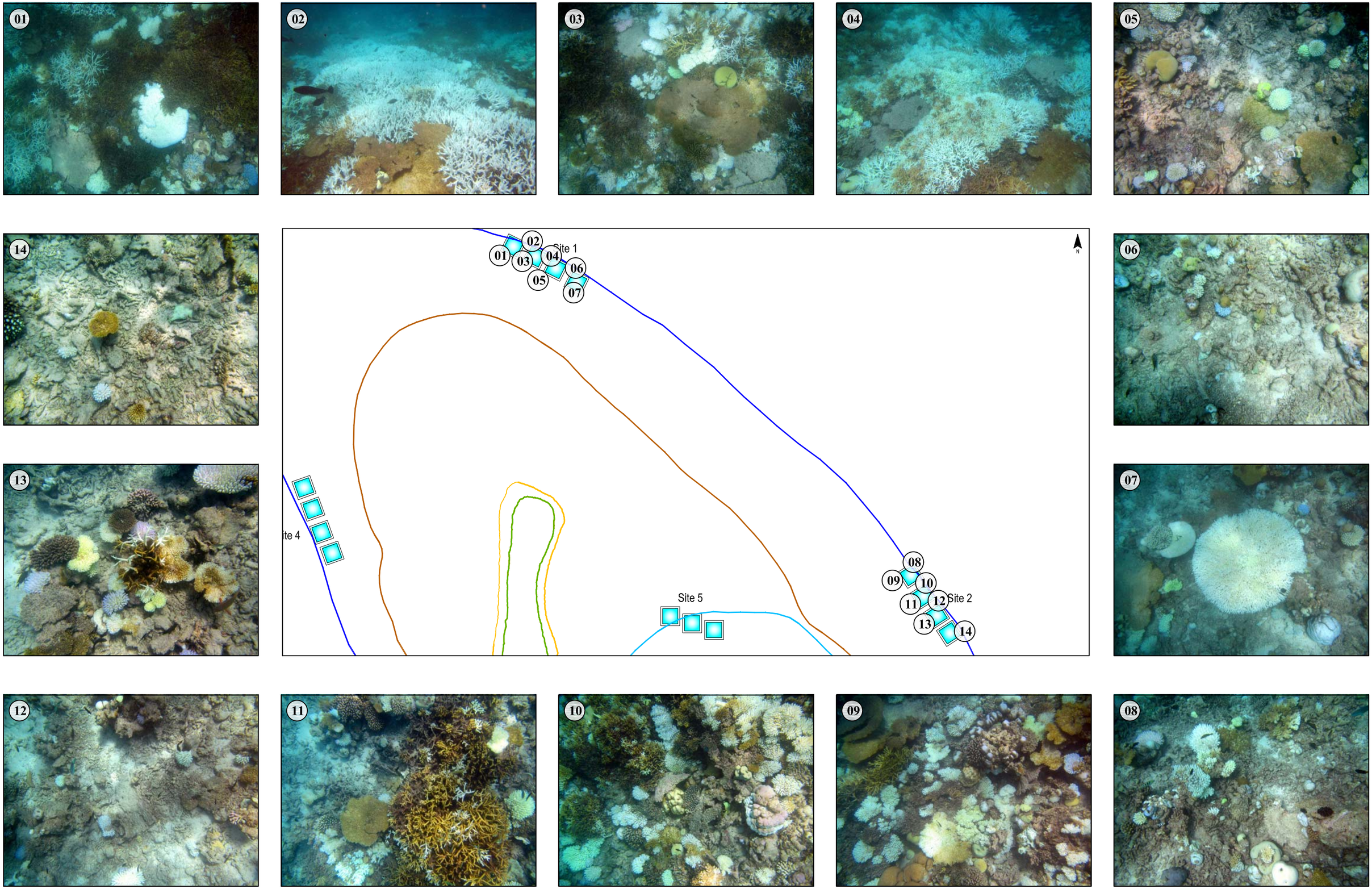
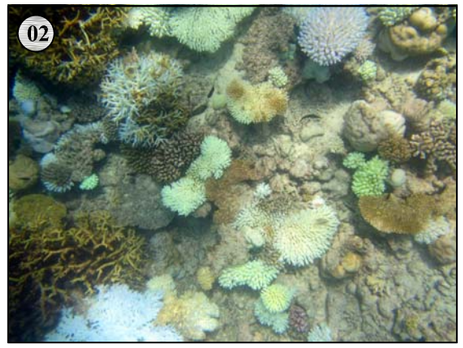
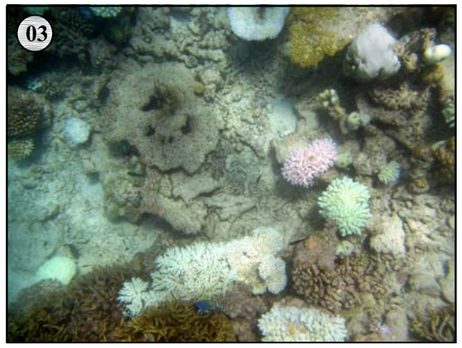
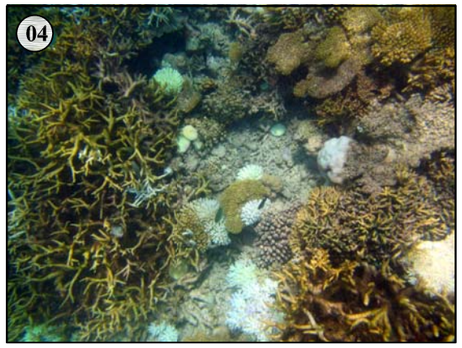
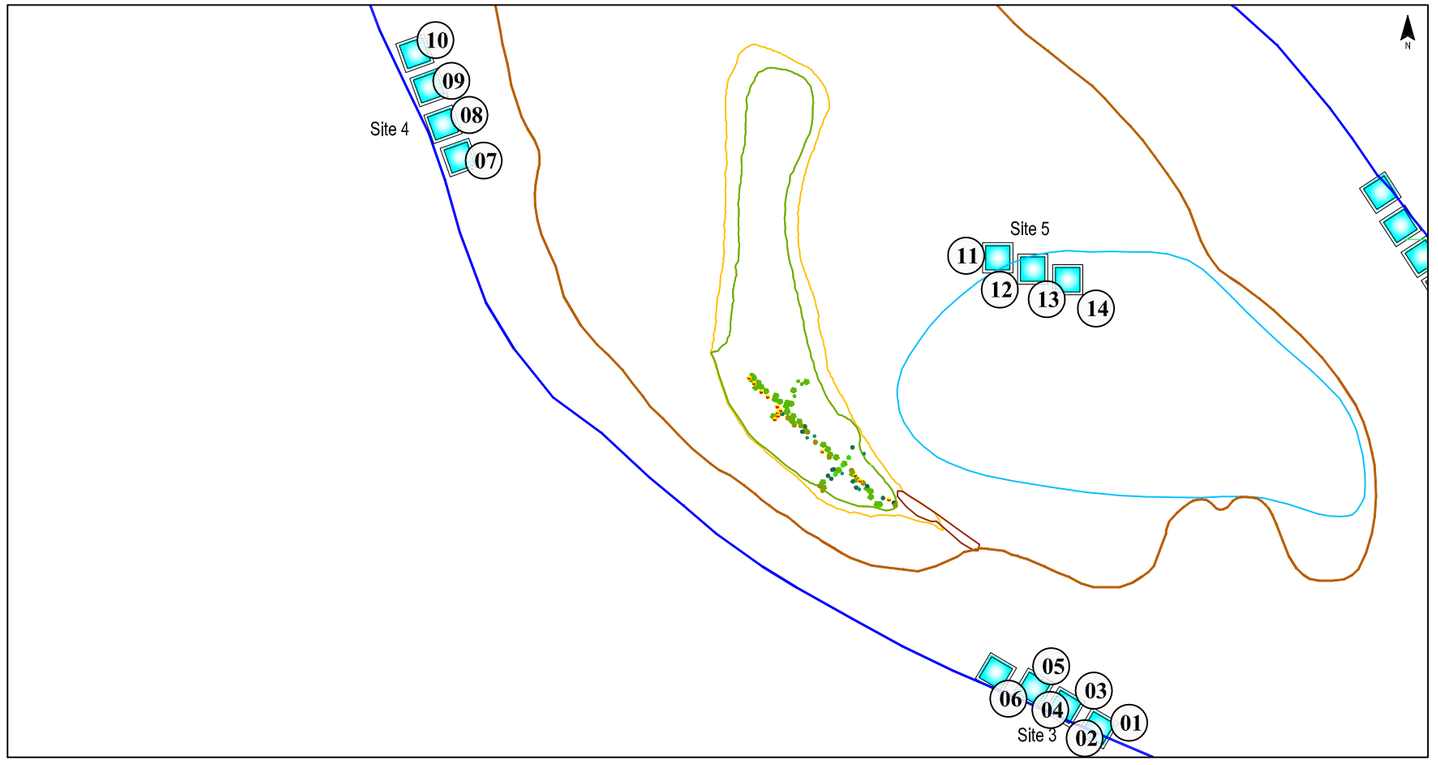


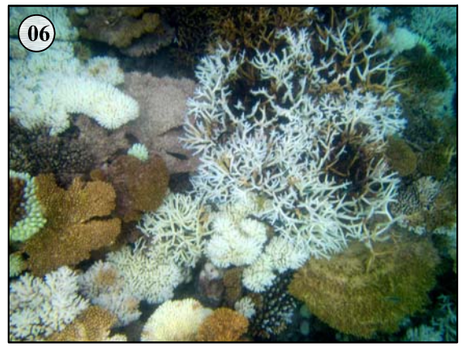
Figure 5-21: Photographic summary of conditions of the marine sites 3-5

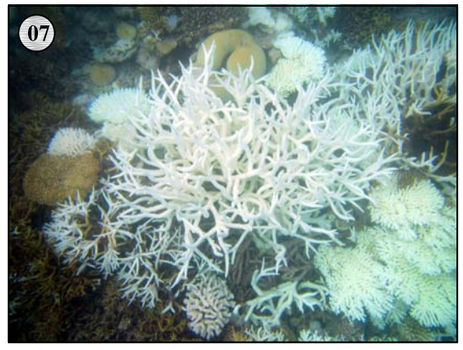


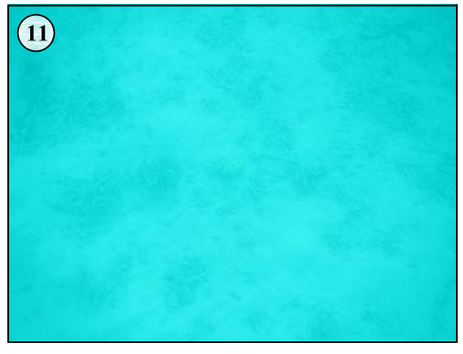


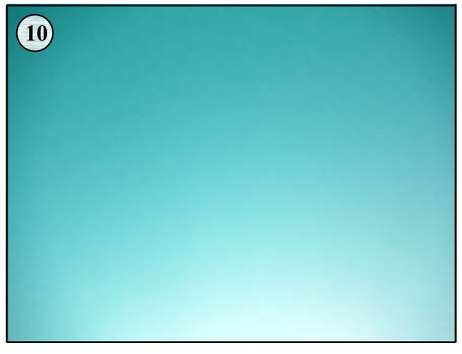












6 Stakeholder Consultations

The key stakeholders of the project include the Atoll Council, Ministry of Fisheries and Agriculture, Environmental Protection Agency, Project Engineers, Consultants and general public. The stakeholders that participated in the Scoping Meeting have extensively discussed on the issues relating to the project.

6.1 Scoping Meeting

The scoping meeting was held to set the scope for the project on 24th April 2016. The meeting was attended by the responsible government agencies, the Proponent and the EIA Consultant.

After a brief overview of the project given by the EIA Consultant, queries from EPA regarding project components were answered by the Proponent. These include species of sea cucumber proposed for rearing, types of enclosure proposed and waste management strategies. EPA also asked proponent how they are planning to obtain hatchlings/fingerlings for the project. To this, the proponent replied they are planning to obtain it from local suppliers. In addition, EPA also questioned how the proponent is planning to provide access to the island during construction and operational phase of the project.

As the proposed project is straightforward no major concerns were raised by the attending stakeholders during the scope meeting. However, EPA strongly advised the proponent to implement all necessary mitigation measures for any adverse impacts that would arise from the project activities.

List of participants of the Scoping Meeting are given in the Appendix.

6.2 Consultations in the field

Informal discussions were held with island caretaker, dinghy captain and his assistant who participated in the survey to discuss about the unique features of the island. The information that they provided have been considered in the Existing Environment section of the report.

7 Environmental Impacts and Mitigation Measures

7.1 Introduction

Development projects involving infrastructure development in island environments are believed to generate a series of environmental impacts, of which some can be felt immediately on the surrounding environment while others can be felt continually and can be far reaching. By far and large the most significant environmental impacts are those that are felt on the immediate environment. Terrestrial environment is directly affected from removal of vegetation resulting in loss of habits. Also coral reef environments are sensitive and highly susceptible to immediate changes that will be incurred from most of the development activities. Therefore, all the development activities must take into consideration the understanding of the environment and changes as well as implications that it will bring about to the environment and surrounding.

The following account describes potential environmental impacts that will be associated with the proposed project involving culture of sea cucumber in the northwest lagoon area of Boduhaikondi.

7.2 Methods and Limitations

The methods used to predict and evaluate the environmental impacts that may be associated with the proposed project may not be the most comprehensive methods as they are quite simple prescriptive methods. The main shortcoming of these methods is that only assumptions have been made to predict the impacts which may or may not be accurate. Also, the degrees at which these impacts are either accurate or inaccurate as well as uncertainties and natural variability are the key factors that affect the accuracy of these methods. Nonetheless, the methods used are concise and provide a general overview as well as the range of impacts that can affect the environment. Also, the EIA report has taken into consideration similar studies undertaken in the Maldives as well as expert judgment in identifying the main environmental impacts that may be associated with the proposed development.

7.3 Impact Identification

Impacts on the environment from various activities of the proposed development have been identified through:

- A consultative process within the EIA team and the Proponent
- Purpose-built checklist
- Existing literature and reports on similar developments in small island environments and other research data specific to the context of the Maldives
- Baseline environmental conditions described in Chapter 5.
- Consultant's experience of projects of similar nature and similar settings

A purpose built matrix has been used to evaluate the overall impacts of the proposed project. The impacts of the project have been evaluated according to the following criteria:

1. Magnitude (or severity): the amount or scale of change that will result from the impact

2. Significance: importance of the impact. Reversibility is considered part of its significance

3. Duration: the time over which the impact would be felt

4. Extent/spatial distribution: the spatial extent over which the impact would be felt

The scales associated with the above criteria are given in the table below.

Table 7-1: Impact evaluation scale

Criteria	Scale	Attribute
Magnitude Change caused by impact	-3	Major adverse
	-2	Moderate adverse
	-1	Minor adverse
	0	Negligible
	1	Minor positive
	2	Moderate positive
	3	Major positive
Significance/Reversibility Impact implications / Reversibility of impact's effects	0	Insignificant
	1	Limited implications / easily reversible
	2	Broad implications / reversible with costly intervention
	3	Nationwide or global implications / irreversible
Duration Duration / Frequency of Impact	0	Immediate
	1	Short term/construction period only
	2	Medium term (five years of operation)
	3	Longterm/continuous
Extent/Spatial Distribution Distribution of impact	0	None/within 1m from point of discharge/no affected party
	1	Immediate vicinity/household level/developer/consumer
	2	Specific areas within the island/atoll/specific parties
	3	Entire island/atoll/nation/all stakeholders

Based on the above scale, an impact matrix was developed for the proposed development to determine the overall impact of the proposed project. This matrix is given in Table 7-2.

An impact potential index was then developed from Table 7-2. The impact potential index table represents a product of the magnitude (M), significance (S), duration (D) and extent/spatial distribution (E) given in the above table. The sum of all key component specific indexes for one activity (i.e. sum by rows) provides the Activity Potential Impact Index (API) and the sum of all activity specific indexes for one key component (i.e. sum by column) provides the Component Potential Vulnerability Index (CPVI) which gives an indication of the vulnerability of each key component to activity related impacts. Table 7-3 represent the impact potential indices for the proposed project.

7.4 Overall Impacts of the Proposed Project

The overall impact of the proposed project is greatly positive due to the strong socio-economic potential of the proposed project.

Table 7-2: Impact matrix for the proposed project

PROJECT ACTIVITIES	KEY COMPONENTS									
	Environment						Socio-Economic			
	Reefs incl. live bait	Soil and groundwater	Lagoon/seawater	Hydrodynamics	Terrestrial fauna and flora	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Costs to consumer/tax payer
Construction										
Construction of culture cages	0	0	-2 0 1 1	0	0	-1 0 1 1	1 1 1 3	-1 0 1 1	1 1 1 3	-1 1 1 1
Infrastructure (jetty, channel and land structures)	-1 1 2 1	-1 0 1 1	0	-1 0 1 1	0	-1 0 1 1	1 1 1 1	-1 0 1 1	1 1 1 2	-1 1 1 1
Construction equipment/machinery	-1 1 2 1	-1 0 1 1	-1 0 1 1	0	-1 0 1 1	-1 0 1 1	1 1 1 2	-1 0 1 1	1 1 1 2	-1 1 1 1
Materials and contruction waste	-1 0 1 1	-1 0 1 1	-1 0 1 1	0	-1 0 1 1	0	0	-1 0 1 1	1 1 1 3	-1 1 1 1
Workforce and workforce management	-1 0 1 1	0	-1 0 1 1	0	-1 0 1 1	-1 0 1 1	1 1 1 2	-1 0 1 2	1 1 1 3	-1 1 1 1
Operation										
Use and maintenance of cages	-1 0 2 1	0	-1 1 2 1	-1 1 2 1	0	-1 0 2 1	1 1 2 1	-1 0 2 1	1 1 2 3	-1 1 2 1
Staff facilities and services	0	0	0	0	-1 0 2 1	0	1 1 2 1	1 1 2 1	1 1 2 3	-1 1 2 1
Waste and wastewater disposal	-1 0 2 1	-1 0 2 1	0	0	-1 0 2 1	-1 0 2 1	-1 0 2 1	-1 0 2 1	1 1 2 3	-1 1 2 1
Sale/processing of adult sea cucumber	0	0	-1 0 2 1	0	0	0	2 2 2 1	1 1 2 1	1 1 2 3	2 2 2 3

KEY: M S Magnitude Significance
D E Duration Extent (spatial)

Table 7-3: Impact potential indices for the proposed project

	KEY COMPONENTS										
	Environment						Socio-economic				
PROJECT ACTIVITIES	Reefs incl. live bait	Soil and groundwater	Lagoon/seawater	Hydrodynamics	Terrestrial fauna and flora	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Costs to consumer/tax payer	TOTAL API
Construction											
Construction of culture cages	0	0	0	0	0	0	0.04	0	0.04	-0.01	0
Infrastructure (jetty, channel and land structures)	-0.02	0	0	0	0	0	0.01	0	0.02	-0.01	0
Construction equipment/machinery	-0.02	0	0	0	0	0	0.02	0	0.02	-0.01	0.01
Materials and contruction waste	0	0	0	0	0	0	0	0	0.04	-0.01	0.03
Workforce and workforce management	0	0	0	0	0	0	0.02	0	0.04	-0.01	0.05
Operation											
Use and maintenance of cages	0	0	-0.02	-0.02	0	0	0.02	0	0.07	-0.02	0.03
Staff facilities and services	0	0	0	0	0	0	0.02	0.02	0.07	-0.02	0.09
Waste and wastewater disposal	0	0	0	0	0	0	0	0	0.07	-0.02	0.05
Sale/processing of adult sea cucumber	0	0	0	0	0	0	0.1	0.02	0.07	0.3	0.49
TOTAL CPVI	-0.04	0	-0.02	-0.02	0	0	0.23	0.04	0.44	0.19	0.82

API = Activity Potential Impact Index
CPVI = Component Potential Vulnerability Index

The table above indicates that the project has minor negative environmental impacts during and after the proposed works, however, the social and economic benefits of the project are higher, as a result of which the total potential impact index for the project is positive. Therefore, the project may be allowed to proceed as proposed.

7.5 Constructional Impacts and Mitigation Measures

Construction phase impacts are limited to the construction of the cages and infrastructure on land. The infrastructure on the island will be of a small scale and the cages are in a very small area of the lagoon. Therefore, the impacts of the actual construction would be minor with respect to scale and duration of the activity. During the construction, there will be some minor disturbances to the seabed, and subsequent sedimentation and sediment re-suspension. This impact is not significant and is short-lived. The main positive impact due to the

construction activities is the economic benefits to contractors and consultants (including the design stage) and job opportunities for locals and foreigners involved in the actual construction work.

Some minor (general) impacts and mitigation measures include:

- Littering by workforce for their convenience in the absence of supervision or awareness on proper care of the environment and constructional waste. This impact is best mitigated by ensuring appropriate waste management from the very onset of the project. Staff shall be made aware to keep the work site clean and tidy at all times. Appropriate waste disposal means and supervision is important
- Staff awareness of the fragility of the ecosystem in which they work. If staff are not made aware, they would often be ignorant of the fragile ecosystem. They may walk on the reef, create unnecessary pathways for their convenience, throw garbage, waste fuel and hazardous chemicals on the ground or even on the beach and keep construction materials on the beach. Staff awareness programmes and especially appropriate signs will help to minimize such impacts.
- Create obstructions to the movement of sand including excavator beds and piles of timber on the beach or swash zone resulting in severe modification of the natural longshore transport patterns. Supervisory staff must be aware of such and ensure that no obstruction to natural processes occur.
- Throw rubbish in the sea. Staff awareness especially signs in seagoing vessels and strict supervision is the key to minimizing impacts related to waste disposal.

Project specific impacts and mitigation measures are discussed below.

7.5.1 Site Preparation

Site preparation would usually involve clearing vegetation. The proposed project would involve clearing vegetation for the proposed infrastructure on land. The site plan is made such that minimal vegetation is removed for the infrastructure. At present there are several walkways that have been cleared of vegetation and therefore these would be used under the proposed project. Therefore, only areas where buildings have been proposed would be cleared of vegetation. This is less than 7% of the vegetated area of the island. Therefore, the impact of clearing is considered to be minor. Any mature coconut palms and trees most would be relocated on the project site.

While cutting down mature trees can and will be avoided, it is proposed to ensure this to the greatest possible extent by planning buildings around major trees or moving the proposed security shelters accordingly. If mature trees were cut or felled, two trees will be planted as replacement in other possible locations in the island, as per the Regulation on Cutting Down, Felling and Transplantation of trees.

7.5.2 Channel dredging and jetty construction

The location of the proposed channel has about 3m depth on average and no dredging will be required. However, some of the coral boulders and outcrops in the channel will need to be removed by excavator. This will cause some degree of short-term sedimentation as well as direct loss of live corals. It would be ideal to transplant all live corals in the area at safe locations on the edge of the deep lagoon, for instance. However, often this does not happen in reality although it is highly recommended to do so.

Jetty construction will involve the burying or placing of concrete columns with large footings. The burying of footings in the lagoon will require use of excavator or similar heavy machinery and there will be some degree of sedimentation, especially for the proposed jetty on the western side. The jetty on the western side would cause damage to several live corals in the area. It is recommended to minimize sedimentation by planning and speeding up the works and using excavator on a barge without using sand beds. It is also recommended to move/transplant affected corals to safe locations. Transplant activity can be carried out under the supervision or according to protocols proposed by a marine biologist.

7.5.3 Construction waste

Any construction site will have construction waste of several sorts. Given that construction activities proposed under the project are less compared to most of the projects in similar settings in the country with a smaller ecological foot print, the impact is considered to be minor to moderate adverse in magnitude and not significant. Yet, it would be necessary to have a specific area to collect and manage waste including green waste and bins for domestic and general waste in areas where staff activities take place. No construction waste shall be burnt on-site but taken to designated landfill or waste management centre. All work areas shall be kept clean at all times.

7.5.4 Workforce and machinery

The proposed works mainly involve general construction tools and heavy machinery such as excavator will be used to place the geotubes or rock for proposed shore protection. Heavy machinery is also not expected to be used on land. Excavator beds would not be required.

During the construction phase there will not be more than 15 persons at one given time. The impact from the workforce is, therefore, considered to be minimal or minor negative. Temporary facilities for toilets may not be required given that rented accommodation in the vicinity of the site will be provided to all workers. Therefore, the impacts from constructional workforce would be minor. However, the following mitigation measures may be considered.

- Appropriate planning and site supervision
- Take advantages of low tides for marine activities
- Take precautions to minimize the potential for any hazards and safety of workers at site

7.6 Operational Impacts and Mitigation Measures

The operation of mariculture/fish farms have five fundamental flaws namely waste, escapees, diseases and parasites, chemicals and feed/food (Staniford 2002). The significance and magnitude of these and other concerns with reference to the proposed project are as follows:

- Increased nutrient loadings from faeces and uneaten food wastes, which will either dissolve or settle on the seabed beneath the cage. Since adequate currents exist and the sand at the bottom of cages would be refreshed, eutrophication is unlikely. Moreover, imported feed would be minimized and seagrass in other islands, where seagrass removal is undertaken would be the feed for the sea cucumbers. They also feed on nutrients in the seabed, thereby helping in cleaning the seabed sediments/nutrients.
- The impact of disease transmissions on wild populations. This impact is considered to be minor negative and depends on stocking densities and feeding, which are not considered to be a problem. Environmental controls shall be established from the very onset of the project to mitigate disease prevalence and ensure a healthy environment.
- The impact cages may have on wild fish populations. Although this impact is not considered to be significant, this impact has to be studied in detail during the implementation stage.

- The genetic or competitive effect escapees may have on wild stock. Since juveniles that are not able to escape are used and exotic species would not be imported, this impact is unlikely to occur.
- Loss of visual amenity of the site. Visual amenity would be a concern, especially if the area is of aesthetic beauty for recreational (tourism) use, however, there are currently no such activities proposed for the island. Yet, it may be necessary to keep the structures well integrated with the environment while ensuring safety and to keep the island environment clean for future potential recreational use.

The potential for contamination of the seabed will be a concern as the farming progresses, however, there will be good flushing of dissolved and suspended effluents. If deposits reach shallow areas, there is the potential for resuspension and further dilution. In deep areas, resuspension is not likely and cumulative degradation of the seabed may be possible.

In the case of cage culture using locally found species, genetic pollution will not be a concern even in case of escapees and new diseases will not be introduced to the wild stock. However, an incubation of local diseases present in the wild stock may be a potential cause for concern in case of high stocking densities. Therefore, stocking densities shall be kept to an optimum at all times. The likelihood for habitat modification could occur in case of imported broodstock causing stress and related disease prevalence. However, this is a minor impact that is not considered to be significant.

It must be noted that a well-managed farm with good husbandry practices will have negligible, if any, of these impacts on the environment. Appropriate monitoring and close supervision on a regular basis would help to minimize impacts and create healthy products. Feed and feed related detritus on the seabed including faecal matter is a cause for concern in fish farming. However, sea cucumber culture is an eco-friendly aquaculture system where it does not require artificial feed and antibiotics. Therefore, feed control measures are not necessary.

In order to minimize the ecological footprint of the proposed sea cucumber culture facility, the Proponent as well as regulatory agencies shall be watchful on the impacts of the operations, especially with reference to introduction of Holothuria scabra in to the wild and wastes and discharges from the fish farm. However, long over-due attention would not be the case as this is an experimental project that is targeted to work towards a successful

commercial facility and the impacts of the operations can be expected to be closely monitored. While feed for the sea cucumber species have been considered, sea cucumbers are expected to rely on the seagrass beds in the area and nutrients embedded within the seabed sediments. However, in case of separate feeding arrangements, it will be necessary to not overfeed the sea cucumbers and plan feeds carefully. A mariculture expert on site will ensure that best practices are followed.

7.6.1 Nutrient loading

Since sea cucumber culture does not require artificial feeds and 90-100% tidal flushing of the water column within the farm area dissipating a large proportion of the aquaculture wastes. Therefore, nutrient loading is not expected. The proposed farm is an extensive not intensive process, therefore, the waste load on the aquatic resource is insignificant given the tidal flux. Assimilative capacity of the lagoon would not be affected negatively. However, there is the possibility of nutrient encroachment in vortices in the lee of high speed currents in the shallow areas leading to algal growth, especially the potential for the growth of seagrass as in many islands of the Maldives, where even low level nutrient loading has created the conditions for the growth of seagrass in these islands. The pristine quality of the lagoons is affected rendering islands unsuitable for tourism developments. Therefore, alternative uses may be affected. This has to be adequately monitored and all risks alleviated. Therefore, stocking densities and the number of cages or even the number of farming operations in the lagoon shall be regulated. It has been reported that in areas with numerous farms, nutrient enrichment and the risk of eutrophication are significant issues (EC 2002, p9) and that there is a link between algal blooms and fish farm waste (Staniford 2002). While this is the case for fish farms, sea cucumber culture reduces nutrient levels as the sea cucumber feeds on sea grass and nutrients in the seabed.

7.6.2 Escapees

Escapees are mainly a concern when genetically modified (GM) species escape a farm. However, escapees are also a concern when their predatory instincts, hunting tactics, etc. have not developed resulting in potentially weaker biological offspring with genetic disabilities present in the wild stock. As well as spreading parasites and ‘genetic pollution’ via interbreeding and hybridisation, escapees have the capacity to spread infectious diseases

(or possibly new strains of a certain disease) to wild fish populations (Staniford 2002). The reverse is also a possibility, however, not likely.

Although the above is a possible and documented impact of intensive fish farms in several places worldwide, the significance of this impact in the case of the proposed culture project is extremely low as GM species would not be used, stocking densities would be way below the carrying capacity and appropriate measures will be in place to minimize escapees.

7.6.3 Disease and behaviour modification

According to Staniford (2002) sea cage fish farms will continue to act as reservoirs for infectious diseases and parasitic infestations highlighting that the spread of diseases and parasites is a function of overstocking and intensive production with reference to Paone (2000). This is the case of several intensive fish farms in Europe, especially those in inland waters and estuaries. However, in the case of the proposed project, the stocking densities are expected to be considerably low and parasitic infestations are not likely due to high levels of natural pristine conditions maintained and low nutrient loading in cages.

In order to minimise inbreeding and vulnerability to disease and infections maintaining a healthy bloodstock with high levels of genetic mixing is required. To meet the demands brood stock will be purchased locally if available at regular intervals. However using brood stock from the same hatchery or breeding facility will only reduce the genetic diversity. Therefore it is recommended to import *Holothuria scabra* from neighbouring countries as per pertinent laws.

7.6.4 Impacts of co-culture

As has been discussed in the Alternatives section, co-culture has a positive impact on ecological balance as one system in a lower trophic level depends on that on the upper trophic level. However, in a study of Holothuria scabra with tiger shrimps, Bell *et al* (2007) reports that while there is no effect on the shrimps in the co-culture system (in earthen ponds), the shrimps affect the growth of H Scabra. They say for large scale (commercial or restocking) operations the problems arise because juvenile sandfish are deposit feeders and require large surface areas to forage for detritus and bacteria. Providing such large surface areas is expensive and threatens to make the cost of cultured juveniles unacceptably high. One possible way of providing the necessary surface areas would be to co-culture sandfish with

shrimp in earthen ponds (Battaglene and Bell, 2004). Preliminary experiments on combined culture of sandfish and Penaeus monodon in Vietnam (Pitt et al., 2004), and with Litopenaeus stylirostris in New Caledonia (Purcell et al., 2006), showed that sandfish had no effects on growth and survival of the shrimp. Sandfish also grew and survived well when reared with P. monodon during many of the trials; however, harassment and predation of sandfish occurred under some conditions (Pitt et al., 2004). Sandfish also survived well when reared with juvenile *L. stylirostris* but their growth was significantly slower due to increased levels of ammonia from shrimp (Purcell et al., 2006). According to James D.B (1999), where he reports that a private company was producing the seed of *H. Scabra* in the Maldives after importing broodstock material from India (Tuticorin), *H. scabra* cultured in a prawn farm has had great results with the sea cucumber removing the pollution on the bottom as they are detritus feeders subsisisting on the organic matter present in the soil. They convert organic waste into body protein that makes them grow faster. And the sea cucumbers in no way affect the prawns but help their growth by minimizing pollution. Moreover, NIWA adds to the above stating that their co-culture research "suggests sea cucumbers could enhance nutrient recycling when ranched under salmon and mussel farms" and "feeding trials show that sea cucumbers thrive on organic material produced by these operations, while tagging trials show that they prefer living under mussel farms to open areas".

Hatchery manager, Dr. Beni Giraspy of Sea Cucumber Hatchery, Queensland, Australia says that "sea cucumber culture is an eco-friendly aquaculture system because sea cucumber culture does not require artificial feed and antibiotics. More over the sea ranched sea cucumber juveniles doesn't need any complicated structures or constant attention. Sea cucumber juveniles can be cultured with shrimps as the sea cucumbers function on different tropic or nutritional level in the same environment. Sea cucumbers are benthic detritus feeders and reduce the bacterial load and improve the water quality" (the fish site).

7.6.5 Large scale release of H. Scabra

Battaglene, S.C. et al (1999) concludes that there should be no impediment to the large scale release of H Scabra provided they can be released successfully at a size of 60 mm and 20 g. This is with reference to their survival in the wild. However, with reference to the impact on the environment, it can be said with some degree of certainty that the practice is not expected to affect species presently found in the wild nor have negative impacts on the environment. If negative impacts are found, it is expected to be easier to reverse impacts due to the sedentary

nature of sea cucumber. However, it would be extremely important to study the behaviour thoroughly and understand the impacts from the very onset of the project. Continuous research and monitoring in the early stages of release would be critical as there is little published data on parasites and diseases of cultured holothuroids (Battaglene 1999).

7.6.6 Processing and process waste

The processing of sea cucumbers can cause considerable harm to fish stocks. In the Maldives Holothurin is also used for poisoning fish before catching them. Many species, especially *Alanaasi, Feeru* and *Holhi*, contain the toxin Holothurin, which is poisonous to fish but used for several medicinal purposes. By boiling sea cucumbers, the toxin leaks out and contaminate the boiling water, which is generally discharged in the island's lagoon, and leads to fish mortality (Joseph 1992 cited in Bers 2005). Holothurin has been shown to be effective in its use for eradication of predators and undesirable organisms from fish farms (James 1986).

In addition to the health benefits of the toxin, Holothurin obtained during processing of H scabra and used to relieve pain and to cure paralysis by some villagers in the North part of Srilanka. Wasted sea cucumbers can also be used in making poultry feed (Mageswaran and Balakrishnan 1985). Wasted sea cucumbers can also be used as a potential source of feed for poultry and other animals.

7.6.7 Waste and wastewater

Construction stage is often a stage in which the impacts are ignored but when the bulk of the impacts often start to take effect, especially that of solid and liquid waste management. This happens because there are no regulatory requirements for constructional waste management. Therefore, it should be in the Developer's sole interest to safeguard the quality of the environment in which he undertakes his business since the sustainability of his business is mainly dependent on that of the environment.

For the proposed project, construction waste is expected to be minimal. However, since construction of the cages take place in the marine environment, waste should be carefully handled. There shall be a zero tolerance for waste disposal into the marine environment. General domestic waste arising from material consumption by construction workforce shall

be managed using bins provided on site. The Proponent shall ensure that all construction-phase waste is disposed of during demobilisation.

7.6.8 Employment and other socio-economic impacts

The proposed project is expected to help the economic development of Raa Atoll during its construction and operation stage. The development would also have indirect impact on the atoll and the national economy due to the development of related services in the atoll and other parts of the country.

The following are considered as the main positive impacts or outcomes of the proposed project.

- Changes to the demographic characteristics of the fishery-related workforce, which may be considered to be a positive effect such as the involvement and learning about a new type of fisheries, namely mariculture or aquaculture
- Direct and indirect employment generated by the construction activities of the different project components.
- Employment created by related service sectors such as transportation, house rental or guesthouse, café, taxi and truck operations.
- Increase demand for local production such as fish, agricultural products and others due to constructional as well as operational workforce.
- Indirect employment generated elsewhere in the handling of import and export of resources and products.
- Indirect employment generated due to the project.

The negative socio-economic impacts of the project may be less important than the positive impacts. However, they cannot be left unconsidered. Therefore, however minor the impact may be, potential negative impacts of the proposed project have also been considered, as follows.

- There may also be cultural issues of attitudes, beliefs and values of fishermen, fishery-related workers and other stakeholders in the community. Some members of the Atoll who have been engaged in conventional fishing activities may find their dominance in the community being affected and may have negative feelings about the project. However, this is considered to be insignificant or irrelevant in the case of the proposed project.

- The development creates a lot of employment during construction and operation. Though priority is given to local contractors in the construction period and Maldivians in the operation stage, foreign workforce needs to be employed as to fill all the jobs due to shortage of locals for the skilled and unskilled jobs. This leads to leakages and related social conflicts in the island communities.

Since negative socio-economic impacts are minor to negligible in terms of their significance, no mitigation measures would be necessary.

7.7 Uncertainties in Impact Prediction

Environmental impact assessment involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place. The level of uncertainty, in the case of the proposed development, may be expected to be low due to the experience of similar projects in the Maldives. However, there is concern over the release of locally cultured Holothuria scabra in to the wild. H scabra is considered to be an exotic species as it has not been recorded to be found in local waters. The uncertainty of the impacts related to the introduction of H scabra is considerate to be small. Nevertheless, it is important to consider that there will be uncertainties and to undertake voluntary monitoring during project implementation as recommended in the monitoring programme given in this report.

8 Environmental Monitoring

8.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are most relevant for monitoring the impacts that may arise from the proposed project are included in the monitoring plan. These include water quality, sedimentation, shore dynamics, live coral cover and nektonic fauna.

Monitoring would ensure that the proposed activities are undertaken with caution and appropriative care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

The purpose of the monitoring is to provide information that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods. This will help to minimize environmental impacts of projects in future.

The monitoring plan shall target to measure:

- Marine water quality and currents at selected/designated locations
- Quality of sediments at potential locations
- Incidents/accidents
- Fuel and water consumption

8.2 Recommended Monitoring Programme

The annual monitoring programme targeted at monitoring the coastal and marine environment of Boduhaikondi in relation to the proposed sea cucumber culture project is given in Table 8-1 and Table 8-2**Error! Reference source not found.**. This programme starts from the onset of the project. The proponent's commitment to undertake this monitoring programme forms part of this report.

8.3 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency yearly based on the data collected for monitoring the

parameters included in the monitoring programme given in this report. EPA may submit the report to the relevant Government agencies in order to demonstrate compliance of the Proponent.

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. The report will also include fuel and water consumption data and species health related information, quarantine events and other experimentation data.

The report will cover the following:

- Details of the site
- Details of methodologies and protocols followed
- Strategy of data collection and analysis
- Sampling procedures
- Quality control measures
- Monitoring results
- Compliance with relevant standards and requirements of the EIA
- Performance of the different project components in achieving the project objectives
- Conclusions and recommendations

Table 8-1: Monitoring programme for construction phase

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (baseline locations)	Water quality: temperature, conductivity/salinity, DO, pH, Turbidity, TSS	Every three months	2	2	2				2			2			10	10.00	**100.00**
2	Marine life/biodiversity (baseline locations)	Live coral cover and fish survey - Photo quadrates/LIT and fish survey	Every six months	5						5						10	30.00	**300.00**
3	Currents/hydrodynamics (baseline locations)	Drogue tracks	Every three months	3	2	2	2			2			2	10		23	20.00	**460.00**
4	Shoreline changes (tide lines only)	High tide line, low tide line	Every three months	3			3			3			3			12	25.00	**300.00**
5	End of construction stage monitoring report		Construction phase only												1	1	500.00	**500.00**
TOTAL																		**1,660.00**

Note:

M indicates Month

Table 8-2: Annual monitoring programme for operational phase

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (baseline locations)	Water quality: temperature, conductivity/salinity, DO, pH, Turbidity, TSS	Every six months	2			2			2			2			8	25.00	**200.00**
2	Marine life/biodiversity (baseline locations)	Live coral cover and fish survey - Photo quadrates/LIT and fish survey	Every six months	5						5						10	30.00	**300.00**
3	Currents/hydrodynamics (baseline locations)	Drogue tracks	Every three months	3			3			3			3			12	25.00	**300.00**
4	Shoreline changes (shorelines only)	High tide line, low tide line	Every three months	3			3			3			3			12	25.00	**300.00**
5	Groundwater quality at baseline locations	pH, EC, TDS, faecal coliforms, hydrocarbon, phosphates and nitrates	Every six months	2						2						4	50.00	**200.00**
6	Production data	Site data	Regularly															**-**
7	Employment, water, fuel and energy data	Site data	Regularly															**-**
8	Air quality at powerhouse and control location	Temperature, humidity, SO2, NO2, PM2.5, PM10, CO and ozone	Every six months				2						2			4	30.00	**120.00**
9	Noise at powerhouse and 4 other locations	SPL (dB)/day and night levels	Every six months				5						5			10	15.00	**150.00**
10	Desalinated water (product tank, staff room, guest room, kitchen)	pH, EC/TDS, total coliforms, faecal coliforms	Every three months	4			4			4			4			16	50.00	**800.00**
11	Annual Monitoring Report		Once a year												1	1	500.00	**500.00**
TOTAL																		**2,870.00**

Note:

M indicates Month

9 Conclusions

In conclusion, it appears justified from a technical and environmental point of view, to carry out the proposed project to commercially culture and grow out Holothuria Scabra and to a lesser extent other species locally available at R. Boduhaikondi.

There are a few negative impacts of the proposed project during the construction phase including benthic loss in the construction of proposed cages and structures on land. Excavator will be used to place precast concrete columns with footings for the jetty as well as for the proposed shore protection. Minimal excavator movement is necessary to preserve benthic habitat. It is highly recommended not to create any sand beds during mobilization and to use excavator on barge during installation of jetty and dredging of channel. In fact, channel dredging would be minimal involving mainly removal of coral outcrops in the channel. Care has to be taken during the construction of minimize sedimentation and sediment resuspension. For every mature tree removed or felled, two trees of palms shall be planted on site. Therefore, it is important to minimize clearing vegetation by planning building around palms and mature trees.

There are no known threats to the wild stock and it is not expected to have any other negative impacts as Holothuria Scabra is considered a localized species that has adapted to local conditions. Also, the broodstock used will be from sites within the Maldives and those obtained and grown during feasibility stage of this project.

The proposed project needs environmental and socio-economic monitoring to be undertaken on an extensive scale to monitor possible impacts to environmental, especially sediment and water quality conditions. Rigorous monitoring of water quality and changes in currents (drogue studies) in the area during the construction phase and especially the operational phase is recommended. Also, socio-economic benefits in terms of products, end-users, employment and associated by-products and business opportunities for local populace need to be understood and addressed.

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12 Appendices

Appendix 1: Terms of Reference

Appendix 2: Commitment letter

Appendix 3: Communication of final draft with Atoll Council

Appendix 4: Approved concept plan

Appendix 5: Work plan

203-EIARES/INDIV/2016/63

Terms of Reference for Environmental Impact Assessment for a Mariculture Project at Boduhaiykodi, Raa Atoll

The following is the Terms of Reference (ToR) following the scoping meeting held on 24/4/2016 for undertaking the EIA for the proposed *Mariculture Development at R.Boduhaiykodi.*

While every attempt has been made to ensure that this TOR addresses all of the major issues associated with the developmental proposal at B.Boduhaiykodi, 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 – S**ubmit 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
- Quarantine facilities required according to Ministry of Fisheries and Agriculture/MRC

Land based hatchery and larval rearing facility

- Land Clearance/preparation
- Water supply for culturing process
- Quarantine facilities
- Describe tanks, size, depth, water quality requirements, construction methods, equipment (water and sanitation system, materials, waste disposal system and waste water management and disposal
- Water intake pipeline location site justification (include map) and construction methods;

Sea cages- marine based

- Details and justification of total area of ocean required, cage location, size, number of cages, materials, installation methods, equipment;
- Justification of distance to shore, water depth required, anchoring system;
- Water pumping system, sanitation and solid waste removal;
- Access to cages from shore and transportation method

Storage facility, other infrastructure, site maintenance

- Project management description (including schedule, labour, housing and machinery management and operation, healthy and safety measures)
- Storage and packaging facility construction, size, methods, machinery required

Jetty Construction

- Justification for selection of location
- Selection of method, construction, equipment
- Duration if any dredging any involved

Task 2. Description 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. The report should outline detailed methodology of data collection utilized. Information of the following shall be provided.

Climate

- Temperature, rainfall, wind, waves, (including extreme conditions)
- Risk of storm surges;

Hydrography

- Tides
- Waves
- Currents

Physical parameters (use maps where appropriate)

- Sea and ground water quality measuring these parameters: temperature, pH, salinity, turbidity, phosphate, ammonia, sulphate and TDS, total and faecal coliforms.

Existing Marine Environment:

- Identify marine and coastal areas 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).
- Benthic and fish community around the island;

Existing Terrestrial (shoreline) Environment

- Shoreline vegetation around the reclamation site
- Details of the vegetation on the island and vegetation to be removed

Natural Hazard and Vulnerability

- Vulnerability of the area to flooding and storm surges

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 approvals to any changes to the proposed concept
- Regulations of Maldives Food and Drug Authority
- Dredging and Reclamation Regulations

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:

Impacts on the natural environment

- Water run off impacts from pesticide and fertilizers on marine environment, include changes in seawater quality assessments especially water turbidity and sedimentation and changes in fish community structures
- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology
- Impacts of noise, vibration and disturbances
- Impacts on ground and marine water quality
- Impacts on vegetation, landscape integrity/scenery.

Impacts on the socio-economic environment, mostly if project is for inhabited islands

- Impacts of food prices and availability
- Impacts on fishing and tourism activity
- Impacts on island employment, income and economy diversification;
- Impacts of increased demands on natural resources and services especially water supply, land availability, waste management, energy supply, harbour capacity;

Construction related hazards and risks

- Pollution of the natural environment (eg: oil spill, solid waste including construction waste)
- Risks of accidents and impacts on workers and local population

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 action 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 will include both environmental and socio-economic mitigation measures with particular attention paid to sedimentation control and future changes in coastal processes. Mitigation measures to avoid or compensate habitat destruction caused by land clearance will have to be considered. Measures for both construction and operation phase shall be identified. Cost 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 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 effect 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 ground water and sea water quality as well as for marine ecosystem in surrounding waters due to water run-off. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction, after project completion then on a yearly basis for five years after. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

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.

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 f or 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.

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24 April 2016

Environmental Protection Agency
Green Building, 3rd Floor, HandhuvareeHingun
Male', Rep. of Maldives, 20392
Tel: [+960] 333 5949 [+960] 333 5951
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Email: secretariat@epa.gov.mv
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بسم الله الرحمن الرحيم

BODUHAIYKODI Private Limited

H.Thuniya Building 3rd floor, Boduthakurufaanu Magu, Male' 20066, Maldives

Tel: 3320157 | Fax: 3329253

15th June 2016

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Malé

Dear Sir,

This is in reference to the EIA report for the proposed sea cucumber aquaculture project in Boduhaiykodi, Raa Atoll.

As the Proponent of the project, we assure you our commitment to undertake the proposed mitigation measures and monitoring programme given in the report.

Yours sincerely,

Ali Ahrush Ibrahim

Sandcays

From: Sandcays <info@sandcays.com>
To: 'frontdesk@raa.gov.mv'
Cc: 'Hussain Fizah'
Subject: EIA Report for the Proposed Sea Cucumber Project at Boduhaikondi
Attachments: EIA for Boduhaikondi Aquculture Project_final.pdf

Dear Secretariat,

Please find the final report of the Environmental Impact Assessment (EIA) for the proposed sea cucumber project on R. Boduhaikondi for your kind information.

Regards,

EIA Consultant

Sandcays Pvt. Ltd.
H. Alihuras
Lonuziyaaraiy Magu
Malé, Maldives
Mobile: (960)9154902
Fax: (960)3009799

Sandcays
Environment specialists
www.sandcays.com

LEGEND:

1	HARBOR ENTRANCE	
2	MOSQUE	110 sqm
3	STAFF MESS & KITCHEN	143 sqm
4	JUNIOR STAFF ACCOMMODATION	403sqm
5	SENIOR STAFF ACCOMMODATION (5blocks)	99 sqm per block
6	POWER HOUSE & RO PLANT	150 sqm
7	WATER RESERVE	
8	FUEL RESERVE	
9	FARMING AREA (sea cucumber) (1, 2, 3)	3100 sqm
10	JETTY	
11	OFFICE & LABORATORY	182 sqm
12	STORES (1 & 2)	364 sqm
13	WASTE MANAGEMENT	350 sqm
14	BEACH GROYNES	
15	SECURITY HUT (2 blocks)	11 sqm
16	TELECOM HOUSE & TOWER	
17	MAINTENANCE & WORKSHOP	364 sqm
18	MANAGER HOUSE	147 sqm
19	PROCESSING UNIT	147 sqm
	LAND USE TOTAL:	=5,563sqm

01/06/2016

N

RAA. BODU HAIH KODI
DEVELOPMENT PLAN

Tentative Work Plan for Proposed Sea Cucumber Facility in Boduhaikondi, Raa Atoll

	Duration	Months											
Activity	**(Days)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Mobilization	30												
Setting Out	15												
Site Clearance & Roads	90												
Temporary Accomodaton	90												
Communications Facilities	120												
Entrance channel dredging	30												
Workshop	30												
Construction of jetties	90												
Power House, RO plant & Workshops	120												
Water and Fuel Tanks	60												
Waste Management Site	75												
Mosque	90												
Sea cucumber cages/farming areas	120												
Staff Accomodation	150												
Staff Mess and Kitchen	150												
Administration Buildings	150												
Storage Facilities	150												
Install Power Distribution	120												
Install Sewerage System	120												
Office and laboratory	90												
Processing unit	90												
Testing and commissioning	90												