

Environmental Impact Assessment Report For Coastal Protection at Gn. Fuvahmulah, Maldives

November 2016

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PROJECT SYNOPSIS

Name of the Project: Proposed coastal protection at Gn. Fuvahmulah

Project Proponent: Ministry of Environment and Energy

Project Financier: ORIO

Project Value: Approximately €18-22 million

Expected Duration: 10 months for planning and 12 months for construction

EIA Consultant: Ahmed Saleem, Maldives Energy and Environmental Company (MEECO)=

EIA Date: November 2016

WEIGHTS AND MEASURES CONVERSIONS

1 metric tonne = 2,204 pounds (lbs.)

1 kilogramme (kg) = 2.2 lbs.

1 metre (m) = 3.28 feet (ft.)

1 millimetre (mm) = 0.03937 inches (")

1 kilometre (km) = 0.62 mile

1 hectare (ha) = 2.471 acres

LIST OF ABBREVIATIONS

CBD	Convention on Biological Diversity
CO ₂ -e	Carbon dioxide equivalent
DA	Decentralisation Act
DDRPM	Development of Disaster Risk Management Profile Maldives
DIRAM	Detailed Island Risk Assessment in Maldives
DNP	Department of National Planning
DO	Dissolved Oxygen
DWT	Dead weight tonnage
EIA	Environment Impact Assessment
EMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
EPPA	Environmental Protection and Preservation Act
ES	Environmental Score
FS	Fuvahmulaku School
GHG	Green House Gas
GoM	Government of Maldives
HAS	Hafiz Ahmed School
HIES	Household income and expenditure survey
H _s	Peak Height
IFC	International Finance Corporation
MAS	Marine Analysis Station
MCA	Multi Criteria Analysis
MEE	Ministry of Environment and Energy
MEE	Ministry of Environment and Energy

MFA	Ministry of Fisheries and Agriculture
MFT	Ministry of Finance and Treasury
MHI	Ministry of Housing and Infrastructure
MJM	Madharusathu-Sheik Mohammed Jamaaluddeen
MMS	Maldives Meteorological Service
MPA	Marine Protected Area
MRDC	Maldives Road Development Corporation
MSL	Mean Sea Level
NBSAP	National Biodiversity Strategy and Action Plan
NDMC	National Disaster Management Centre
NEAP	National Environmental Action Plan
NSWMP	National Solid Waste Management Policy
ORIO	Facility of Infrastructure Development (Fund from the Netherlands)
PPE	Personal Protective Equipment
RS	Range Values
SRWMP	Southern Regional Waste Management Project
TOR	Terms of Reference
SA	Social Assessment
UAE	United Arab Emirates
WAMCO	Waste Management Corporation Limited
MNDF	Maldives National Defense Force
MPS	Maldives Police Service
IWMC	Island Waste Management Centre
SRWMC	Southern Regional Waste Management Centre

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DECLARATION OF THE CONSULTANT AND PROPONENT

Consultant

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

Ahmed Saleem (EIA 03/13)

Signature:

A handwritten signature in blue ink, appearing to read 'A. Saleem', with a long horizontal line extending to the right.

Proponent

The Proponent's declaration and commitment to undertake the mitigation and monitoring is given in **Annex 9**.

سَمَرْ دُخْرَم

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NON-TECHNICAL SUMMARY

This environmental impact assessment (EIA) report highlights the findings of the EIA carried out for the proposed coastal protection of the north-eastern coast at Gn. Fuvahmulah, the Maldives. The EIA was prepared as a fulfilment of the mandatory requirement under the EIA Regulations 2012 of the Maldives and the international standards of the International Finance Corporation (IFC) to comply with the requirements of the ORIO Fund from the Netherlands and to obtain environmental clearance from the Environmental Protection Agency of the Maldives prior to the commencement of the Project.

The Proponent of the project is the Ministry of Environment and Energy, Government of the Maldives. The Project cost is estimated to be between €18 – 22 million.

This EIA report has been prepared in accordance with the Terms of Reference agreed between the proponent and the Maldives' Environmental Protection Agency (EPA) following the scoping meeting held on 20 June 2016.

Technical consultancy for the Project is provided by Royal HaskoningDHV from the Netherlands and the Maldives Energy and Environmental Company (MEECO) Pvt. Ltd has been sub-contracted to carry out the Environmental Impact Assessment and the related studies.

Coastal erosion is one of the most serious environmental issues facing Fuvahmulah. According to the present assessment, coastline regression due to erosion has been on average 0.8m/year over the period of the past 47 years (1969 – 2016). It is believed that approximately 15 ha of land had been lost from the island due to erosion. As a result, several important buildings, facilities and palm trees have been found at the border of the eroding coastline. The project Island has an elongated shape with raised ridges at the coastal margin sloping down towards the middle where depressions with swampy areas and two freshwater lakes in the middle. The ridge forms a natural protection against flooding of the island. However, erosion is threatening the integrity of the ridge at the north-eastern side of the island. When the ridge breaches serious flooding of a large part of the island will occur affecting the livelihood of the people, freshwater bodies, agricultural produce and infrastructure on the Island. The population on the Island is highly concerned about this serious risk resulting in feelings of insecurity and limiting socio-economic development of the island.

Although coastal erosion is experienced by many other islands in the Maldives, Fuvahmulah has become the priority island, because it is one of the biggest and most populated islands in the Maldives with good infrastructure, social services, wetlands, freshwater bodies and a high potential for agriculture. This is an exception for the Maldives. The Government of the Maldives has recently accorded city status to Fuvahmulah. The city status will draw further investments to the island.

Fuvahmulah is considered one of the envisaged growth centre islands in the Maldives for the future. The Government of the Maldives is further investing infrastructure and development of the island through several ongoing projects, and has the intention to develop Fuvahmulah as a safe island with a concentration of population and facilities that will attract people both from smaller less populated islands as well as offer an alternative for migration to the congested capital Male'.

According to current assessments the 2.6 km of northeast coastline is undergoing serious erosion, starting just north of the port and reaching till about 700 meter from *Thundi* Beach in the north of

the Island. In severely eroding areas, beach sand has been completely lost exposing the bedrock underneath. During high tide, waves reach the island's coastal ridge.

While rubble, beach rock and coarse sand form the main composition of the material on the eroding coast, the lagoon region found along the northeast coast had very poor live coral cover. Due to the erosion the coastal vegetation belt is getting damaged, with tall coconut plants being lost to erosion.

Information and data for the EIA was collected by making two field visits to the island in May 2015 and July 2016. During these visits baseline data was collected and stakeholder discussions on the project were held. In addition, all available relevant literature and comparable studies were reviewed.

In order to identify the most appropriate alternative to protect the coastline, a long list of eight potential coastal protection measures was compiled. This long list was assessed against a number of criteria to select the most favourable ones. Two feasible and effective options that are believed to be most appropriate to the existing conditions of Fuvahmulah have been selected– an offshore breakwater and an onshore revetment. These two alternatives were further investigated in a quantitative multi-criteria analysis (MCA).

While an offshore breakwater will reduce the erosive force of the approaching waves, therewith creating calmer conditions on the lee of the structure, the onshore revetment will protect against erosion at the shoreline itself. The effectiveness to protect against erosion is considered higher for the onshore revetment than for the offshore breakwater. The offshore breakwater has more uncertainties in the design, making it less certain that erosion will be prevented completely. In addition, the risk that *Thundi Beach* may be affected by additional erosion due to the coastal protection structure is considered higher for the breakwater option than for the onshore revetment. Based on these main considerations the onshore revetment was selected as the most preferred option.

The onshore revetment has been designed taking into account wave characteristics and predicted sea-level rise for the Maldives. The structure will be placed seawards to limit the effect on the vegetation belt after profiling the broken ridge with a quarry run. Underneath the rock armour geotextile layer may be placed to prevent undercutting. The crest level of the structure will be +3.5m from MSL and will have a design life of 50 years. The structure will have a length of 2,650 meters and a width of 27 meters, starting at the port towards the north. A total volume of 131,979m³ of granular rock will be required.

A bulk carrier would transport the materials to the island (most probably from India) while smaller bulk carriers, trucks and equipment that are commonly used for such works will be utilised for the processing and the placement of the rocks. Rocks will be unloaded and stockpiled in the outer harbour and transported to the site of placement by trucks running over the revetment itself, therewith minimising transport over the island itself. The construction is expected to take 12 months.

Quality assurance during designing and constructions will ensure minimum maintenance during the design life of the structure.

All environmental and socio-cultural (positive and negative) impacts expected from the Project have been identified for both the onshore revetment and the offshore breakwater. Cost effective, robust measures have been identified to mitigate against adverse impacts and to enhance the

positive impacts. Highlighted below are the likely impacts and related measures for the preferred alternative – the seaward onshore rock armour revetment.

The main positive impact of the project is the minimisation of the risk that the island will be flooded as a result of breach in the ridge due to coastal erosion. This limits the risk of loss of life, damage to natural and economic assets, feelings of insecurity in the population and limitations to socio-economic development and in the ultimate scenario an abandonment of the island. Protecting the island's integrity will enhance the sustainable development of the island in economic, social and environmental terms. To coordinate and enhance integrated development of the island an integrated development plan should be prepared, implemented and monitored in close cooperation with the population and local stakeholders.

Construction of 2650 m long and 27 m wide revetment would mean irreversible altering of a footprint of 71,550m² of existing coastal environment, which is inevitable. The long term erosion of the island's coastline has already effectively converted the footprint area into an area of low habitat value consisting mostly of rubble, beach rock and limited beach. Since the objective of the revetment is to provide protection and security to the people and the terrestrial habitat, the benefits of coastal protection far outweigh the negative impact of permanent conversion of the existing coastline.

Quarrying of rock boulders changes landscape, creates noise, dust and safety risks at the location of the quarry. Hence, obtaining rocks from a certified supplier is required and the design has been optimised to limit the material requirements.

Transport (both land and sea) of materials from the source country to the project site and the energy utilised by the machineries and trucks would generate emission of Green House Gases (GHGs) and other polluting gases. A total of 9,650 ton CO₂ emissions will be generated by the production and transportation of the construction material and the placement of the materials as the revetment. Consequently supplying materials from the closest available source, efficient use of vehicles, equipment and bulk supply and proper maintenance of vehicles and equipment are required to limit the CO₂ emissions.

In addition to climate change impacts, the movement of vehicles when used on the island itself can damage unsurfaced roads, create risks of accidents, noise, vibrations, dust and risks of spills of fuel or waste on land.

However, a construction method has been proposed to use the revetment itself as a transportation route to get the construction material from the port to the site of placement. Construction of the first layer of the revetment will start at the port and while working towards the north a path will be laid for the vehicles to use. The second layer of the revetment will be laid starting in the north, working backwards towards the port still driving over the revetment. In this way transportation overland can be kept to a minimum and will mainly consider staff, small supplies and supervision. Access paths for vehicles will be located in areas of low habitat value, away from sensitive receptors and public to minimise transport related impacts.

An advantage of the offshore breakwater would have been the creation of a large safe swimming area at the lee side of the structure, which is not the case with the onshore revetment. This has been compensated by including steps in the design so that the water will be easily accessible and by reinforcing the current small tetrapod breakwaters with rocks and installing a safety line to enhance

the current swimming areas. Works in the coastal zone create risks of damaging coastal vegetation and sites of historical and cultural importance. Therefore, fencing and/or delineation of these areas prior to construction along with carefully selected routes for vehicle movement have been proposed. In addition mature trees will not be removed unless all options have been explored. In the unlikely event of a tree removal existing regulations will be followed and implemented.

Next to the vegetation, there is also a risk of damaging the geological features such as the island ridge and beach rock. It can also cause soil compaction and can affect the beach fauna. Setting up access routes and using protective boarding for vehicles and low ground pressure machinery to drive on have been proposed to mitigate these effects.

Generation of construction waste, waste oil and other hazardous wastes, fuel spills have a potential to pollute the environment, as well on land as in the sea. Hazardous and non-hazardous waste generated by the Project shall not be allowed to be discarded on the island since Fuvahmulah lacks a waste management system. It is proposed to designate an area for waste collection for subsequent disposal at Thilafushi landfill site. Hazardous or potentially polluting materials such as fuel, oil, batteries, chemicals etc. will have to be stored on an impervious base (concrete pavement) away from water and properly banded and kept locked when unattended. In addition, storage of fuel, equipment and construction materials have also been proposed to be properly stockpiled so as to minimise the risk of soil or sediment contamination or water pollution and to avoid material wastage.

Vessel and barge movements shall be coordinated by the authorities to limit the risks of grounding or collisions, which can potentially cause spills or other hazardous substances.

An emergency plan that shall be submitted by the contractor will further ensure that procedures to prevent or mitigate impacts due to accidents or spillages are in place and operate effectively during the Project implementation.

The risk of moving the erosion problem to north with the risk of affecting *Thundi* area is an uncertain element in the current assessment. This is mainly due to lack of long-term data on longshore currents and sediment transport regime around the coast. However the expert opinion is that the risk of *Thundi* beach erosion is low and is considerably lower in the case of the onshore revetment compared to the offshore breakwater structure.

Due to the uncertainties involved it is required to implement a detailed monitoring program to evaluate changes of *Thundi* area following the construction of the structure.

The visual impact of the revetment viewed from the beach may not be appealing to some people and may be considered an eyesore. In designing the structure measures that can minimise the visual impacts have been considered.

The rock armour revetment can also cause difficulties to access the beach and the sea for the people. Hence for convenience of the people steps have been incorporated into the design.

The magnitude and importance of all impacts has been evaluated and their significance assessed in the EIA report with necessary mitigation measures so that the residual impacts are well within accepted limits. With the mitigation measures in place, no activity planned under the project is expected to result in residual impacts that are of concern to the environment or to the people.

This assessment confirms that the project will adhere to the relevant existing laws and regulations and is in accordance with government policies and development plans.

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

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1. INTRODUCTION

1.1 PROJECT BACKGROUND

The Ministry of Environment and Energy (MEE) of the Government of the Maldives (GoM), intends to build approximately 2.6 km long coastal defence structure to control prolonged acute erosion of the coastline on the north-eastern side of Fuvahmulah Island, Gn. Atoll, Maldives (hereinafter referred to as the Project).

A Feasibility Study for the Project has been carried out under financial and technical assistance from the Government of the Netherlands under the ORIO grant program (Facility of Infrastructure Development). The grant application was submitted by the Ministry of Finance and Treasury (MFT) on behalf of the GoM and the grant agreement was signed on 11 November 2015. Initial ORIO grant agreement covers the “Development Phase” of the Project, in which preparatory studies are completed.

The purpose of the Feasibility Study was to evaluate the existing environmental conditions that currently exist on the Project site, as well as assess potential alternatives that may be viable solutions to stabilize the eroding coast and thereby improve the socio-economic condition and well-being of the island. The feasibility study consisted of field data collection, numerical modeling of coastal processes, evaluation of the alternatives, and conducting socio-economic studies. All elements of the Project were geared towards arriving at a technically feasible, cost-effective, and long-term solution at north-eastern coastal areas of Fuvahmulah.

Following the acceptance of the Feasibility Study and the Environmental Impact Assessment study by ORIO which is part of the development phase, preparation of the detailed design, Bill of Quantities (BoQ) and tender documents will commence once the project progresses to the implementation phase. Royal HaskoningDHV of the Netherlands has been selected to undertake the technical and financial assessments related to the project under the Development Phase which in turn subcontracted EIA related works to Maldives Energy and Environmental Company (MEECO) of the Maldives.

1.2 INTERPRETATION OF SPECIFIC TERMINOLOGY USED IN THE REPORT

Certain specific terms used in this report shall be interpreted in the context of the current project taking into account legal and administrative requirements for preparing the EIA report in the Maldives. The term Environment has been used in a broad context to include, natural environment, human environment, heritage, recreation and amenity assets and livelihood, lifestyle and well-being of those affected by the Project. Hence the term Environmental Impact Assessment (EIA) shall be taken synonymous to Environmental and Social Impact Assessment (ESIA).

Proponent in the document implies the project owner which is the Ministry of Environment and Energy and the Island shall be interpreted as the project island of Fuvahmulah. The term Project

means ‘Coastal Protection at Gn. Fuvahmulah’ and the Contractor shall be interpreted as the party undertaking the construction works of the Project.

1.3 AIMS AND OBJECTIVES OF THE PROJECT

The Project aims to seek a sustainable solution to the acute erosion issue and severe potential flooding problem facing Fuvahmulah Island by designing, implementing and maintaining an appropriate coastal structure on the north-eastern side of the island. The long term objective is to protect the island to the best extent possible and thereby ensuring well-being of the local community and safeguarding its economy and livelihood. The proposed Project also aims to demonstrate locally acceptable and appropriate climate adaptation measure taking into account predicted future environmental effects associated with climate change and sea-level rise.

1.4 THE PURPOSE OF THE EIA

The Environment Protection and Preservation Act (Law No 4/93) of the Maldives states that all development projects carried out in the Maldives will require carrying out an Environmental Impact Assessment prior to its undertaking. The details of the EIA procedure is stipulated in the Environmental Impact Assessment Regulations, 2012 (Reg No: 2012/R-27). Since coastal protection projects are listed under *Schedule D* of the EIA Regulations (2012) the EPA required the current Project to undertake an EIA prior to its commencement. Hence this EIA is prepared to fulfil the legal requirement under the Environment Protection and Preservation Act (Law 4/93) and the EIA regulations and to obtain environmental clearance for the Project.

More specifically, this EIA focuses on the management of potential environmental and social impacts and risks of the coastal protection works for the most favourable alternative.

Three major objectives of the EIA are to:

- Identify and assess potential impacts or consequences of the project on the natural and human environment in the project area;
- propose measures to avoid or mitigate or control potential adverse impacts and risks and to enhance beneficial impacts; and
- develop an environmental management plan (ESMP), where the operator should adhere to during construction and operations.

The EIA is prepared combining the complete process of preparation, construction, operation and decommissioning of the selected design of the coastal protection.

The purpose of the EIA also includes enhancing sustainability of the project and to promote environmentally sound decision making.

The EIA follows, next to the relevant Laws and Regulations of the Maldives, the IFC Performance Standards, see **Chapter 3**. The Project can be defined as a Category B project. Category B means ‘business activities with potential limited adverse environmental or social risks and/or impacts that are few in number, generally site-specific, largely reversible, and readily addressed through mitigation measures. Adverse impacts are expected to be limited and site-specific and mitigation

measures can easily be formulated and implemented'. The project has rather the purpose to improve the environmental and social conditions, than adversely affecting them.

1.5 THE EIA IMPLEMENTATION PROCESS

The EIA implementation process is explained in detail in the EIA Regulations. The process given in the Schedule of the Regulation is summarised below in Figure 1.

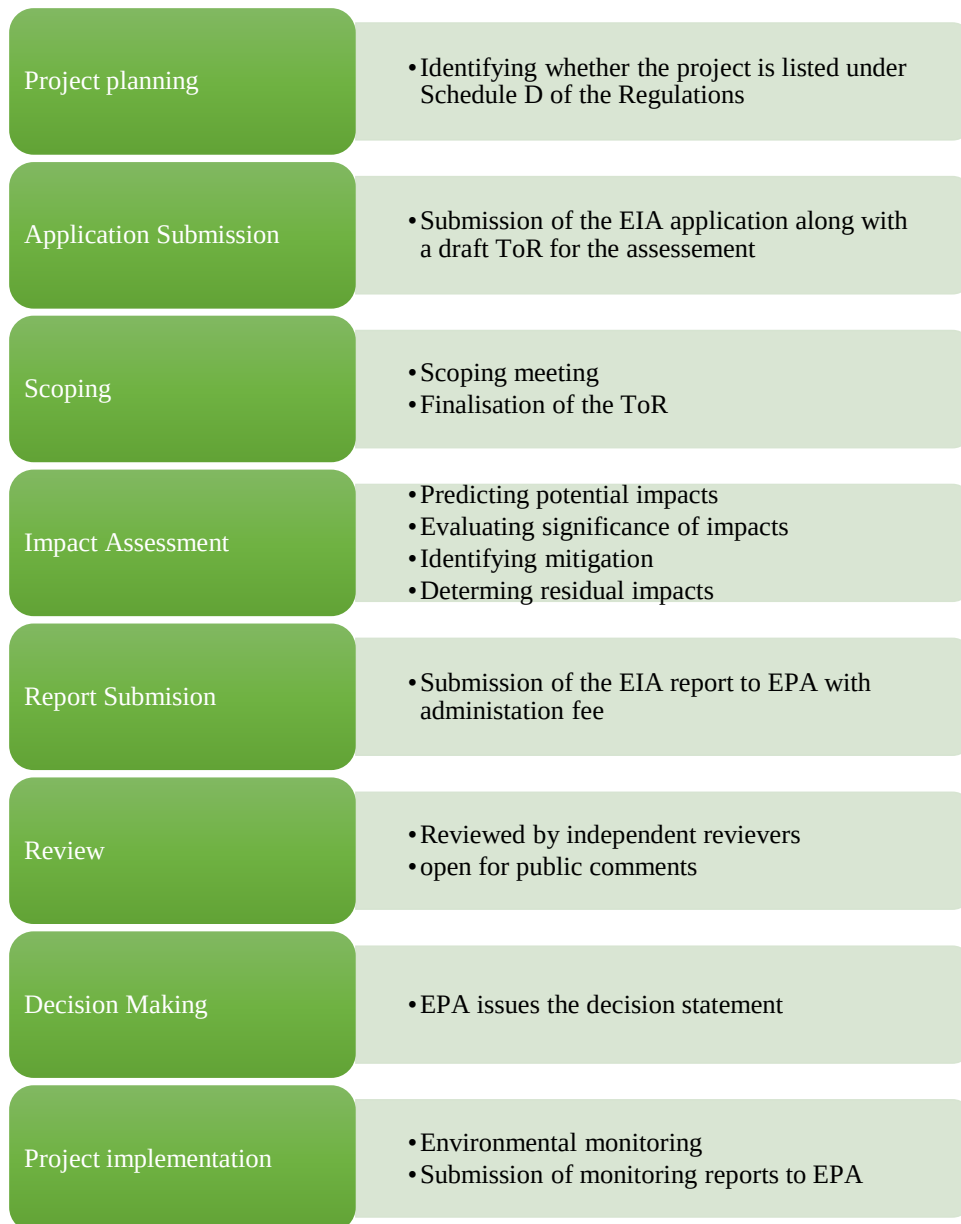


Figure 1: EIA implementation process

1.6 THE APPROACH & METHODOLOGY OF THE EIA

1.6.1 EIA Approach

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

The approach used in this EIA study involved systematically understanding and evaluating the project components, analysis of the erosion problem faced to the island, selecting the most feasible solution to address the erosion problem through a comprehensive alternatives evaluation, identifying the impacts (both positive and negative) of the selected alternative on the bio-physical and socio-environment followed by determination of practical and sound mitigation measures and proposing an appropriate monitoring mechanism to evaluate the effectiveness of the proposed mitigation measures.

Two most important aspects in impact prediction involved understanding in detail the all aspects related to the proposed project including, design, construction, operation, maintenance and decommissioning and the characteristics of the natural and social environment of the project location. Once these have been achieved, it was followed by prediction of potential impacts and evaluation of the impact characteristics to determine their significance using generally accepted methodologies. For the identified negative impacts, regardless of the significance level, practical cost effective mitigation measures have been proposed to avoid, or further minimise the negative effects. The overall method followed in the current assessment is depicted in Figure 1.

1.6.2 Scoping and Terms of Reference

Scoping and finalising the Terms of Reference (ToR) was one of the very first steps in the initiation of the EIA process. The ToR was initially drafted by the EIA team based on judgement and experience of other development schemes of similar nature in the Maldives. All critical aspects that are believed to be critical for the EIA were identified in the initial draft of the ToR which was submitted to the EPA for review and approval on 30th June 2016. Following the submission of the draft ToR along with the EIA application a scoping meeting was held at EPA on 20th June 2016. Stakeholders present at the meeting discussed the ToR and suggestions were made to the ToR. These suggestions were then incorporated into the revised ToR and submitted to EPA.

Following the review of the revised ToR, EPA gave no-objection to carry out the EIA and the revised document was endorsed as the final ToR. All issues identified in the ToR have been carefully considered in the relevant chapters of this report. The final ToR for the EIA is provided in the **Annex 1** and the list of participants at the scoping meeting is given in **Annex 4** of this report.

1.6.3 EIA Methodology

The main objective of the EIA was to assess all negative and positive impacts of the Project on the project on the environment in a logical and systematic manner and to describe actions that will be taken to avoid or minimise the significant negative impacts and to enhance the positive benefits of the Project.

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

1.6.3.1 Identifying impacts and analysis

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

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

A modified Leopold matrix was applied in evaluating the impacts identified. The steps involved are briefly summarised below:

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

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

Importance

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

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

Magnitude

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

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

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

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

Table 1: Categorization of the significance

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

Significance categories of negative impacts given in table 1 are defined as explained in Table 2.

Table 2: Impact characterization matrix

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

Different colour codes have been used in the impact matrix to distinguish between positive and negative impacts as depicted in Table 3.

Table 3: Colour codes used for distinguishing positive and negative impacts

Significance categories	Colour code
Major positive	Dark Green
Major negative	Red
Moderately positive	Blue
Moderately negative	Orange
Minor positive	Light Blue
Minor negative	Yellow
Negligible	

1.6.3.2 Social Assessment

The aim of the social assessment (SA) is to study the potential social and community benefits and adverse effects of coastal protection works project in Gn. Fuvahmulah. In recognition with this, the report also includes aspects related to social inclusion, gender assessment, labour impacts, land take and health and safety. The specific objectives of the social assessment are to:

1. Identify the stakeholders of the project;
2. identify appropriate mechanisms for providing information about the project to all stakeholders;
3. investigate the impacts to the stakeholders from the implementation of the project;

4. understand the current social, cultural, socio-economic and poverty conditions of the island;
5. understand the impacts of the project on the social and socio-economic profile of the island with particular reference the following:
 - a. Impacts of the design, construction and decommissioning works on the communities, businesses and way of living, giving particular attention to vulnerable groups;
 - b. Impacts on demographic developments (migration);
 - c. Impact on coastal fishing and tourism related activities and navigation;
 - d. Impacts on agricultural development;
 - e. Impacts on island employment, income and economy diversification;
 - f. Level of protection against hazards like sea-level rise storm surges etc;
 - g. Impacts of workers on the local population;
 - h. Impacts on cultural sites and heritage;
 - i. Impacts of increased demands on natural resources and services especially water supply, land availability, waste management, energy supply, harbour capacity;
6. formulate mitigation and enhancement measures to optimise the benefits for the communities and limit the adverse effects; and
7. monitoring of socio-economic impacts during implementation of the Project.

1.6.3.3 Cumulative Impacts

Cumulative impacts which may be defined as impacts that result from incremental changes caused by other past, present or reasonably foreseeable activities together with the project are generally considered in EIA studies. The environment where the proposed coastal protection will be situated is relatively undeveloped and no projects have been planned for the immediate future in the close vicinity of the project site. Hence the proposed approach for assessing cumulative impacts was to consider those that had already been completed (drainage system, harbour, short breaker) in close proximity the project site, Efforts have been made to understand activities that have been carried out and are planned for within the Project boundary.

1.6.4 Impact Mitigation

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

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

1.6.5 Gaps in Baseline Information

Availability of quality baseline data is an important element for any EIA study. However, even with the best effort to collect all relevant primary data required for the EIA, inherent challenges make it almost impossible to have all such information collected within a relatively short period of time available to complete the assessment. Certain environmental features such as erosion, accretion patterns, and near-shore wave characteristic require long term data collection and evaluation. Hence in certain cases it becomes necessary to make assumptions when limited or no information is available. There has not been any scientific literature available on the project environment although some rapid survey assessments had been conducted in the past. Lack of long term past data resulted certain degree of uncertainties in evaluating baseline conditions and predicting future environmental changes.

Limited understanding of the baseline conditions as studying existing environment was limited to a short period of time. Ideally, a site should be visited multiple times during the two monsoons to ensure to properly capture the environmental conditions at the site. However, this is rarely possible due to time and cost constraints and therefore, the data captured is representative of the conditions at the time of the surveys. The coastal processes around the islands of the Maldives are known to change due to changes in monsoonal winds associated changes in approaching wave characteristics. Similarly, marine flora and fauna described in the report are those observed at the sampling locations and therefore is assumed to be representative of the site. This represents a sufficiently conservative and cautious approach which takes account of the study limitations. These gaps however have been supplemented with numerical modelling, use of relevant information from reliable published literature and judgement.

1.6.6 Gaps in Understanding Impacts

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

As described above the coastal dynamics around Fuvahmulah was little understood. Although a number of reports including the EIAs for various projects had been carried out and was available for review these lacked long-term information on processes that govern the island's coastline.

The present assessment is no exception to these as time limitation and resource constraints and the urgency to implement coastal protection measures did not favour commissioning long term studies. Information on exposure to waves, long-shore sediment transport and near shore currents was not available. Spot measurements of currents and predictions based on mathematical modelling using satellite data formed the basis for wave characteristics. Similarly tide information for Fuvahmulah was not available and had to be dependent on tide information from the nearest atoll of Addu. Hence lack of clear understanding of longshore and offshore sediment transport regimes resulted in certain degrees of uncertainties in impact predictions associated with alternatives that were found to be for both onshore rock armour revetment and offshore breakwater. While both offshore breakwater and onshore revetment can mitigate erosion, in making final decision on the most preferred alternative uncertainty factor was taken into consideration.

1.6.7 Review of Similar Reports

EIA reports of similar coastal protection works in Maldives were reviewed for this EIA. Major findings from the EIAs show that the project islands start to undergo significant erosion after the implementation of coastal modification works such as construction of harbours or major land reclamation works. The reports agree on the fact that coastal modification works in the islands alter, or in the case of harbours, bring a stop to the natural sediment transport around the island, which aids the increased erosion.

The potential significant negative impacts identified from the coastal protection works for the reviewed EIA's are similar in nature. The most prominent of those being sedimentation from dredging of sand for backfilling material, and hydrodynamic changes brought about to the coastal area, in addition to changes to beach morphology and erosion and accretion patterns of the islands. Loss of habitat and disturbance to the lagoon bottom and reef area due to dredging and breakwater construction is also one of the significant impacts of such projects.

The main positive impact identified by the EIAs is the restoration of the eroding area of the coastline, while positive socioeconomic impacts have been identified as benefits to the island economies, improved services and infrastructure, and increase in property value.

Environmental Impact Assessment For Proposed Coastal Protection Works in AA. Ukulhas Island

Zuhair, M. & Shakir, I. (2015)

This EIA was conducted for the project proposed by MEE to protect the northern side of AA Ukulhas which has undergone extensive erosion. The proposed project includes 6,600m² of beach replenishment and a 280m long rock boulder revetment at the northern coastline of the island.

The EIA states that erosion started immediately after the development of the harbour, and initially the eroded area was reclaimed and "sand-cement bag" revetment was constructed as coastal protection. This revetment was damaged immediately after installation due to strong cross currents from swells generated from North East and South West.

Key environmental impacts from the project were identified from the activities below:

- Dredging borrow site for fill material for the estimated 9,240 cbm required
- Reclamation of eroded land from borrowed material
- Movement of rock boulders within the lagoon

The impacts include short term and long term impacts, damage to the marine environment from sedimentation, deterioration of seawater quality due to increased turbidity and destruction of marine habitats.

The reclamation of the area is expected to alter the natural wave and current patterns of the area, thus bringing on changes in beach dynamics. This can cause the sand to be transported within the lagoon, to the reef environment.

There is also a potential flooding impact due to the blocked or altered water circulation due to reclamation.

The main positive impact from the project is stated as the restoration of the northern beach. A socioeconomic benefit is stated as the direct and indirect benefits to the island economy from the construction workforce. The structures under immediate danger from the erosion being protected are also noted as a positive impact.

The EIA also states that the alternative option of implementing an offshore breakwater for the coastal protection would be costlier as it would require a greater length than the onshore revetment, to be effective.

Environmental Impact Assessment Report for Beach Nourishment and Coastal Protection works at Velaa Private Island, Noonu Atoll

Zahir, H., Sattar, S. A., Aslam, M., & Abdulla, A. (2015)

The EIA was conducted for the beach nourishment and coastal protection of Velaa Private Island. The island had undergone erosion, prominently of the north-western side and the eastern side of the island. The proposed activities include construction of 55 segments of breakwater structures using rock boulders in addition to beach nourishment.

The proposed breakwater structure will consist of imported rock boulders weighing between 250 – 450 kg. The 55 segments of breakwater structures include 52 of 20m long segments and 3 of 5m long segments. The method of construction proposed was by using excavator on barge.

Impacts identified from the activities include

- Loss of habitat and disturbance to the lagoon bottom and reef area due to dredging and breakwater construction
- Sedimentation due to dredging and breakwater construction
- Hydrodynamic changes due to the construction of breakwater structures; the breakwaters can change the current flow direction as well as reduce the wave energy.

In the selection of alternatives, the report states that the alternative option for the coastal protection is the construction of a groyne field around the island. This alternative is stated as feasible, although aesthetically unpleasant.

The alternative of using geo-bags to rock boulders as breakwater material is stated as having a greater environmental impact due to the additional dredging required to obtain sand for geo-bags.

Environmental Impact Assessment for M. Naalaafushi Coastal Protection

Zahid, A. & Fizah, H. (2014)

This EIA was conducted for the proposed coastal protection project at M. Naalaafushi Island, where significant erosion was found on the north-eastern side of the island. The proposed project includes a revetment of 510m long on the north-eastern shoreline of the island. The revetment proposed consists of rock boulders and geotextile. A total required workforce of 27 workers is stated in the report.

Excavator, barge, concrete machine, dump trucks and cranes are proposed to be used during the construction.

The report presents implementation of groynes as an alternative to the proposed construction of revetment. It is stated that a well-designed groyne field (four to five groynes of 20-30m length) would provide a similar level of protection against erosion as the proposed method. Although, it is stated that at least 6 months of coastal sediment transport data will be required for the design of the final groyne field.

The report states the project has minor negative impacts, and a moderate impact on the longshore transport regime. It is stated that the sediment movement from the eastern side to the northern tip of the island will be halted due to the proposed revetment. Due to this, the northern tip is likely to erode to some extent although significant erosion is not expected.

Potential socio-economic impacts are highlighted as positive impacts on services and infrastructure, and increase in property value

Initial Environmental Examination for the Coastal Protection Works at HA. Dhidhdhoo

Saeed, S., Shaaig, A., Faizan, M. (2011)

The IEE report was prepared for the coastal protection works at the southern coastline of HA Dhidhdhoo. The report states that the southern coast of the island had undergone erosion, especially after various coastal modifications to the island, which include the construction of a harbour and land reclamation on the northern side of the island. The construction of the harbour ended the year round sediment flow around the island.

The project includes a 356m of foreshore seawall constructed from armour rock and backfilling of the foreshore breakwater with dredged material.

The potential significant impacts identified from the dredging and backfilling activity were:

- Changes to hydrodynamics at the borrow site (long term)
- Changes to beach morphology and erosion and accretion patterns (long term)
- Sedimentation and turbidity (short term)
- Impacts on marine life (short term)

The significant impacts from implementation of the coastal protection measures also include

- Sedimentation and turbidity
- Changes to hydrodynamics and beach morphology

The report states concern that protecting a small stretch of the island will cause erosion where the protected beach meets the unprotected beach. And thus, extending the edges of the protection up to the vegetation line and replenishing at least 20m on the edges is recommended to compensate for erosion.

The report also states deep dredging close to the shoreline will likely cause significant impacts on long term erosion, and it was recommended to dredge within the existing harbour or existing deep lagoon slopes.

The review revealed very similar effects both positive and negative with respect to coastal protection regardless of the location of the project location. Environmental monitoring reports were not published for any of these reports hence it was not possible to verify the effectiveness of the proposed mitigation measures.

1.7 THE EIA TEAM

This EIA report was prepared by a multi-speciality team of local and international experts. The team was led by Mr. Ahmed Saleem, a registered EIA consultant with the EPA. The team members, their respective field of expertise and areas of contribution to the assessment is given in Table 4.

Table 4: The EIA Team

Name	Qualification	Designation/Field of Expertise	Contributing Area
Mr. Ahmed Saleem	MSc. Ecology & Environment	Lead EIA Consultant	• Overall administration of the EIA • Contributed to the various chapters • Report review
Ms. Margriet Hartman	MSc Geography PGCert Social Impact Assessment	Environmental & Social Expert	• Deputy Team Leader • Social and environmental Impact Assessment, • community consultations • Report review
Mr. Ali Hammadh	BSc. Environmental Management	EIA Consultant	• Existing environmental assessment • Chemical and physical analysis • Contributed to the various chapters of the report
Ms. Sofoora Kawsar	Masters of Health Economics and Policy Graduate Certificate in Economics	Socioeconomic Expert	• Community consultations • Undertaking socio-economic impact assessment • mitigation
Mr. Lars Hoogduin	MSc. Civil Engineering	Hydraulic & Coastal Engineer	• Coastal assessments • Hydrological assessments • Option analysis • Engineering aspects
Mr. Dinal		Surveyor	• Topographic & bathymetric surveys • Preparation of maps and charts

CV's of contributing consultants to this EIA report is given in **Annex 5**.

1.8 STRUCTURE OF THE REPORT

The structure of the report followed the direction provided in the Schedule E of the EIA regulations. In this regard, the report begins with a synopsis consisting of name of the report, location of the Project, names of the EIA team members, name and signature/stamp of the Proponent and the date of the report. This will be followed by a non-technical summary both in Dhivehi Language and in English covering the Project scope, location, alternatives and the major impacts and mitigation measures.

Chapter 1 of the report is the **Introduction** explaining the background, aims and objectives of the Project, Project proponent, purpose of the EIA, EIA implementation process, EIA methodology, project setting (boundary), Project justification and rationale, Terms of Reference and structure of the report.

Chapter 2 covers the **Description of the Project** providing necessary details on the Project including but not limited to Project proponent Project phases, location details, objectives and the

main development features. It also covers Project boundary, the impact zone, construction methodology and the work schedule. Further, details on Project risk mitigation, quality assurance aspects, workforce, Project inputs and outputs, institutional arrangements and Project maintenance plan has been provided.

Chapter 3 covers **Administrative and Regulatory Framework** related to the Project as such project planning aspects as such the relevance and compliance, as appropriate, of the Project in the context of existing plans, policies, guidelines, laws, regulations and international conventions and protocols to which Maldives is a Party to.

Chapter 4 gives the **Existing Environment Study Methodologies** used in the various assessments in understanding the baseline environmental conditions. information gaps and uncertainties in data collection and information obtained.

Chapter 5 describes the **Existing Environmental Conditions** (baseline) of the Project site including appropriate maps, charts, information on marine and terrestrial habitats and important ecosystems, coastal processes, oceanography and hydrology of the Project site, climatic analysis, description of the socio-economic and cultural environment and other relevant information.

Chapter 6 covers the **Socio-economic Environment** of the Project site; including an over of the island's history, island's relative importance, land use aspects, population, households, gender aspects, migration, education, health, and information on social services and amenities.

Chapter 7 details the **Stakeholder Consultations**, including details of the people/groups consulted and the summary findings from the consultations.

Chapter 8 describes **Alternatives** considered including no-project alternative for controlling erosion problem faced to Fuvahmulah and how the preferred alternative was derived.

Chapter 9 covers the **Environmental Impacts and Mitigation**. The chapter includes details on the impacts and proposed mitigation for the two main alternatives evaluated, i.e. offshore breakwater structure and the on-shore revetment structure. Impact evaluation has been divided into construction phase and operational phase of the Project.

Chapter 10 includes proposed **Environmental Management and Monitoring** program for the construction, decommissioning and operational phase of the Project including cost estimates for undertaking the program.

Chapter 11 describes the **Conclusions and Recommendation** derived from the EIA study.

The report also includes Consultant's declaration with regards to the findings as true, complete and written to the best of the abilities of the EIA team.

Annexures to the report would include, supplementary information such as the terms of reference, lists of participants in various meetings, references. CVs of the contributing consultants to the preparation of the EIA report.

1.9 PROJECT SETTING

The proposed project is planned to be carried out in the island of Fuvahmulah Island, the Maldives. The island is considered a separate administrative division hence it is the only one-island administrative atoll in the Maldives called Nyaviyani Atoll.

The island is located between zero-degree channel and the southern-most atoll of Addu. The island is the third largest inhabited island in the country with a resident population of over 8000.

Fuvahmulah house-reef covers an area of 546 ha. The total land area of the island being approximately 486 hectares, the island occupies 89 % of the house-reef. The land available for development is limited due to two large wetland areas occupying it.

The island has a number of modern infrastructures and amenities developed including its domestic airport, harbour, telecommunication facilities, healthcare, higher secondary education, medical services, communication services, playgrounds, police, youth centre, social centre and post office and numerous shops and cafes.

In addition to its relatively large size, the island possesses historical and cultural features of significance. People of Fuvahmulah speak a different dialect of Dhivehi language called Mulaku Bas which is not spoken elsewhere in the Maldives. Its history dates back to pre-Islamic period and still possesses historical remnants of Buddhist culture indicating that the island had been populated for over a thousand years.

The island also possesses several important ecological features. It has relatively large inland water-bodies in the central areas surrounded by marshy land. The marsh area is fairly fertile and is used for crop production. Due to the geophysical constraints fishing is not as developed as agricultural sector in the island. *Thundi* – a natural white beach formed on the northern most coastal area of the island is one of the most unique features of the island. This beach is unique since the material is composed on small polished pebbles which are unusual to the rest of the islands in the Maldives. In contrast to the white pebbles that occupy the northern coast, black pebble beach is found on the southeast coast.

The saturated nature of the island on its house reef leaves very narrow lagoon space. This narrow space that surrounds the island means approaching waves has little resistance before hitting island's shoreline. The inherent geophysical characteristics of the island makes it extremely exposed to ocean waves and storm events. As a consequence, the more exposed coastline – northeast coastline of the island has been undergoing severe erosion as a result with resulting loss of land and protective layer of the coastal vegetation.

Comparing aerial photo taken in 1969 with the land survey carried out under this study, it is evident approximately 15ha of vegetated land has been eroded away from the north-eastern coastline of the island. Erosion taking place on the south-western side does not appear to be serious as no marked net change in coastline has been noticed for the last 47 years (1969 – 2016). The rate of erosion taking place on the north-eastern coast according to this survey is 0.8 m/year on average over this period. However, this may vary considerably per year. Since the construction of the harbour, it is said by several stakeholders that erosion rates have increased considerably.

During the same period, it is estimated that *Thundi* beach lost approximately 2.2ha accounting for loss of some 35m³ of sand. Considering the expected consequences of climate change and

associated sea-level rise and increased incidences of storm surges the rate of erosion may even get worse if an urgent solution is not sought. Detailed survey of the project location also revealed erosion has reached the boundaries of several important infrastructures making them susceptible to falling down. Severe erosion also means destruction of the protective ridge of the island which in turn making the island more and more vulnerable to flooding.

Hence, the project has been planned to protect the vulnerable north-east coastline. The planned measure involves constructing a rock armour coastal revetment. The footprint of the planned shore protection does not fall into protected *Thundi* region nor would it directly impact the coral reef environment.

When successfully completed the project is expected to provide climate adaptation to one of the largest islands in the Maldives.

1.10 PROJECT JUSTIFICATION

There exists clear historical evidence showing the net loss of land from the north-east coastline of Fuvahmulah. Comparison of historical aerial image of the island with the shoreline survey conducted in 2016 show significant loss of protective island ridge as explained in the Chapter on Existing Environment. The inherent geomorphological characteristics of the island make it extremely vulnerable to future abnormalities in weather events. Once the raised island ridge is destroyed, the island becomes highly susceptible to flooding due to the ‘concave’ shape it possesses. The main livelihood of the people of Fuvahmulah being agriculture, frequent seawater flooding would mean destruction of the agricultural land and salinization of the valuable groundwater resource.

The acute erosion faced is believed to be due to a combination of human interference and natural causes. Despite the gravity of the problem, the problem continues to persist and to date except for constructing a low-lying seawall covering a small region of the eroding coast no other intervention had been made. Government records indicate efforts by the successive governments in finding a suitable solution to the problem. In 2010, then the National Planning Council approved a proposal for submission to Japanese Aid as a ‘first priority’ project titled ‘Coastal Protection of Gn. Fuvahmulah from Sea Induced Flooding and Predicted Climate Change and Associated Sea Level Rise¹’ and also in the same year the Council proposed to submit another projective with the same objectives to Indian Exim Bank² for loan financing indicating the importance attached to the issue at national level.

The findings of the feasibility study carried out for the current Project further highlights the national importance and uniqueness of Fuvahmulah Island. The island ranked as the highest priority needing coastal protection at the national level (RHDHV, 2015) among many islands needing coastal protection in the Maldives and feasibility study team noted consensus among all stakeholder consulted that the north-eastern coast of the island needed coastal protection due to the seriousness of the problem occurring on the island.

¹ <http://isles.egov.mv/Project/Index.aspx?lid=1&pid=3661esQqew4rty234>

² <http://isles.egov.mv/Project/Index.aspx?lid=1&pid=471>

The impact of global warming and associated impacts of climate change will become increasingly important for low-lying islands, in particular those that are already facing severe coastal erosion such as Fuvahmulah. It is expected that rising sea levels, an increased probability of storm surges and associated coastal floods will result further increasing the vulnerability of the island and its inhabitants. The Fifth Assessment Report by Intergovernmental Panel on Climate Change (IPCC) describes sea-level rise, increase in incidences of tropical and extra-tropical cyclones, among others as current and future climate-related drivers of risk for small islands during the 21st century. The report highlights sea-level rise as one of the most widely recognized climate change threats to small islands. This is particularly important considering the island has almost all of its infrastructures and houses are located within close proximity to the coast.

The inherent characteristics of the island provides very little or no opportunity for the population to migrate in-land when the coastal areas become inhabitable due to erosion or increased events of sea flooding. It is obvious that the projected sea-level increase of 0.35–0.7 meters by the year 2100 can cause catastrophic consequences to the island as well as its population.

Climate change induced sea-level rise will reduce opportunities for drainage and increase inundation, and also seriously compromise freshwater wetland viability. It is likely that some freshwater wetlands will only be sustained using tidal barrages and gates.

The proposed project when successfully completed would yield significant benefits including but not limited to the following;

The project is of significance for a number reasons including but not limited to the following;

- Fuvahmulah has the highest priority with regards to the need for coastal protection in the Maldives;
- the island is unique geographically, geo-morphologically and culturally and therefore the project will significantly contribute to preserve these values;
- the benefit of the project would reach to a significant proportion of the country's population as the Island is ranked as the 3rd most populous island of the country;
- important investments and infrastructures that are now threatened due to erosion will be safeguarded;
- sense of security and safety to the people of the island will be greatly enhanced due to the project;
- the project will have significant positive impacts to both local and national economy; and
- no sensitive habitat or species are expected to be affected as a result of the project whereas unique habitats and local economy will greatly benefit from the project.

Based on these reasons that are detailed out in the relevant sections of the report, the project can easily be justified from ecological, environmental security, climate adaptability and socio-economic well-being of Fuvahmulah and its people.

2. DESCRIPTION OF THE PROJECT

2.1 PROJECT PROPONENT

The Project is proposed by the Ministry of Environment and Energy (MEE) of the Government of Maldives (hereinafter referred to as the Proponent). MEE as the competent authority of the Project will be responsible for the implementation as well as post-project monitoring of the Project outcomes.

The contact details of the Proponent is given below;

Ministry of Environment and Energy
Green Building
Handhuvaree Hingun, Maafannu, Male', 20392
Republic of Maldives
Tel: + (960) 301 8300, Fax: + (960) 301 8301
Email: secretariat@environment.gov.mv

2.2 PHASING OF THE PROJECT

The project planning, development involved three main phases which involved feasibility study, design and EIA preparations and detailed project planning for implementation and operations and maintenance phase (see Figure 2).

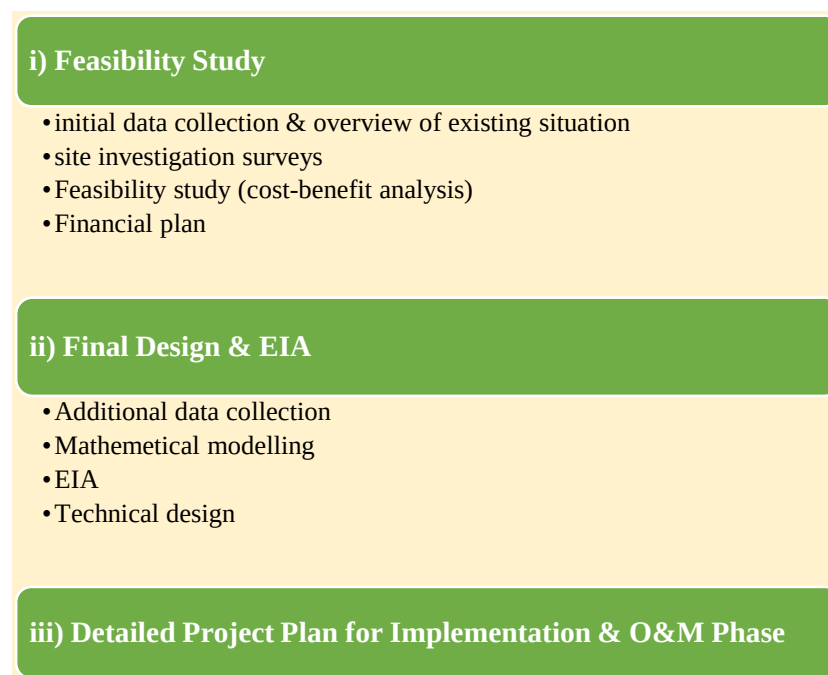


Figure 2: Project development stages

2.3 PROJECT LOCATION & SITE AREA

The Maldives forms the central and largest section of the Lacdives-Chagos chain of atolls, which extends southwards from India to the centre of the Indian Ocean. The country consists of a series of 19 coral atolls and associated coralline structures. There are about 1190 islands of which 202 are inhabited. The majority of islands are small, with only nine being larger than two square kilometres. Around 80% of the total land area lies less than one metre above sea level.

The proposed project is planned to be carried out in Fuvahmulah Island. The island is both geographically and administratively considered a one island atoll. For administrative purposes the island is referred to belonging to Gn. Atoll. The island is located at 73°25'40"E, 0°17'53"S and lies between the equator and the southernmost atoll of the Maldives; Addu Atoll. The island is unique due to its geographical and geomorphological aspects and due to its rich terrestrial habitats including presence of wetlands, lakes, tropical woodlands and marshy areas. The island is well known for its fertile soils and agriculture. The people of the island speak a unique dialect of Dhivehi Language which is endemic to the Island. The island is 424 hectares and is about 5 km in length and between 1 and 1.3 km in width. A summary of the geographical features of the island is given in Table 5 and geographical location of the island is shown in Figure 3.

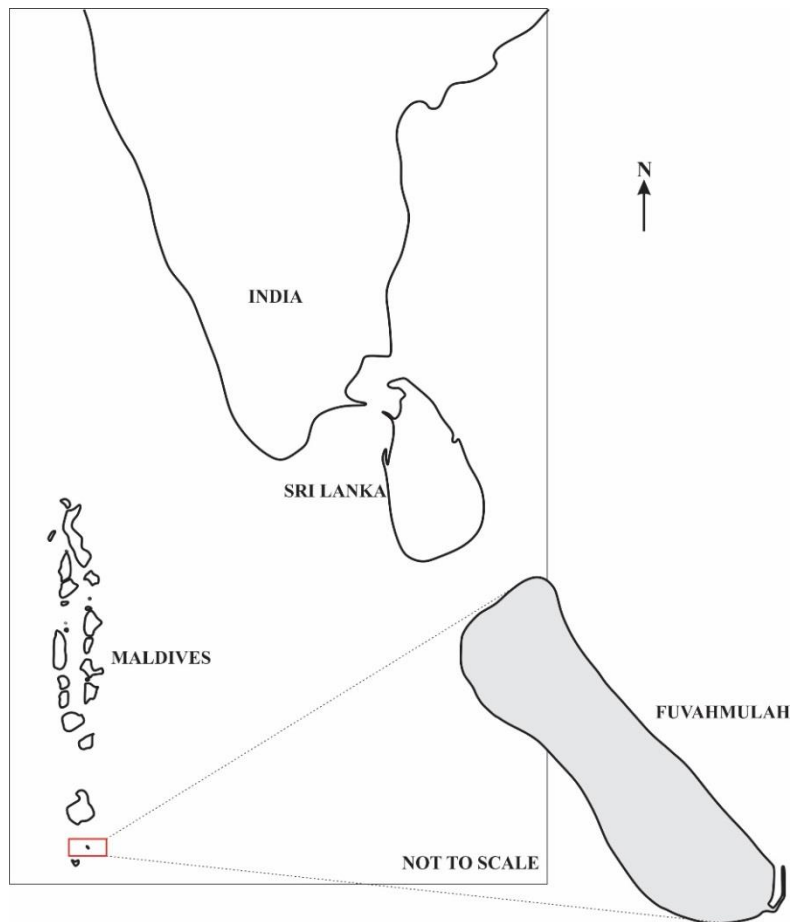


Figure 3: Project location

Table 5: Geographical features of Fuvahmulah Island

Physical feature	Measure
Area ³	485 ha
Length ⁴	4.1 km
Width ⁵	1.6 km
Length of the island's coastline ⁶	11 km
Distance from capital island Male'	493.7 km
Distance from nearest atoll of Addu	38 km
Longitude	73°25'40"E
Latitude	0°17'53"S

2.4 PROJECT OBJECTIVES

Specific objectives for the coastal protection at Fuvahmulah included the following:

- Reduce the impacts of long-term beach erosion along the north-eastern coastline of the island;
- improve the stability and longevity of the coastal areas and shore protection structures in general;
- reduce storm flooding and wave damage to the upland infrastructures; Protect the population of Fuvahmulah and their livelihood and enhance the socio-economic development of the Island.
- ; and
- preserve, restore and maintain the environmental character of the areas affected

In evaluating the most suitable alternative for the coastal erosion problem faced to the island these objectives were considered (see **Chapter 8**). In addition, economic feasibility is critical in deciding the most appropriate recommendation to solve the erosion problem.

2.5 MAIN FEATURES OF THE PROJECT

The main objective of the project is to protect the north-eastern coastline of Fuvahmulah which is facing severe coastal erosion problem. The length of the region facing most severe erosion on the north-eastern coast was found to be approximately 2.6 km. Hence the project aims to develop a coastal defence structure that will achieve this purpose. A feasibility study explored five potential solutions; these solutions along with distinctive criteria to select the most appropriate option are discussed in detail in **Chapter 8 on the Alternatives**. Based on the evaluation of the alternatives a rock armour seaward on-shore structure has been selected to be the most suitable. The structure

³ Based on land survey on July 2016

⁴ Based on land survey on July 2016

⁵ Based on land survey on July 2016

⁶ Based on land survey on July 2016

will have a design lifetime of 50 years and will be based on a 1/100 per year extreme storm event, including 0.75m Sea Level Rise as per IPCC predictions (IPCC, 2013) (MEE & UNDP, 2013).

2.5.1 Design Conditions

Important design aspects were considered in the final design of the coastal protection. These include the determining the extent of the erosion, projecting the sea-level for the extreme situation and the identifying the ridge elevation.

The length of the coastal zone needing protection was determined by a detailed topographical survey carried out during the Feasibility Study stage comprising of 29 cross-sectional profiles (see Figure 4: Overview survey profiles of cross-sectional (purple) and longitudinal profiles (red); indicative locations. The length of the coastline protected under the Project will be 2650m.

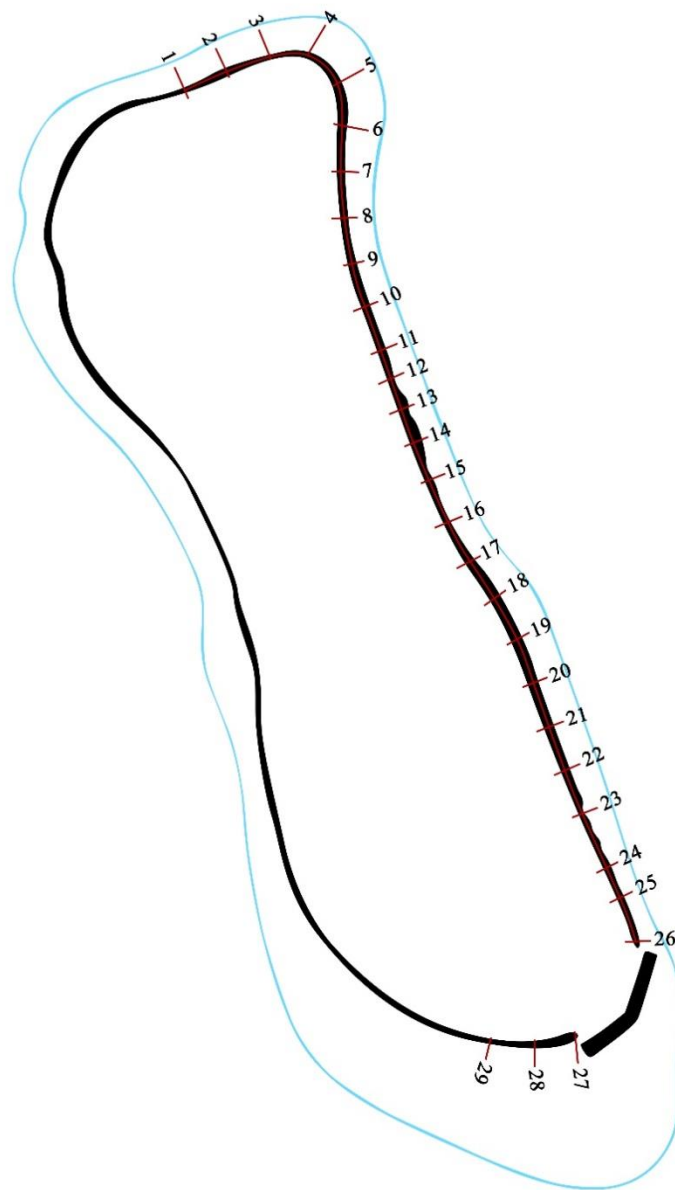


Figure 4: Overview survey profiles of cross-sectional (purple) and longitudinal profiles (red); indicative locations

Analysis of cross sectional profiles showed that the region between profiles 16-26 covering a length of 2000m having most erosion characterised by greater steepness and deprived of sand whereas region falling between profile 5 – 15 were less steep and contained more sand on the coast.

The entire north-eastern coastline of Fuvahmulah was surveyed to map the longitudinal profile of the shoreline. The results show that the height at the edge of the ridge varies between +1.5m MSL in the south and +3.5m MSL at the northern beach area. The highest point of the ridge varies

between +2.0m and +2.5m MSL at the southern part. At the northern beach area, the ridge is higher and the highest point is between +3.0 and +4.2m MSL (see Figure 5). (RHDHV, 2015).

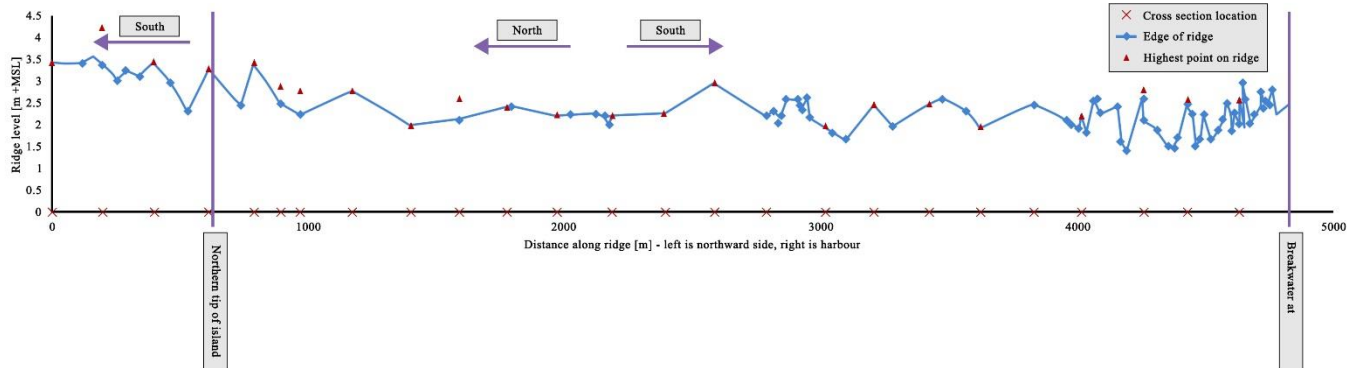


Figure 5: Longitudinal profile of north-eastern coastline of Fuvahmulah (blue line represents the edge of the ridge where erosion starts, the red triangle shows the highest measured point on the ridge of the cross section) (Source RHDHV, 2015).

The representative water level for the design was based on a combination of a tidal elevation and various contributions to water level set-up. The design lifetime of the construction is 50 years, based on national building code developed by the Ministry of Construction and Public Infrastructure in 2008 and consultation with the Ministry of Environment and Energy. Typically, a storm with a return period larger than the design life time (50 years) is chosen, in this case a storm with a 100 year return period. This extreme event is combined with a ‘daily’ high tide (mean high water level) which is likely to occur simultaneously with the storm event. For the design period of 50 years, also sea level rise at the end of the design life time has to be accounted for. Table 6 summarizes the various design components.

Table 6: Water levels for extreme situations (1/100 per year) (Source: RHDHV, 2016)

Design water level	1/100 per year	Unit
Mean High Water Level	0.34	+MSL
Barometric-pressure induced set-up	0.1	m
Seasonal variation	0.1	m
Wave induced setup	0.01 (at -1.5m MSL contour)* 0.07 (at -0.5m MSL contour)*	m
Storm induced setup	Negligible	m
Sea level rise	0.75	m in 2070
Resulting water level	1.30 at -1.5m MSL contour	m +MSL

	1.36 at -0.5 MSL contour	

Extreme wave conditions are based on extreme-value analysis of a 10 years' offshore time series (NOAA). Offshore conditions have been translated to near-shore wave conditions using numerical models.

A combination of extreme significant wave heights and wave periods have been derived at different locations on the reef flat (-1.5m MSL and -0.5m MSL). The representative combination is shown in Table 6. The design wave conditions originate from the South-eastern direction, approaching the coastline perpendicular due to refraction effects. For the design of the coastal protection 1/100 per year wave conditions are considered normative for the designated design lifetime of 50 years. (Table 6).

Table 6: Wave conditions for extreme situations (1/100 per year) for various locations on the reef flat (Source: RHDHV, 2016)

Location on reef flat		Parameter	
-1.5m MSL	Significant wave height	H_{m0} (m)	3.25
	Mean wave period	$T_{m-1,0}$ (s)	18.33
	Peak wave period	T_p (s)	23.15
-0.5m MSL	Significant wave height	H_{m0} (m)	2.49
	Mean wave period	$T_{m-1,0}$ (s)	17.63
	Peak wave period	T_p (s)	23.61

2.5.2 Project Value

Project will be developed in a single phase and approximately €18-22 million will be invested towards the completion of the Project.

2.5.3 Site Layout and Design

Extensive environmental investigations were conducted and the information collected were applied in developing the concept with a view to achieve the best design fit for the existing environment of the island. The development concept intends to create environmentally sound solution that is financially feasible and socially acceptable. In this regard constructing a rock revetment was arrived after exploring all pros and cons related to cost, environmental effects and social issues.

The structure will be placed at the coastal ridge. Prior to the contraction of the structure profiling of the eroding beach will be carried out with appropriate materials to create a gentler slope (approx.1:3) for smooth transition. The toe of the structure will be trenched below the beach toe to prevent failure of the structure. The structure will have a height of +3.5m from MSL high enough to prevent overtopping by high waves.

On top of the filling, a protective armour layer of rock boulder will be constructed which prevents erosion of sub-layers or the ridge. On top of the revetment, possible small constructive measures will be taken into consideration which prevents nuisance due to overtopping of the ridge during storms (Figure 6).

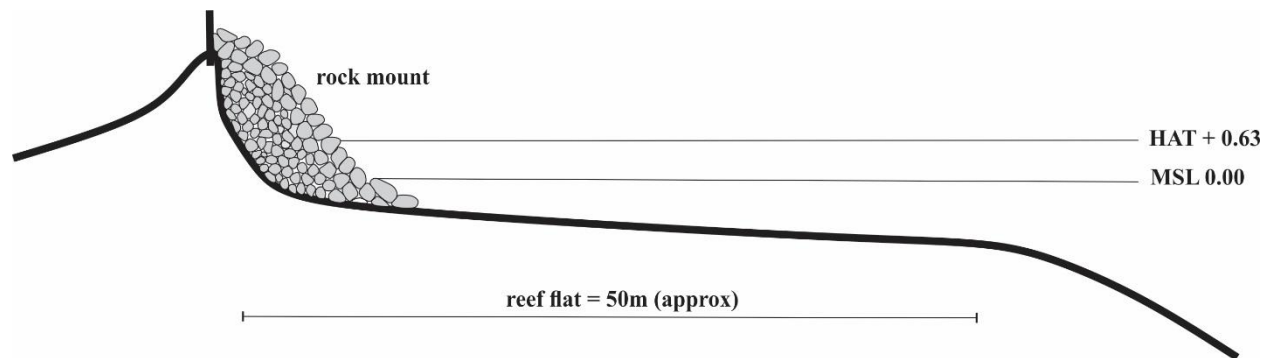


Figure 6: Typical cross-section of onshore revetment (adapted from RHDHV, 2015)

2.5.4 Design of rubble mound armour layer

For the armour layer, Table 7 presents the design rock size (D_{n50}), design weight (W_{50}) and rock grading have been determined based on the ‘van der Meer’ shallow water equation given below.

$$\frac{H_s}{\Delta D_{n50}} = C_x P^{-0.13} \left(\frac{S_d}{\sqrt{N}} \right)^{0.2} \left(\frac{H_s}{H_{2\%}} \right) \sqrt{\cot \alpha} (\varepsilon_s - 1, 0)^P$$

Based on the required armour layer weight and dimensions, the revetment core dimensions are determined based on generic stability/filter layer rules for these types of structures (CIRIA, 2007). These dimensions are presented in Table 7.

Table 7: Design weigh calculations (Source: RHDHV, 2016)

Top layer grading		[-]	1,000-3,000 kg
Characteristic stone size	D_{n50}	[m]	0.92
Design weight	W_{50}	[kg]	2,088
Under layer grading		[-]	60-300 kg
Design weight (min)	$W_{50;\min}$	[kg]	139.2
Design weight (max)	$W_{50;\max}$	[kg]	208.8
Characteristic stone size (50%)	D_{n50}	[m]	0.42
Characteristic stone size (15%)	D_{15}	[m]	0.40
Core Material		[-]	45/125 mm or quarry run
Characteristic stone size (85%)	d_{85}	[m]	0.12

The crest height for this construction is based on the allowable overtopping, preventing damage to the construction (+3.5m MSL). The location of the crest line is based on the actual coastline. After which it has been shifted seawards, to prevent removal of trees in the vegetation belt. This has been illustrated in in Figure 7.

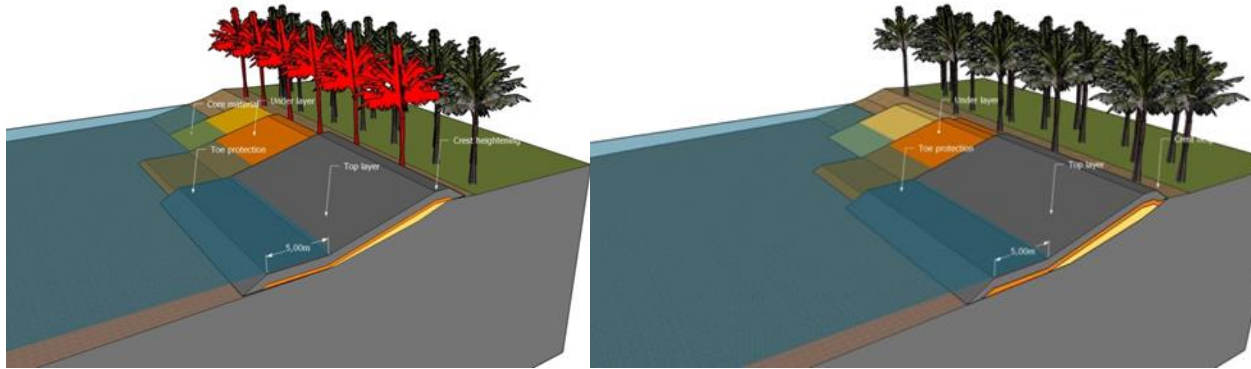


Figure 7: Landward (left) and seaward (right) shifted crest line which has been considered (Source: RHDHV, 2016)

2.6 PROJECT BOUNDARY AND IMPACT ZONE

Project boundary has been defined based on the direct footprint area of the proposed seaward shore protection revetment which stretches up to 2650m along and measuring a width of 27m. Hence the project area would take up 71,550m² of the coastal zone as shown in Figure 8.

. Structural and environmental modifications to this area will be inevitable as a result of the proposed project. The benthic environment of the footprint is almost exclusively composed of rubble, sand and beachrock and does not contain any significant biodiversity. The placing of the footprint does not directly fall into coastal vegetation belt, hence vegetation is not expected to be directly affected as a result.

In determining the impact boundary, two important considerations have been made; the primary impact zone which is the area that may be directly affected by the construction of the structure and the secondary impact zone which is the area that may be negatively affected by as a result of indirect impacts of the project.

1. **Primary impact boundary:** The projects primary impact boundary is the area enclosed within 100 m from the project boundary from all sides. Therefore, the primary impact area encloses 200 m x 3500 m (and contains public structures such as mosques, playground, roads and some private houses and to some extent the harbour). The main road which will be used during construction phase for transportation of small supplies is within this boundary. The majority of the construction material will be transported over the revetment itself (see section 2.8). Most of the amenities that fall in the project impact boundary are expected to receive minor impacts stemming from noise, dust etc. The primary impact area

also contains significant amounts of coconut palms however these are not anticipated to be directly affected.

The coastal biodiversity contained within this boundary was found to be minimal based on existing environmental reef assessments. The primary boundary does not contain any of the protected areas in Fuvahmulah as the project and its impacts are localized to the coastal areas. The outer part of the harbour is part of the primary impact boundary.

2. **Secondary impact boundary:** The projects secondary impact boundary is identified as the area enclosed within 440 m x 4400 m from the Project boundary. The secondary impact area overlaps the protected areas and the harbour area of Fuvahmulah. The secondary impact area has been specified in order to account for the uncertainty, the proposed project would have on the *Thundi* area, accidental impacts such as oil spills that might affect areas outside the primary impact boundary and sedimentation as a result of slope adjustments before installation of the revetment. The inner harbour area falls under this boundary as the preferred method of access and transportation of material is in the outer port area. The inner harbour area will be used in cases of emergency. This would avoid congestion at the harbour and the need to modify harbour area.

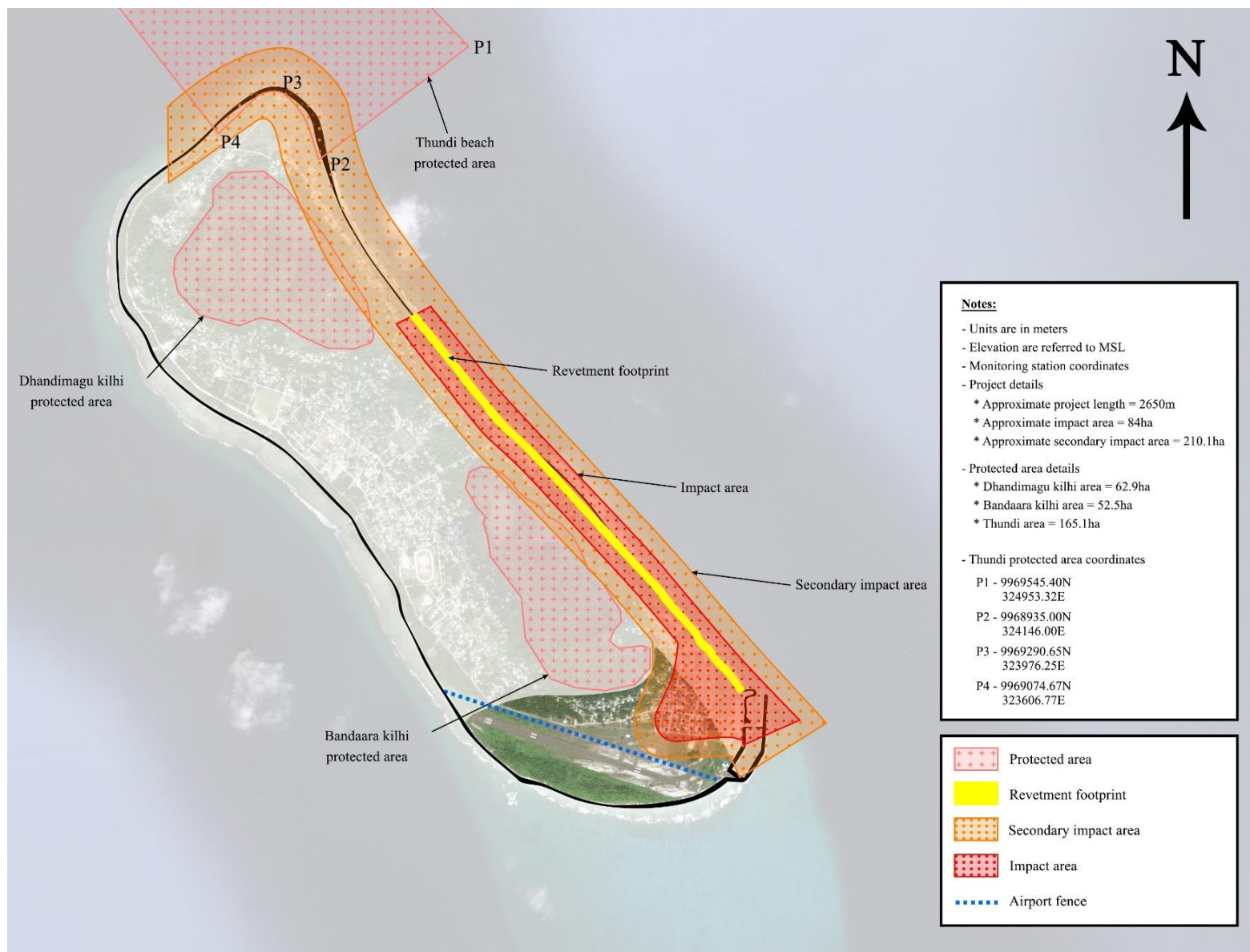


Figure 8: Project area and impact boundary

2.7 CONSTRUCTION METHODOLOGY AND WORK SCHEDULE

2.7.1 The Approach

The typical approach to constructing the onshore revetment comprises the following, but not necessarily sequential, stages:

- Setup the site office, lay down areas and other preparatory works;
- mobilization of equipment, machineries and vehicles, welfare and personnel to site; and
- begin construction works.

Project will be carried out as a single phase project through a contractor procured through general contracting. As soon as the EIA and other mandatory requirements have been completed, the Project scope will be competitively bid to a construction firm for a fixed lump sum. Once the contractor is selected the proponent will enter into a legal contract with the contractor. The approved EIA will become part of the legal contract and the contractor will be responsible for the implementation of the mitigation measures and taking necessary environmental safeguards as given in the EIA during the construction phase.

2.7.2 Organization

The key personnel on the project have the following responsibilities:

The key personal involved in the successful implementation of the Project will be the project manager, the site supervisor and foremen.

The project manager will be the key person responsible for overall managing and delivering the project within the allocated budget, accountable for such issues on the Project relating to health and safety, environmental safeguards and quality assurance. Directly under the project manager, a site supervisor will be recruited, and is answerable to the project manager. Site supervisor will be involved in managing the daily operational duties of the construction activities on site with regards to programme, budget, health and safety, environmental safeguards and quality assurance.

The Foremen are responsible for individual areas of the project works and will work under the direct supervision of the site manager. In addition, the project will employ various support staff to the project manager that will undertake financial and commercial monitoring and administration roles.

2.8 CONSTRUCTION METHODOLOGY

Prior to the starting on site, the chosen contractor will meet with the Proponent's team in order to confirm the full understanding of the project development plan, project constraints, and the objectives. Through this consultative process, a robust, comprehensive and purposeful construction method statement and construction phase health and safety plan and environmental management system (EMS) will be finalized. The method statement will be an important management tool and will set out certain key actions, milestones and events against which the project performance will be monitored to ensure success of the Project. The subsequent Sections highlight some of the key aspects of the method statement.

Project completion within the specified period is important as delays in project implementation not only incurs additional and unnecessary costs but also more environmental damage and losses. Hence in order to effectively implement the project, during construction phase of the Project, the contractor will be responsible to undertake the following tasks;

- Coordination of the works with the Project proponent and island authorities;
- Management of health and safety including induction of all personnel;
- Safeguarding the island's environment and ensuring the mitigation measures proposed in the EIA report are fully implemented during the construction;
- Setting out of the works;
- Agree schedule of condition before work commences;
- Control the flow of Project information;
- Keep full and accurate records;
- Ensure compliance with Project specifications;
- Supervise the works;
- Attend meetings with the Proponent, Donor and Specialists as necessary;
- Monitor progress against the contract programme and take necessary action to avoid delays; and
- Prepare written progress reports on a regular basis to the design team.

2.9 SITE PREPARATION AND ESTABLISHMENT

As soon as the Contractor is selected, the site preparation activities will commence. Initial activities include, improving access to the Project site, setting up of temporary office, making arrangements for the workers, staff welfare, and storage for the materials.

A separate temporary workers quarter is not recommended in order to minimise environmental impacts of the project, to minimise costs and to enhance project benefits to the community.

The Contractor will also put in place rules and procedures for the workers to ensure social harmony during the work period.

2.10 METHODOLOGY, MACHINERIES AND EQUIPMENTS

At the time of the EIA report the contractor has not been selected and therefore the actual methodology for the project was not available. However, since revetment works are very common

in the Maldives, the methodology expected under the current Project is not believed to be significantly different from that of past projects of similar nature although minor difference can be expected. The Proponent shall carefully review the method statement as soon as it is submitted by the contractor and ensure that it is in line with the relevant parts of the EIA report. The work methodology described for the revetment works at Fuvahmulah is based on experiences of the past projects of similar nature. The main document referred in the report is the methodology proposed for Hulhumale' Phase -2 Development: Coastal Protection Works which had a greater scope of work than Fuvahmulah coastal protection project in terms of length of the coastline protected by rock armour revetment (MTHojgaard, 2015).

In order to construct 2650 m of revetment, initial activity will be profiling of the beach slope, followed by placing a geo-textile layer on top of the sand and layers of granite armour rock placed above it.

Excavator will be used for profiling the coastline to achieve the correct slope and for placing rocks on the revetment.

Wheel loader will be used for loading the dump trucks with rocks and assisting excavator when placing stones for breakwater.

Dump trucks will be used transportation of rock armour from stockpile to the site of revetment.

Number of sets of plants and machineries may differ from contractor and availability of more sets of equipment can fast-track the project implementation. Envisaged numbers and specifications of equipment are given in Table 8.

Table 8: Expected equipment need for the project

Type	Spec	Nos	Purpose
Excavator	30t	2	Placing stones on revetment
Excavator	2t	2	Profiling the coastal ridge
Wheel loader	30t	3	Loading of dump trucks with stones. Assisting excavator when placing stones for revetment
Dump truck	40t	6	Transportation of rock armour from stockpile at site to breakwater
Pickup truck	25t	1	Carrying workers, goods, etc
Genset	25kW	1	For producing onsite electricity
Large bulk carrier	7500 DWT	1	For transport of rock from quarry to Fuvahmulah
Small bulk carrier	1000 DWT	2	For local transport from large bulk carrier to harbour

2.10.1 Work Sequence

Table 9 gives sequence of actions for the onshore revetment alternative.

Table 9: Revetment work procedure

Sequence	Activity
1	Sourcing materials from nearest supply country
2	Transport of materials from source country to Fuvahmulah
3	Unloading the materials at Fuvahmulah
4	Stockpiling of materials at a designated site
5	Transport to the site
6	On site processing (grading, placement etc.)

2.10.2 Sourcing of Materials

Source rock material will come from quarries outside of the Maldives. Nearest quarries are found in India (Tuticorin or Mangalore), Malaysia or UAE.

2.10.3 Material Transport

The Project will require large volumes of materials to the Island. It has been planned to deliver materials in bulk from overseas directly to the site in coordination with the relevant authorities. This would ease the logistics as well as minimize transport costs and improve sustainability aspects of the Project. Much of the materials needed for the Project will be delivered by sea in a bulk carrier of capacity 3,300 – 7,500 DWT. Vessels has to be self-unloading, as no large cranes are available at Fuvahmulah. Bulk supply and secure storage and recordkeeping of the materials needed for the Project will be critical during the construction phase to avoid delays, reduce the risk of theft and to ensure smooth workflow in keeping with the Project schedule. Delays in material availability and supplies in small volumes can not only add to the cost of the project but also will lead to unnecessary environmental and social impacts. The material stockpiling and storage space for the project has been allocated considering several factors including minimising social and environmental impacts, close proximity to project site, avoiding legal complications and availability of adequate space. Storage sites in this regard have been selected in consultation with the island authorities.

Two potential locations for material unloading and stockpiling have been identified. The sites studied include using island's harbour area for unloading and stockpiling materials at nearby vacant space (Figure 9(A)) or use of *Bandahafannu* channel for unloading and using the nearby football pitch at *Rasgefannu* for stockpiling (Figure 9 (B)). A brief evaluation of the two alternatives is given below:

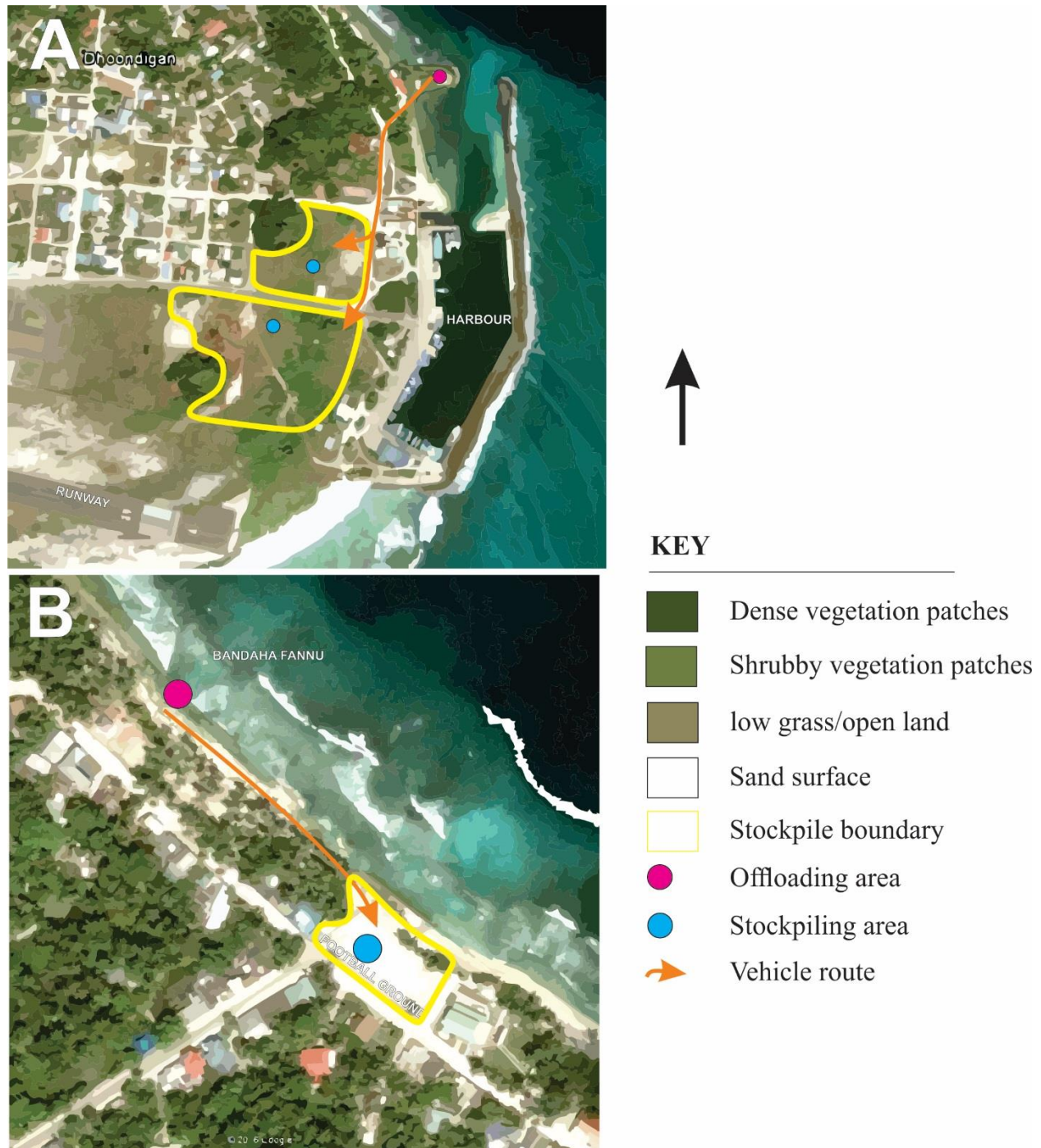


Figure 9: Proposed locations for stockpiling and vehicle route (A) location near the harbour (B) location near Bandahafannu

While use of *Bandahafannu* could spare harbour area from project activities, navigation and safety risks seem to be greater in the case of *Bandahafannu* than the harbour area. In addition, modifications to the *Bandahafannu* may be necessary for convenient passage of rock-carrying vessels considering the existing shallow depths of the area.

Additionally, by this way, much of the work will have to be carried out on water and given the high-energy waves that approach the island at times, greater risks to vessels and human life makes this alternative less preferred.

Location A (Near Harbour)

This site is mostly clear of vegetation and is currently not used for any purpose. More than 3 ha of vacant land space is available from this location and can be used for temporary storage of materials with temporary fencing. Island authorities are of the view that the site can be put use without any difficulties. The site is just next to the location where material landing will take place. Existing road network can be used to transfer materials from landing site to the stockpile area. The site is relatively far away from the residents and hence noise and dust generated during the unloading and stockpiling will have no impact on the local population. Materials can be placed without having to remove any large trees in the area. The officials from the island stated that if the harbour is to be utilised for unloading, they would be concerned that in the process harbour quay wall may get damaged. Also they were of the view that such an operation could cause difficulties for the regular users of the harbour. Hence, the work methodology has been developed to avoid having to use inner harbour for unloading.

Location B (Bandahafannu/Rasgefannu area)

This site is at Rasgefannu area and is currently used as a fenced sand-surfaced football ground. Due to its close proximity to the coast, during the construction of the breakwater segment at Rasgefannu, the area may have to be kept out of bounds for public safety. Island authorities were of the view that due to availability of several other alternative football grounds allocating the site for temporary storage will not have a negative social impact. Approximately 0.15 ha of land space available is mostly free from vegetation and the materials can be kept without having to remove any mature tree. The site is centrally located considering citing of the proposed shore protection structure and is therefore expected to be very conveniently located. Since the revetment construction work has been planned to start from the south end, as the work progress reaching the half way, the site may have to be used for ease of executing the works. If the site is to be utilised for storage, any damage during the use and changes brought will have to be rectified by the contractor at the end of the works.

The preferred alternative, hence, is using the harbour area for unloading purposes since mitigation measures have been identified to address all concerns of the island authorities. While using the harbour area, barges carrying rocks from the large bulk carrier to the land do not have to enter the inner harbour, but they can unload in the outer harbour. A conceptual plan of this approach is shown in Figure 10.

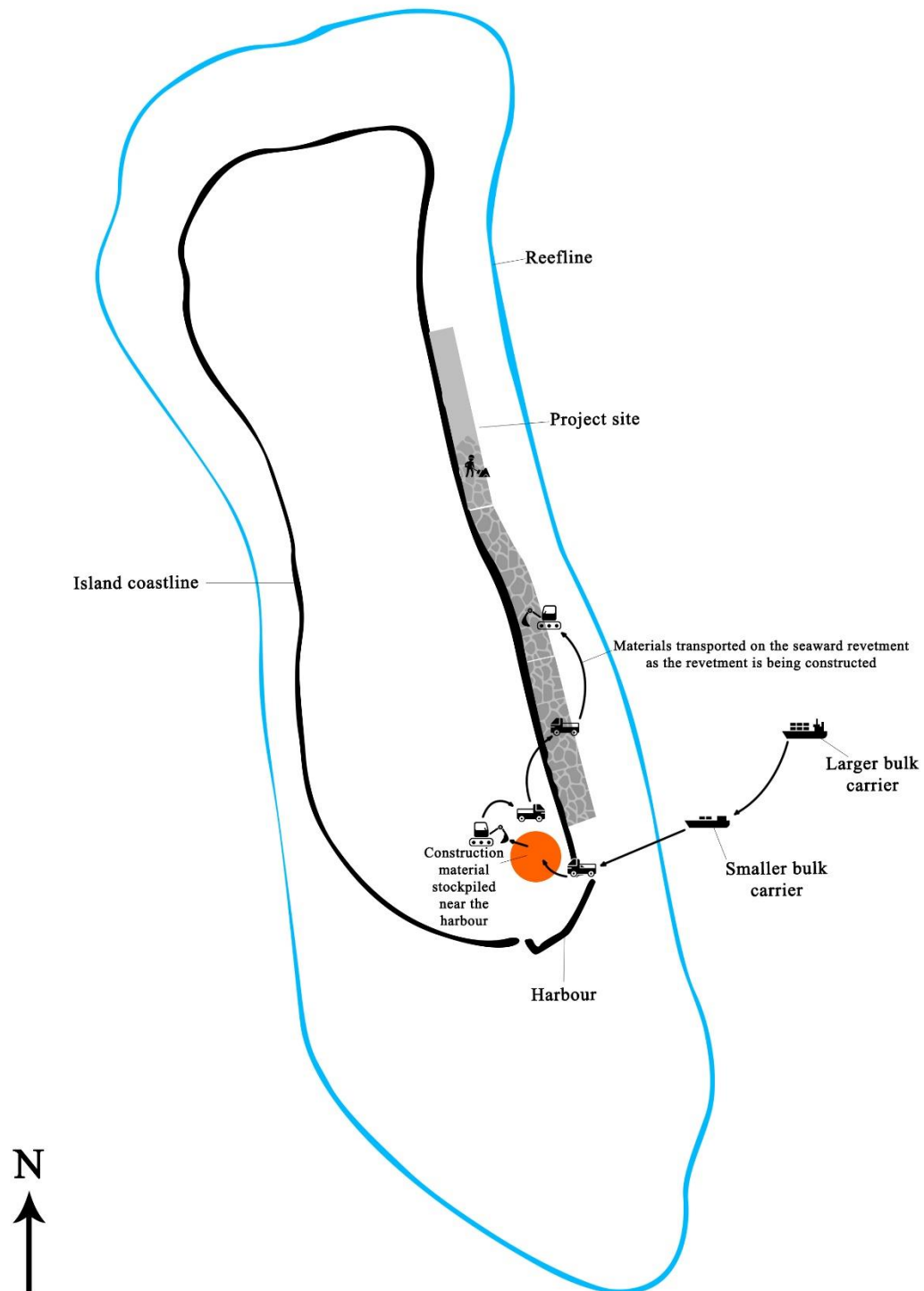


Figure 10: Conceptual illustration of unloading of materials near harbour

2.10.3.1 Transport to site and on-site processing

A construction methodology is proposed where damage to the vegetation belt and the existing roads and houses on the island is minimized. It is proposed that the contractor uses the core material of revetment to drive on. The revetment can be accessed near the harbour restaurant. For efficiency reasons, 1 or 2 extra access locations along the revetment can be used by trucks during construction. For transport and on-site processing, 5 steps are distinguished:

- i. Cleaning of revetment footprint
- ii. Transport rock with 20 tons dumpers from stockpiling area to the project site.
- iii. Unloading, placement and profiling of quarry run core material. Working from the harbour northwards. Herewith a track is created where trucks and cranes can drive on. Rock can be placed in front of the crane which is operating from the revetment core material. This way damage to the vegetation belt due to manoeuvring equipment is minimized.
- iv. The outer revetment consisting of a filter layer (60-300 kg) and top armour layer (1,000-3,000kg) is placed on top of the core material. Transport and placement will take place from the revetment core. Working from the harbour northwards.
- v. Placement of filter layer (60-300 kg) and top armour layer (1,000-3,000kg) on the revetment crest. Transport and placement will take place from the revetment core. Working from the north side southwards (towards harbour)

2.10.4 Workers' Camp

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

2.10.5 Oil Spill Prevention

Appropriate precautions will be taken to prevent pollution from oil spillage or spillages of other hazardous materials. Any pollution will be swiftly cleared up to prevent contamination of soil and groundwater. Similar measures will be in place during marine-based construction activities. An oil spill kit will have to be maintained on site at all times. Spill kit and fire extinguisher to be kept in all areas where fuel is handled.

2.10.6 Waste Management

During construction and maintenance works solid and hazardous wastes will be generated. The island has no waste management system in place and hence waste generated from the project if allowed to find its way into island's waste stream will be an added burden to the island. Hence, waste management area will be designated for collection, sorting and disposal. A paved area within this will be designated for hazardous waste such as waste oil, used batteries, chemicals, etc. Wastes that cannot be reused will be transported to Thilafushi waste management centre.

Development of a regional waste management centre in S. Hithathoo is currently undertaken by the MEE and the project is expected to be completed by 2018. As part of the project the IWMC of

Fuvahmulah will be upgraded to store and handle construction and hazardous waste which will be transported to the Regional waste Management Centre (SRWMC) at S. Hithadhoo for further treatment and final disposal. Under this ongoing project the IWMC at Fuvahmulah will be upgraded and its management will be assigned to Waste Management Corporation Limited (WAMCO), who would also formulate a fee for service arrangement as per the *Polluter Pays* principle. If SRWMC at S. Hithadhoo becomes operational at the time of the implementation of the proposed Project IWMC at Fuvahmulah may be utilised to temporarily store and manage construction waste generated from the Project rather than long distance transport of the waste from Fuvahmulah to Thilafushi.

2.10.7 Health, Safety and Security

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

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

Proposed Occupational Safety and Health Measures:

- Wear personal protection to protect the skin from concrete, wear long sleeves as well as long trousers and water proof boots;
- Conduct concrete mixing in well ventilated areas;
- Work upwind from dust sources;
- Properly fix and secure any objects that may fall;
- Use personal fall arrest equipment;
- Label any openings with warnings such as dug trenches;
- Wear high visibility clothes when working with vehicles and machinery;
- Not entering any trench without proper shoring;
- Identify any utilities before commencing work;
- Keep a safe distance from power lines;

- Wear the required Personal Protective Equipment when in risk of hazards such as atmospheric hazards, biological hazards, chemicals and high noise levels;
- Employ licensed personnel to operate machinery and vehicles;
- Provide all required safety training before commencing work; and
- Keep workers aware of all potential risks and hazards before commencement of work.

2.11 PROJECT RISK MITIGATION

Identifying Project risks and putting in place mitigation measures prior to commencement of work is critical to avoid delays which often results in environmental, social and financial consequences. The risks and proposed mitigation measures are thus aimed at smooth implementation of the Project avoiding environmental damages as a result of unnecessary work stoppages.

Acceptability of the Project by all stakeholders is an important factor for smooth implementation of any project. Taking this into accounts, during the Project formulation both government and island stakeholders were consulted. During the EIA process further consultations were conducted with the stakeholders. In addition to the two trips that had been conducted to the island for consultations, an additional trip has been planned to Fuvahmulah to explain to the stakeholders the preferred alternative that emerged following the feasibility study and proposed in the EIA report. These efforts are aimed at be eliminating any misunderstandings, enhance transparency and thereby increasing public ownership of the Project.

Political risks for the Project is considered extremely low given that governments past and present have given high priority for the coastal protection at Fuvahmulah.

Navigational hazard related risks cannot be completely ruled out based on past experiences of unfortunate incidents that had caused heavy losses to cargo vessels. However navigational hazards can be avoided with better coordination with authorities and responsible navigation during travel within the atolls and especially during approach to Fuvahmulah. Cargo vessels carrying goods running aground on reefs have not only caused delays but also significant financial losses for the Projects.

Claims from the public are also risks to consider especially related to ownership of trees in situations of cutting down or removal of trees. This EIA report has discouraged to remove trees from the Project site and therefore cutting down or removal of a tree will happen only when all other options have been exhausted. In such an unlikely event, the contractor shall have a robust mechanism of insurance in place to mitigate any adverse effects. During site preparation the contractor in collaboration with island authorities will mark the project boundary and will undertake an assessment of vegetation needing absolute removal or relocation and the compensation issue will be settled in advance to reduce the risk of any adverse implications.

Given that the works will be executed at the coastline and strong near-shore wave conditions that normally exist at Fuvahmulah, environmental risks have the potential to cause delays to the Project. Evaluation of the existing environmental conditions of Fuvahmulah (Chapter 4) have shown that the risks of heavy rain incidents are lower during the first quarter of the year while the east coast of the island will be more exposed to easterly wind generated waves during the same

period. Looking at the weather data analysis, east coast will have relatively calm conditions during the months of August to November when the winds are predominantly from west and southwest and the wave heights are significantly lower when compared to first months of the year. Environmental risks may be completely unavoidable careful planning and making arrangements to receive weather forecast information can considerably lower such risks.

Assigning work to an incompetent contractor can also be a potential cause of risk to the Project. Competitive bidding and robust selection process planned for selecting the contractor is aimed at mitigating such risks.

2.12 QUALITY ASSURANCE

Quality assurance has been one of the main important design philosophy used in the Project. Quality assurance was critical to ensure that the structure lasts the design life as well as to ensure minimum or no requirement for the maintenance during the life-time of the structure. Frequent maintenance work would be associated with environmental and social impacts on the Project site, hence need to be avoided. Bearing this in mind, the design of the revetment structure was carried out to meet the National Building Code (2008) as well as international design standards and criteria. In order to ensure quality of the finished works, the most important aspect is selecting an experienced and reputed contractor through a rigorous process. For the proposed Project exact standards required and a detailed and specific inspection and test plan will be developed. The plan will identify items or elements within specification which need to be inspected, confirmed and/or verified before the subsequent work or activity can commence.

Materials which require testing certification or inspection are also highlighted in the inspection and test plan and they too are check for correctness and the results recorded before the materials are released or incorporation into their works. In the prices any non-compliant materials will be quarantined in a specifically designated area to prevent accidental incorporation into the works.

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

For quality assurance and material testing of the rock material, method statements provided by The Rock Manual (CIRIA, 2007) or equivalent international design standards shall be applied.

See also Maintenance Plan given in **Section 2.17**

2.13 EMPLOYMENT

It is estimated that between 50 – 60 workers will be employed during construction phase of the Project. Contractor will be encouraged to hire locals and local sub-contractors to enhance Project's benefit to the community and for transfer of knowledge and experience to the locals.

2.14 PROJECT INPUTS AND OUTPUTS

The Table 10 provides a synthesis of major project inputs and outputs including how the resources will be sourced for the project. This synthesis is closely linked to identifying potential impacts of the project and recommendation of associated mitigation measures.

Table 10: Major inputs and outputs of the Project

Phase	Project inputs	Quantity (approx.)	Use	Source	Remarks
Inputs	Quarry run	14,477 m ³	Core material for profiling of the eroded coastal ridge	Imported either from Malaysia or India or UAE Priority shall be given to closest source area not accounting for minor differences in prices.	
	Rock boulders 1000 – 3000 kg	68,024 m ³	For primary armour layer		
	Rock boulders 60 – 300 kg	21,817 m ³	For core-material		
	Rock boulders 1000 – 3000 kg	27,661 m ³	For toe protection		
	Heavy machinery		Construction of the revetment and related works	All machineries and vehicles will be locally obtained.	Responsibility of the contactors to obtain all necessary plant and machineries.
	Excavators (30t)	2			
	Excavator (2t)	2			
	Wheel loaders	3			
	Dump trucks	6			
	Pickup truck	1			
	Power genset (25kW)	1			
	Large bulk carrier	1			
	Small bulk carrier	2			
	Workforce approx.	50 labourers	For all project related works	Most of the semi-skilled workers are expected to be foreign labourers. Priority will be given to hire locals for the project.	Main contractor is responsible for the workforce during construction period. When employing foreign labourers their legal documents will have to be checked,
	Fuel	220,000 litres for completing the works	For the operations of the plants and machineries		Based on assumption, 2 sets of equipment will be used and work will be completed in plants and machineries/day, and also assuming the work will be completed in max 5 months.

Phase	Project inputs	Quantity (approx.)	Use	Source	Remarks
	Geo-textiles	To be decided	Laying underneath rocks to prevent under cutting by wave action.		Some geo-textiles may be needed
Outputs	Revetment protecting a shoreline	2650m	N/A	Rock armour revetment	
	Greenhouse Gas	9,650 ton of CO ₂	N/A	By burning diesel fuel for the production and transportation of the construction materials and operation of machineries and for generating power. This is for the onshore revetment. For the breakwater option this will be about 50% more.	See Appendix 6
	Noise	insignificant	N/A	Operation of vehicles, plants and placing of rocks	
	Dust	Low dust content	N/A	Vehicle movements on sand roads. During loading and offloading from vehicles Dust content in the rocks expected to be very low.	Vehicles carrying rocks will be mostly travelling away from residential areas, hence the dust is not expected to be an issue.
	Solid waste	Low volumes	N/A	Construction waste is not expected to be significant. However, some solid waste will be generated from workers activities.	All solid waste will be collected, stockpiled and removed from island and transported to Thilafushi. Site Waste Management Plan will be an integral part of the Environmental Management System
	Hazardous waste	Small quantities	N/A	Used oil, fuel, lubricants, soiled clothes, used batteries, oil contaminated soils. and chemicals	All hazardous waste will be kept in closed containers and transported to Thilafushi.

2.15 PROJECT MANAGEMENT

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

2.15.1 Institutional Arrangements

As described earlier the proponent of the Project is The Ministry of Environment and Energy (MEE) which is also the Project executing agency. The Coastal Unit within the Environment Department of MEE will be the focal point and Project Implementation Unit (PMU). It is expected that a Project Manager (PM) will be appointed for the Project before the implementation phase begins. Procurement of works for the project will be in accordance with the Government's Rules of Procedure for the procurement of goods and works using the relevant standard bidding documents. Once the funding and the EIA for the works are approved the selection of the civil works contractor will begin through international competitive bidding. The Ministry of Finance and Treasury is responsible for managing the funds on behalf of the government including approval of payments and preparation of disbursement applications during the implementation of the project. The project will be overseen by the ORIO which is the main financier for the Project. The MEE will ensure that the recommendations, mitigation and monitoring under the EIA will be implemented during all stages of the Project. The roles and responsibilities of the key stakeholders during the construction and operational phase of the proposed project are given in Table 11.

Table 11: Project stakeholders and responsibilities

Organisation	Roles and responsibilities
Ministry of Environment and Energy	Project owner, management of the Project, reporting to the donor, managing the civil works contract. Maintenance works in coordination with the island authorities and MRDC
ORIO Grant Facility	Provision of financial resources
Civil works contractor	Implementation of the project as per the contract and implementation of the EIA
Environmental Consultant (independent)	Environmental monitoring, reporting and environmental auditing
Atoll Council ⁷	Facilitations, coordination's with island councils, monitoring of the project progress.
Island Council	Respective island councils will provide necessary facilitation, coordination and providing necessary information to the public, make arrangements for temporary site closures.

⁷ Fuvahmulah was declared a City during the time of the preparation of the EIA report, hence by the time of the Project implementation, functions stated under Atoll Council would have been transferred under the City Council.

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

2.16 PROJECT SCHEDULE

Project is expected to be completed within a period of 22 months which has been divided into 10 months for pre-constructions activities and 12 months for the construction activities. Provisional schedule for the construction phase of the Project is given in Table 12. The schedule does not include maintenance as it would be carried out as and when necessary. As explained in the Quality Assurance and Maintenance Plan, the revetment structure has been designed for a life time of 50 years in keeping to local and international standards. For the first 5 years no major maintenance is anticipated.

Table 12: Project work schedule

		Duration (months)	Start (month)	End (month)	Activity ID	Month																	
ID	PRE-CONSTRUCTION PHASE										6					12					18		
P1	Financing and permits in place	0.1	0.0	0.1	P1																		
P2	Selection of party for preparation of construction design	2.0	0.0	2.0	P2																		
P3	Field surveys as input for the detailed design	2.0	2.0	4.0	P3																		
P4	Preparation of detailed design and methodology statements	3.0	4.0	7.0	P4																		
P5	Preparation of tender documents	2.0	4.0	6.0	P5																		
P6	Tender procedure	3.0	6.0	9.0	P6																		
P7	Selection of Contractor	0.1	9.0	9.1	P7																		
P8	Selection of quarry arrangements with supplier	1.0	6.0	7.0	P8																		
P9	Site arrangements, operations of construction yard, labour facilities and infrastructure	0.5	9.0	9.5	P9																		
10	Mobilisation of construction equipment	0.5	9.5	10.0	10																		
Total duration pre-construction phase		10.0 months																					
	CONSTRUCTION PHASE																						
C1	Transport and profiling of core material	1.0	8.0	9.0	C1																		
C2	Transport and profiling of filter layer on outer slope [working from south to north]	3.0	9.0	9.0	C2																		
C3	Transport and profiling of top layer on outer slope & toe [working from south to north]	4.0	9.0	13.0	C3																		
C4	Construction of concrete steps	1.0	9.0	10.0	C4																		
C5	Transport and profiling of crest working from north to south	3.0	13.0	16.0	C5																		
C6	Strengthening of offshore tetrapods	2.0	16.0	18.0	C6																		
C7	Repair of damage by construction works	1.0	17.0	18.0	C7																		
C8	Cleaning site, demobilisation	2.0	18.0	20.0	C8																		
Total duration construction phase		12.0 months																					

2.17 MAINTENANCE PLAN

A robust design approach is chosen, for a sustainable and effective solution. Due to its geographical properties, maintenance to the coastal protection is complicated from a logistics and financial point of view. Therefore maintenance effort have been minimized in the design.

The proposed structure is designed according to international standards and guidelines. In the design, the choice is made to not allow significant damage or movement of the rock structure. During a 1/100 year event no damage is allowed which can endanger the integrity of the revetment. So the design is not expected to lead to any major maintenance/repair programs.

It is believed that, the construction quality can have an impact on the required maintenance effort in the future. All granular rock will need to be placed with care. Therefore adequate quality control during construction will be required to ensure that all rock is placed in the right position, creating a stable structure.

A maintenance period of 5 years is proposed to include in the contractors contract. The contractor can set up a small stockpile of rock material is placed on the island, which can be used for small maintenance required in these first 5 years after construction. Including a maintenance obligation in the contract, encourages the contractor to perform well.

For any unforeseen repairs to the rock revetment after 5 years shall require new supply of rock to the island.

As the project Proponent MEE in collaboration with the local authorities will bear the responsibility for post-project maintenance. MEE has plans to conduct short training courses with regard to the maintenance of coastal protection structure. Since MRDC already has the required machineries to undertake maintenance tasks, a local from Fuvahmulah who will work for MRDC will be trained to undertake maintenance as part of the Project.

2.18 DECOMMISSIONING

Decommissioning of the constructed revetment structure is not foreseen in the near future and when decommissioning becomes necessary, there will normally be a replacement of the structure for the same function.

The timing and the activities that will take in the decommissioning phase are not well-known at this moment in the course of the project, if it will ever happen. The starting point is that the structures will remain operational for a long time. However, there may be external factors at a certain time, making the stakeholders of that time to decide to decommission the coastal protection works. These external factors are impossible to predict and can only be speculated on and could relate to changes in the (international) market for agricultural produce, climate change, changes in water regime, construction of new land or a port at this location, a natural disaster or migration of the population.

3. ADMINISTRATIVE AND REGULATORY FRAMEWORK

3.1 INTRODUCTION

This Chapter highlights relevant national policies and legislative framework applicable to the proposed Project. The relevant national policies and legislative framework provides guidance on several aspects related to planning, and implementation of coastal projects. The legal framework pertaining to the proposed Project is also aimed at sustainable development, impact mitigation and conservation of the country's natural resources.

The EIA also follows the IFC Performance Standards to meet the requirements of the donor agency. Hence the compliance of the Project to IFC standards is also covered in this chapter.

An institutional mapping and analysis was conducted in the context of the proposed Project on environmental policies and legal frameworks and roles and responsibilities of key institutions driving development and environmental management at the national and local levels as required in the ToR (Task 3). The chapter describes pertinent legislation, regulations, standards, and environmental policies that are relevant and applicable to the Project. In addition, appropriate authority jurisdictions that will specifically apply to the project are also discussed. In keeping to the ToR, the review also identified different articles and clauses in laws and regulations that applies to the Project and explanation provided on how the project meets these requirements.

3.2 ENVIRONMENTAL GOVERNANCE

Environmental governance in the Maldives takes places at two distinct levels; national and local. Central administration in the Maldives is conducted through national ministries headed by Cabinet Ministers based in the capital of Male'. Ministries are responsible for formulating relevant policies, planning development, coordination with donors and to a large extent formulating and implementation of projects in the country. Below the central government are 19 administrative units (roughly one per atoll) and each administrative atoll having an Atoll Council elected under the DA (2010). Each atoll in turn is divided into smaller administrative units comprising usually of inhabited islands and uninhabited islands. The governance system in the Maldives consists of 19 atoll councils, two city councils (Malé and Addu) and 188 island councils. The specific roles and responsibilities of the councils in relation to the project are discussed in detail in the following sub-sections. The island councils are supported by advice from Women's Development Committee comprising of elected members from the community. In addition, Island Councils can seek opinion of youth groups, community elders and individuals on matters related to them. Public information on projects and other important matters is shared through formal and informal meetings organised by the council. All land is the property of the state, however uninhabited islands and land parcels from inhabited islands may be rented out by the government to private individuals or businesses.

The Maldivian institutional structure to protect the environment is relatively young, having been developed in the 20 years or so. Presently, the Environment Department within the Ministry of Environment and Energy (MEE) and Environment Protection Agency (EPA) are the main focal point for all environmental issues in the Maldives.

3.2.1 Ministry of Environment and Energy

The Environment Department of the MEE has a policy making and developmental role in relation to coastal protection and management and even though there is no specific aspect of coastal protection that is mentioned in the mandate of MEE, the MEE has a general mandate to formulate policies, regulations and standards needed for the protection of the coastal environment and prevention of coastal degradation pursuant to Environmental Protection and Preservation Act (EPPA). The Environment Department has the function of developing and implementing projects targeted for the building of coastal protection infrastructure to prevent coastal degradation, and pursuant to this, the department seeks funds from the national budget and donor sources. The beneficiaries of such projects are determined on the basis of national development priorities. The department though it has a regulatory function has limited its role to promulgation of regulations, and has delegated monitoring and enforcement function to the Environmental Protection Agency.

3.2.2 Environmental Protection Agency

The EPA is a semi-autonomous regulatory body affiliated to the MEE and operates under the guidance of the Minister in-charge of the MEE.

The EPA has been assigned the following functions pertaining to coastal protection and management:

- research changes to the island beaches and causes of beach erosion, and providing advice to solve these issues;
- obtain data on the formation and changes to the islands of the Maldives through the use of satellite imagery and aerial photography;
- obtain data needed for the geographic information systems, and dissemination of this data;
- identify the impacts of land reclamation, harbour development and reef blasting, research methodologies in an environment-friendly manner, and provide the data and experience gained to relevant organizations; and
- develop, administer and implement the matters of the physical oceanography of the Maldives.

EPA is responsible for the discharge of functions in relation to coastal protection and enforcement of regulations and standards promulgated by the MEE for coastal protection including the following;

- Implementation of the EIA regulations;
- implementation of waste management regulations; and
- implementation of environmental damage and liability regulations.

3.2.3 Ministry of Housing and Infrastructure

The Ministry of Housing and Infrastructure (MHI) has the following functions that have a bearing on coastal protection and management:

- planning, building and management of coastal protection structures that are included as part of land reclamation activities or dredging activities undertaken for building ports infrastructure;
- maintain information (database) on use and condition of government and public infrastructure;
- maintenance of an infrastructure register;
- formulate policies for the development of public infrastructure and give technical advice for implementation of such projects;
- develop and implement land reclamation and coastal excavations and such type of major government projects;
- formulate land reclamation and dredging rules, policies and standards;
- plan and manage public infrastructure projects that does not fall under the purview of a specific institution;
- co-ordinate and manage reconstruction of public infrastructure damaged by natural disaster or any other event;
- undertake reclamation and coastal excavations, building coastal revetments and design and manage coastal protection activities; and
- co-ordinate activities for reconstruction and repair of public infrastructure damaged by natural calamities.

Specific functions pursuant to the above activities are undertaken and supervised by the Infrastructure Department and the Planning Department of the MHI.

The Infrastructure Department is involved in the planning and budgeting processes within government to ensure harmonisation of implementation of infrastructure development projects, through coordination and collaboration of the work through relevant Ministries and government departments.

3.2.4 Public Works Services

The Public Works Services, which is an entity operating under the stewardship of the MHI has the following mandates relating to the development, management, repair and maintenance of coastal infrastructure.

- Repair and maintain ports, jetties and island coastal protection infrastructures; and
- produce concrete blocks and revetments needed for government projects.

Public Works Services is located in Male' and their engagement in coastal protection activities is limited.

3.2.5 Atoll Councils and Island Councils⁸

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

In the case of Fuvahmulah each of its 8 wards are considered as "islands" under the DA and thus have 8 elected island councils. These comprise three elected councillors in each of the island's eight wards: *Dhiguvaadu Council*, *Dhadimagu Council*, *Maadhado Council*, *Miskiymagu Council*, *Maalegam Council*, *Dhoodigum Council*, *Funaad Council* and *Hoaadhadu Council*. The largest ward is *Dhanimagu* and the most populous is *Dhundigan*.

Among other functions entrusted on the island councils, the Decentralisation Act (DA) reposes the function of management, repair and maintenance of island ports and jetties on the Island Councils in addition to which the role of taking the necessary measures to prevent coastal erosion and repair and maintenance of the breakwaters or sea walls also lies with the Island Councils (Clause 24, DA). Island Councils have associated rights to enter into ventures with the private sector under Public Private Partnership models to build harbours and other such infrastructure (Clause 86, DA) and to formulate regulations governing the maintenance of jetties and harbours of the island in consultation with the Local Government Authority (Clause 151, DA). In practice, however, the Island Councils have a limited role in coastal protection activities, and the Councils depend on the sectorial ministries to take the necessary actions for building coastal protection infrastructure.

Fuvahmulah has an Atoll Council comprising of six elected councillors headed by a President elected for a three-year term. The atoll council is mandated to oversee administrative and development work and to coordinate and monitor the activities and functioning of the island councils. The president and the vice-president of the atoll council are indirectly elected by a secret ballot of the elected members of the council.

The Atoll Councils do not have a specific role in relation to island level activities related to coastal protection, other than the oversight function reposed on the Atoll Councils pursuant to the law (Clauses 8 and 9, DA). It must however be noted that coastal protection and management of areas

⁸ Fuvahmulah island and atoll councils will be soon dissolved, as the island has recently been accorded the City status. The new City Council which will take over the responsibilities under the current island and atoll council will come into effect after the next local council election which is scheduled to take place in Jan 2017.

that do not fall within the purview of a sectoral ministry or a specific Island Council in an Administrative Division, would be the responsibility of the Atoll Council, since it is a statutory responsibility of Atoll Councils to administer and implement projects in the Development Plan of Administrative Divisions that have not been assigned to a particular Island Council (Clause 9 DA).

3.2.6 Ministry of Fisheries and Agriculture

In summary in the Maldives there are number of state institutions that have a role in coastal developmental activities. The assessment indicates that institutional mandates of organisations appear to be fragmented with a lack of certainty regarding the actual mandates of the organisations regarding coastal protection and management. The Island Councils functions overlap with the some of the functions of the national regulators, leading to uncertainties regarding the actual role of different institutions.

3.2.7 Ministry of Defence and National Security

The Armed Forces Act (Law No. 1/2008) includes as a mandate of the Maldives National Defence Force (MNDF), responsibility to lead and co-ordinate activities necessary to save the lives of people and to protect property in case of disasters, including in case of fires, maritime incidents and maritime hazards and disasters (Clause 7).

3.2.8 Maldives Police Service

The Police Act (Law No. 5/2008) assigns the Maldives Police Service (MPS) the responsibility in case of natural or other types of disasters, accidents, to save lives of people, households and property. In practice there is unit of MPS in Fuvahmulah and limited mandate to assist only in the case of theft, accidents or disputes.

3.2.9 Ministry of Health

The Public Health Preparedness and Response and Epidemiology Division under the HPA has been tasked with the mandate to take the initiative to respond to medical emergency situations brought on due to natural disasters and other crisis situations and to maintain emergency stock of medicines and medical equipment's in accordance with the manner stipulated in disaster preparedness plans prepared and implemented by the Division. The Division has the responsibility to provide the necessary guidance to local level health sector institutions to prepare rapid assessment of medical emergencies or natural disasters and crisis situations and work in accordance with Health Sector Emergency Risk Framework (2014). The Division has also been assigned the function of conducting training programmes and drills to prepare health care personnel on emergency preparedness and response.

3.2.10 Local Government Authority

The LGA is working in close collaboration with the National Disaster Management Centre (NDMC) to incorporate disaster management and disaster risk mitigation into island level development planning. For this purpose, the LGA is revising Island Development Plan templates

to include and integrate disaster risk mitigation measures where coastal development is also considered.

3.2.11 Women's Development Committees

The Women's Development Committees have an advisory role in relation to services provided by Island Councils.

3.2.12 Maldives Red Crescent

The Maldives Red Crescent, which is an NGO established in accordance with Maldives Red Crescent Act (Law No. 7/2009) has been created with the prime objective to provide disaster relief and assistance and to protect and take to safety persons faced with such conditions (Clause 3). The NGO is very active and conducts additional activities such as preparing island hazard risk plans in collaboration with the NDMC in Fuvahmulah.

3.2.13 Maldives Road Development Corporation

A Unit of the MRDC is located in Fuvahmulah. The Unit is engaged in limited coastal protection activities and is active in providing road development services in the island.

3.2.14 Labour Relations Authority

The Labour Relations Authority established under Employment Act (Act No 2/2008), which is an entity operating under the stewardship of the Ministry of Economic Development determines the fundamental principles relating to employment in the Maldives, the rights and obligations of employers and employees while Employment Tribunal protects such rights, and makes provision for all other matters related to employment. Thus, contractors and employees hired for the coastal work of Fuvahmulah should follow these law and regulations.

3.3 REGULATORY CONSIDERATIONS

The national measures, policy and legal governing coastal protection are located in the following policy and legislative instruments on the protection of the environment:

- Environment Protection and Preservation Act (Law No. 4/93)
- Law on Coral, Sand and Aggregate Mining from Inhabited Islands (Law No. 20/98)
- Coastal Dredging and Reclamation Regulation (2013)
- Environment Impact Assessment (EIA) Regulations (2012)
- Regulation on Sand and Aggregate Mining
- Regulation on uprooting, cutting and relocating trees and plants from one island to another
- National Adaptation Program of Action (NAPA) (2006)

There is no flagship law governing coastal protection and management in the Maldives, even though problems associated with degradation of the coastlines is a national and regional level area of great concern. The lack of a legal framework governing this area has meant that at the organisational level, there is a lack of clarity of designated roles of national and local level institutions. The coastal protection and management institutional framework is fragmented with different institutions at the national and local level having overlapping roles and mandates.

The mapping reveals that different organisations are engaged in different aspects of coastal protection and management with activities ranging from, providing policy guidance, development of standards for coastal modifications, collection and dissemination of data to formulation and implementation of projects for coastal protection in different parts of the country. The main institutions with the responsibility for coastal protection activities are discussed below.

The main national legislative frameworks relevant to this proposed project and proposed compliance arrangements are summarised in Table 13.

Table 13: Relevant laws and regulations pertaining to the proposed Project and measures to be implemented to ensure compliance.

Law/Regulations & Policies	Measures to comply with the laws/regulation
The Environmental Protection and Preservation Act of the Maldives, EPPA (Law No. 4/93)	
Article 5 (a) of the Act, an Environmental Impact Assessment shall be submitted to the MHE.	EIA prepared
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 disposal of such substances becomes 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.	Fully complied to – see Section 2.10.7 for details.
Environment Impact Assessment (EIA) Regulations (2012)	All processes followed, EIA has been conducted and produced as per the guidance given in the Regulations
Bylaw about the cutting down, uprooting, digging out and export of trees and palms from one island to another, 2006. The purpose of this by law is to educate citizens and developers about the importance of trees including best management practices for maintaining trees and to provide standards for the preservation of trees in Maldives and to set down rules and regulations to be adhered to prior to commencing felling, uprooting, digging out and exporting of trees and palms from one island to another in Maldives	
Clause 3 states trees that are prohibited to be removed	
(a) The coastal vegetation growing around the islands extending to about 15 metres into the island are protected by this by law	Has been fully addressed in the Environmental Impacts and Mitigation chapter (Chapter 9).
(b) All the trees and palms growing in mangrove and wetlands spreading to 15 metres of land area is protected by this by law	N/A since no mangroves on the island

Law/Regulations & Policies	Measures to comply with the laws/regulation
(c) All trees in Government protected areas	N/A since no protected area on the island
(d) Trees that are being protected by the Government in order to protect species of animal /organisms that inhabit on such trees.	N/A
(e) Trees / palms those are abnormal in structure.	N/A no such trees were observed in the vicinity of the Project site.
The regulation states that prior permission must be obtained for removal and/or relocation of 10 or more trees or palms. For indiscriminate removal and land clearances and EIA and Decision Note is required. The size of the trees and palms that are allowed to be relocated should have more 15feet from lowest point to the crown spread for palms and 8 feet from the lowest point to the trunk to tip of the highest branch for trees other than palms. The law also states that cutting down and uprooting of the trees shall be made under supervision of the island / atoll offices (in the current context Atoll / Island Councils).	Will be fully complied to in an unavoidable circumstance of having to remove a large tree although the current EIA has encouraged opting for options other than removing or cutting down a tree. The details are found in Chapter 9 .
Clause 5 of the bylaw describes Issuance of permits to cut down, uproot, dig out and export trees and palms from one island to another.	
(a) Prior to the commencement of any project(s) that would require the indiscriminate removal and export of trees/palms from one island to another for the purposes of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under this Regulation to prepare an Environment Impact Assessment Report stating clearly the details of the project(s) with all necessary information and submit the same through the relevant Ministry to Ministry of Environment, Energy and Water, and the project(s) can only commence upon the grant of written approval from Ministry of Environment, Energy and Water.	The Project does not involve transfer of trees from one island to another.
(b) In the event that a need arises to remove 10 or more Trees/palms at a time that are grown in private dwellings for one's own use, then the requirements stated in clause 8 a) and b) must be fulfilled.	It is not anticipated 10 more mature trees will be required removal.
(c) All the persons who are granted a permit to remove trees/palms by the Ministry of Environment, Energy and Water must complete the work of removal of the trees/palms before the end of the stipulated time. If the work is	

Law/Regulations & Policies	Measures to comply with the laws/regulation
not completed in time, then the concerned parties must apply in writing to extend the period to Ministry of Environment, Energy and Water and cease work until the issuance of a new permit.	
(d) If it is necessary to export the trees/palms with soil, then it must be done only in nursery bags that measure up to 8"/10".	N/A
(e) In the event that the trees/palms are larger than the size specified in clause 8 a) of this Regulation and they are to be removed for export to another island; the tree/palm must be cleaned of all excess black soil from the root balls before it is exported to another island.	N/A
(f) If excavators/bulldozers are used for the removal of trees/palms and if it might cause injury to another tree, then such machinery should not be used to remove the tree(s)/palm(s). If damage is caused or might be caused to a neighbouring tree/palm while in the process of removing the desired tree/palm, then the desired plant/palm cannot be removed.	Will be complied as when required
Clause 6 states Special permit issued to cut down, uproot dig out and export trees and palms from one island to another	N/A
A special permit is required from Ministry of Environment, Energy and Water for the export of trees/palms from one island to another if port of export has five or less of the particular species of trees/palms.	N/A
(b) Trees/palms that are in inhabited/uninhabited islands that are used by species of birds as a roosting or breeding spot are protected under this Regulation and if any of these trees/palms are to be removed, a special permit should be obtained from Ministry of Environment, Energy and Water. In addition, if a tree/palm that is a roosting or breeding spot for certain species of birds are to be cut down permission has to be sought from the Ministry of Environment, Energy and Water.	Will be complied as when required
Clause 8 states certain conditions have to be met for the grant of a permit for the removal and export of trees/palms from one island to another.	N/A
The holes created from uprooting trees/palms must be covered with soil and made firm, and it is prohibited to put anything else but soil into the holes.	Will be complied as when required
The Law on the Palms and Trees in the Inhabited Islands of Maldives (21/98)	

Law/Regulations & Policies	Measures to comply with the laws/regulation
Clause 8 says that cutting down of any palms or trees that belong to the public can only be done after receiving advice from the Ministry of Fisheries and Agriculture and in accordance with the direction given by the Ministry of Atolls Development ⁹	Alternatives assessment showed that cutting down or removal of coconut palms can be avoided by opting either seaside coastal revetment or offshore breakwater. Landside coastal revetment has been ruled out to avoid any degree of coastal vegetation clearance.
Regulation on Dredging and Reclamation (2013/R-15)	
The regulation requires having permission of EPA on projects requiring alternation of the island, either by reclamation or dredging. Specifically, the regulation requires producing scaled maps of the island before and after the proposed intervention. Special provisions have been made on protected and sensitive area restricting changes to the environment of the islands.	N/A since imported quarry run has been planned to be used for ridge profiling works..
Regulation on Sand and Aggregate Mining (2000)	No locally mined sand or aggregate will be used for the construction purposes and as an alternative quarry run has been proposed to be used which is imported from abroad.

⁹ The ministry doesn't exist anymore and the function is believed to be with the respective island council.

Law/Regulations & Policies	Measures to comply with the laws/regulation
Waste Management Regulation, (No. 2013/R-58)	
The regulation provides set of comprehensive guidelines on collecting, storing, transporting and managing solid waste as well as management of hazardous waste. The waste management regulation identifies the following areas prohibited from dumping of waste; protected areas under the Environmental Protection and Preservation Act, mangroves, lagoons of islands, coral reefs, sand banks, beaches of islands, coastal vegetated areas of islands, harbour, parks and roads. Additionally, waste management regulation states that those involved in waste management must be permitted by the Environmental Protection Agency.	Will be fully complied to – see Section 2.10.6 on Waste Management for details.
Controlling of blasting reefs and lagoon areas by use of dynamites (1990)	
Blasting of reef environment or lagoon areas for any purpose is highly discouraged in the Maldives. The Ministry of Environment via its public announcement on 02 December 1990 stated that dynamite blasting shall only be carried out after prior written approval of the Ministry.	No blasting is involved under this Project.
Employment Act (2/2008)	
The Employment Act of the Maldives prohibits the employment of a minor under the age of sixteen except for the purpose of training in relation to such minor's education and requires parental consent be obtained for employing minors. The Act makes an exception for children participating, with their consent, in work undertaken by their families. The Employment Act also prohibits the employment of a child (below 18 years of age) in any work or employment that may have a detrimental effect on a child's health, education, safety or morals due to the work or job undertaken or the conditions of work. Those who employ minors are required to maintain a register of minors employed containing their names, addresses and dates of birth. The Act also requires a medical fitness test prior to employing minors on vessels and further such tests for continued employment on vessels.	No minors will be allowed to work in the Project

3.4 NATIONAL POLICIES

3.4.1 National Adaptation Programme of Action (NAPA) (2007)

NAPA presents the framework to climate change adaptation to enhance the resilience of the natural, human and social system to ensuring their sustainability against predicted climate change. NAPA lays out the national policy framework for the Maldives. The document comprehensively describes the climate vulnerabilities faced to the Maldives. Coastal erosion faced to the islands have been highlighted in NAPA as one of the most critical challenge faced to the Maldives. Outlining the inherent challenges the islands face in mitigating against erosion, it rules out options such setbacks or retreating into higher grounds as realistic alternatives due to the scarcity of land, the smallness of the islands and extreme low elevation of the islands. Hence NAPA stresses that building setback as of limited value and beach replenishment as a temporary remedy for the Maldives. Hence engineered coastal protection measures have been stated as the most tangible solution against sea inundation (MEEW, 2006).

NAPA also emphasizes wetland conservation through priority actions such as flood control, recognizes the importance of coral, and also includes enhancing capacity for solid waste management as a priority action to prevent pollution of the marine environment.

Protection of Fuvahmulah coastline has been identified as an urgent activity in the National Adaptation Plan of Action (NAPA). It is aimed as to reduce vulnerability of the Fuvahmulah Island to current climate risks and future climate change risks. The project aims to facilitate the construction of appropriate coastal protection for Fuvahmulah and ensure that risks from climate change impacts are adequately addressed in the design of the coastal protection measures against the predicted climate change and sea level rise. The implementation of the project will help to increased resilience of the Fuvahmulah islands community and their properties to climate change impacts.

3.4.2 Maldives National Strategy for Sustainable Development (MNSSD) (2009)

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

3.4.3 Third National Environmental Action Plan (NEAP3 2009 – 2013)

NEAP 3 was formulated to set the environmental agenda for the five year period with an objective of creating livable and sustainable places in which protection of the environment while making people and properties resilient. It was aimed at promoting resilient island communities, conserving environment, promoting healthy communities, providing safe water and environmental stewardship among other objectives.

3.4.4 The Strategic National Action Plan (SNAP)

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

3.4.5 Maldives Climate Change Policy Framework (MCCPF) (2015)

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

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

3.4.6 National Biodiversity Strategy and Action Plan (NBSAP) (2016 – 2025)

NBSAP recognizes beach erosion as an existential threat faced to the islands of the Maldives with no long term solution available. Under Strategy 5 – addressing threats to biodiversity – it sets the target of eliminating pressure on coral reefs and other vulnerable ecosystems due to anthropogenic activities and climate change by 2025. Specifically it states protecting and managing representative areas of the ecosystems and recognizing and relieving pressures on ground water lenses and other important ecosystems for water, human health, wellbeing and livelihood (MEE, 2015).

3.5 CONVENTIONS AND AGREEMENTS

The GOM has become a Party to a number of international conventions and agreements among which United Nations Framework Convention on Climate Change is of particular relevance to the proposed Project. the United Nations Conference on Environment and Development (UNCED) (Rio de Janeiro, 1992) and its Agenda 21 Resolution; the United Nations Convention on Biological Diversity (1992) all calls for sustainable development, vulnerabilities of low-lying coral islands such as the Maldives and their special needs against mounting challenges.

The Fifth Assessment Report by Intergovernmental Panel on Climate Change (IPCC) describes a wide

range of current and future climate-related drivers of risk for small islands during the 21st century, which include sea-level rise, tropical and extra-tropical cyclones, increasing air and sea surface temperatures, and changing rainfall patterns. The report acknowledges sea-level rise as one of the most widely recognized climate change threats to small islands where the majority of human communities and infrastructure is located in coastal zones with limited on-island relocation opportunities especially on atolls. It is obvious that the projected sea level increase of 0.35–0.7 meters by the year 2100 will threaten the existence of the Maldives unless the trends are reversed and rapid adaptation measures are taken.

3.6 IFC PERFORMANCE STANDARDS ON ENVIRONMENTAL AND SOCIAL SUSTAINABILITY

The Table 14 below lists the objectives of the eight IFC Performance Standards and discussed their applicability for the Project.

Table 14: IFC performance standards and their applicability to the Project

Objective	Applicability	Compliance
PS 1: Social and Environmental Assessment and Management System Guidance note on the categorisation of projects during Project screening, provisions for sector investing and financial intermediaries, exemptions for emergency situations, requirements for institutional capacity and requirements for public consultation and disclosure. An ESIA for a Category A project like this, is required to identify and assess potential negative and positive environmental and social impacts, compare these with those of feasible alternatives (including the no project alternative), and recommend mitigation measures to reduce negative impacts and enhance benefits. An effective Environmental and Social Management System (ESMS) is a dynamic and continuous process initiated and supported by management, and involves engagement between the Project components, its workers, local communities directly affected by the project (the Affected Communities) and, where appropriate, other stakeholders.(1) Drawing on the elements of the established business management process of “plan, do, check, and act,” the ESMS entails a methodological approach to managing environmental and social risks (2) and impacts in a structured way on an ongoing basis. A good ESMS appropriate to the nature and scale of the project promotes sound and sustainable environmental and social performance, and can lead to improved financial, social, and environmental outcomes.	Yes	The Project is classified as a category B project. However, a comprehensive ESIA is covered in the report
PS 2: Labour and Working Conditions Recognizes that the pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. For any business, the workforce is a valuable asset, and a sound worker-management relationship is a key ingredient in the sustainability of a company. Failure to establish and foster a sound worker-management relationship can undermine worker commitment and retention, and can jeopardize a project. Conversely, through a constructive worker-management relationship, and by treating the workers fairly and providing them with safe and	Yes	Contractor will be required to meet the basic rights of the workers and providing them with safe and healthy working conditions

Objective	Applicability	Compliance
healthy working conditions, the Project shall create tangible benefits, such as enhancement of the efficiency and productivity of their operations.		through the legally binding contract agreement to be signed between the Proponent and the selected Contractor.
PS 3: Pollution Prevention and Abatement Recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water, and land, and consume finite resources in a manner that may threaten people and the environment at the local, regional, and global levels. There is also a growing global consensus that the current and projected atmospheric concentration of greenhouse gases (GHG) threatens the public health and welfare of current and future generations. At the same time, more efficient and effective resource use and pollution prevention and GHG emission avoidance and mitigation technologies and practices have become more accessible and achievable in virtually all parts of the world.	Yes	Covered in detail in the report
PS 4: Community Health, Safety and Security Recognizes that project activities, equipment, and infrastructure can increase community exposure to risks and impacts. In addition, communities that are already subjected to impacts from climate change may also experience an acceleration and/or intensification of impacts due to project activities. While acknowledging the public authorities' role in promoting the health, safety, and security of the public, this Performance Standard addresses the Project's responsibility to avoid or minimize the risks and impacts to community health, safety, and security that may arise from project related-activities, with particular attention to vulnerable groups.	Yes	Community safety and security aspects that shall be followed by the Contractor is given in the report
PS 5: Land Acquisition and Involuntary Resettlement Recognizes that project-related land acquisition and restrictions on land use can have adverse impacts on communities and persons that use this land. Involuntary resettlement refers both to physical displacement (relocation or loss of shelter) and to economic displacement (loss of assets or access to assets that leads to loss of income sources or other means of livelihood) as a result of project-related land acquisition and/or restrictions on land use. Resettlement is considered involuntary when affected persons or communities do not have the right to refuse land acquisition or restrictions on land use that result in physical or economic displacement. This occurs in cases of (i) lawful expropriation or temporary or permanent restrictions on land use and (ii) negotiated settlements in which the buyer can resort to expropriation or impose legal restrictions on land use if negotiations with the seller fail.	No	The Project is undertaken in state-owned land and therefore does not involve forceful or involuntary resettlements
PS 6: Biodiversity Conservation and Sustainable Natural Resource Management Recognizes that protecting and conserving biodiversity, maintaining ecosystem services, and sustainably managing living natural resources are fundamental to sustainable development. The requirements set out in this Performance Standard have been guided by the Convention on Biological Diversity, which defines biodiversity as "the variability among living organisms from all sources	Yes	A thorough evaluation of the existing environment and proposed mitigation measures are

Objective	Applicability	Compliance
including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species, and of ecosystems.”		aimed at making the Project’s impact on the Island’s biodiversity is kept insignificant.
PS 7: Indigenous Peoples Recognizes that Indigenous Peoples, as social groups with identities that are distinct from mainstream groups in national societies, are often among the most marginalized and vulnerable segments of the population. In many cases, their economic, social, and legal status limits their capacity to defend their rights to, and interests in, lands and natural and cultural resources, and may restrict their ability to participate in and benefit from development.	No	Not applicable in the context of the Maldives as explained in the report
PS 8: Cultural Heritage Recognizes the importance of cultural heritage for current and future generations. Consistent with the Convention Concerning the Protection of the World Cultural and Natural Heritage, this Performance Standard aims to ensure that Proponent protects cultural heritage in the course of the project activities.	Yes	Maldives is a Party to the Convention Concerning the Protection of the World Cultural and Natural Heritage. Although the Project will not have a direct impact on the cultural sites of the Island, as a precaution mitigation measures have been proposed in the report for those sites which are likely to fall within the impact zone.

4. METHODOLOGY OF THE IMPACT STUDY

4.1 INTRODUCTION

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

A team from MEECO & RHDHV travelled to Fuvahmulah from 10th to 15th July 2016 for conducting environmental and Socio economic surveys for the EIA report (Figure 11). An official from the MEE also attended the visit List of participants in the field visit is given in **Annex 4**.



Figure 11: Team inspecting the eroding coastline during July 2016 visit

4.2 FLORA AND FAUNA

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

A combination of visual observations and aerial photos were used to identify the major types and extent of vegetation at the north-eastern coast of Fuvahmulah. Crowns of palm trees were used to identify the

number of palm trees at the sites. Photographs taken at the sites were used to identify the other types of vegetation.

4.3 GROUNDWATER AND SEAWATER QUALITY

Water quality was measured in situ using *Horiba* Multi Parameter Water Analyser and in the MWSC laboratory. Parameters tested include Temperature, pH, Turbidity(NTU), Dissolved Oxygen (mg/L), Electrical Conductivity ($\mu\text{s}/\text{cm}$), Salinity (ppt), Total dissolved solids (mg/l) and in the laboratory Sulphate(mg/L) and BOD₅(mg/l).

Groundwater quality testing for salinity was done from sites close to the coast and in land. Salinity reading were then compared with the distance to the closest shore to determine if a correlation was observed between distance from the coast and salinity of ground water using linear regression. The locations groundwater and seawater quality are given in Figure 12.

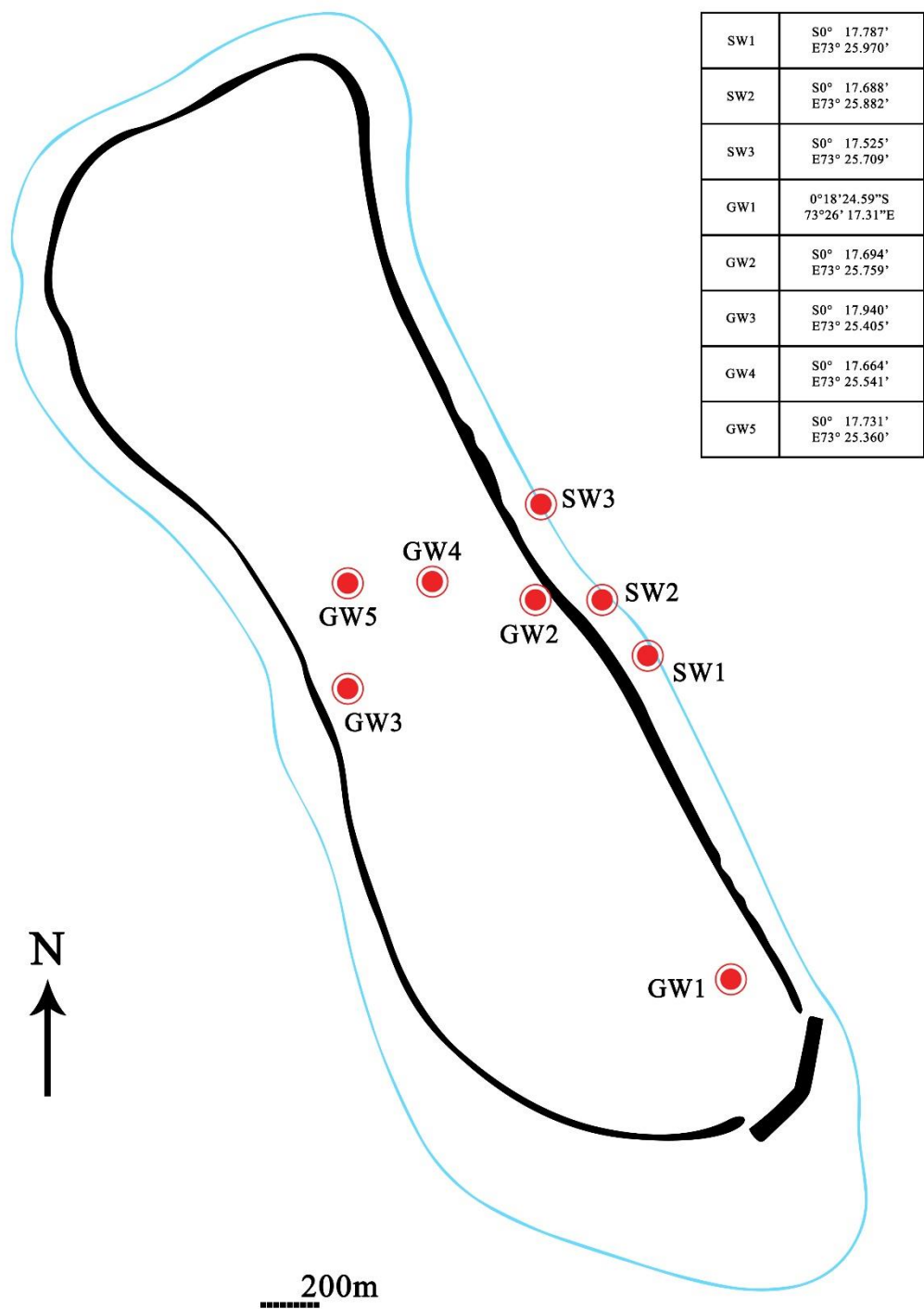


Figure 12: Water sampling locations (SW represents seawater & GW represents groundwater)

4.4 CLIMATE CONDITIONS

Climate conditions at the project site was assessed after compiling 37 years of weather data for the period 1978-2015 for S. Gan International Airport obtained from planning.gov.mv, (2016). Gan was chosen as it was the nearest weather station to Fuvahmulah. The weather station at Gan is maintained by the Maldives Meteorological Service (MMS). Limited weather information that was available since 2006 was also used in comparative assessments where appropriate.

The statistical data was analysed for the following:

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

4.5 TOPOGRAPHY & BATHYMETRY

The coastal features of the island were mapped using GNSS RTK system. The shore line of the island including the high tide, low tide and vegetation lines of the island was measured during the field work. Three cross sections of Fuvahmulah was taken covering the top, middle and bottom section of the island. Beach profiles were taken at intervals of every 20 to 40 m around the whole island. As part of the EIA, three coastal monitoring stations were set up along the north coast of the island. These stations were used to take cross sectional profiles of the beach which can be utilised to measure erosion rates at the coast in the future. The island cross sections and beach profiles were analysed to better describe the coastal features and elevations of the island (see Figure 13 for locations of the profiles). The island cross sections were used to determine the existing ridge width of the north-eastern coast of Fuvahmulah. Erosion rate and loss of sediment budget at Fuvahmulah *Thundi* beach were calculated by comparing the data obtained during field visits with geo referenced satellite images taken during 1969.

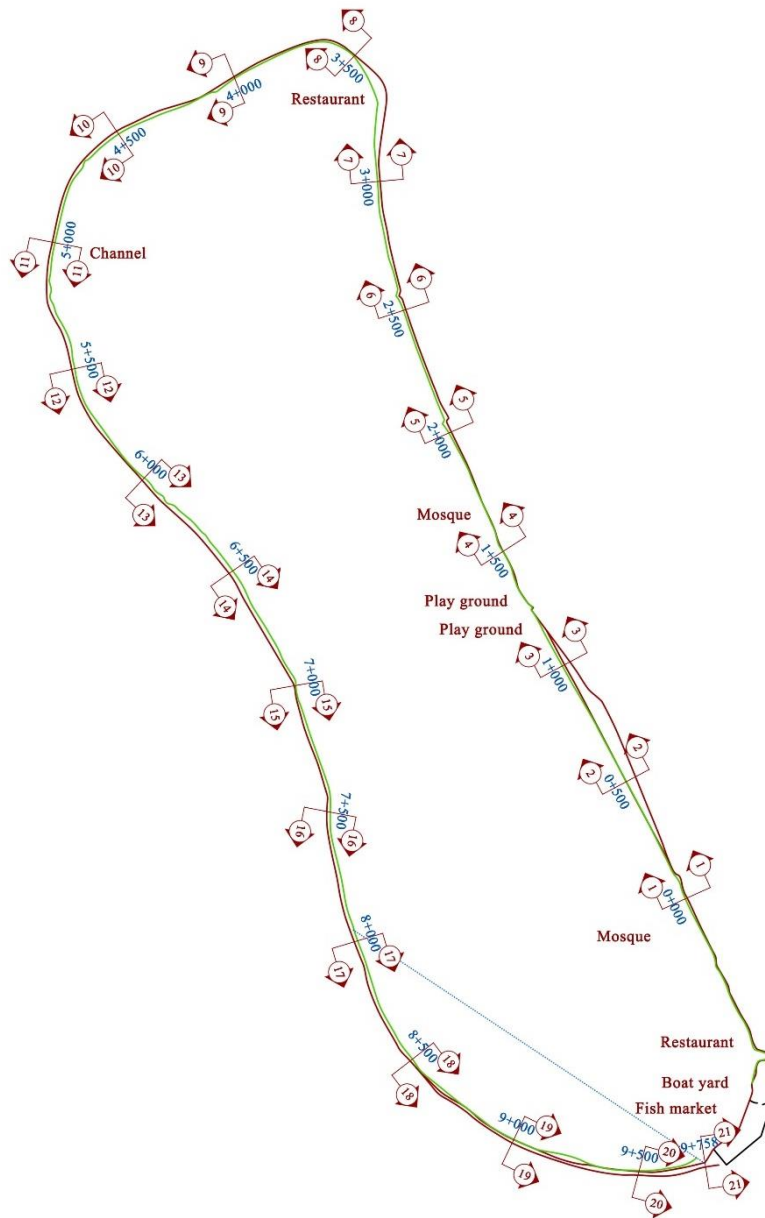


Figure 13: Locations of beach profiles

Bathymetry of the north-eastern reef flat and reef edge of Fuvahmulah was done by combining two methods due to the access difficulties to the area. Although the reef flat area was very shallow it was very rough as a result of incoming waves, which limited access to the area even with a shallow dingy. Hence to map the reef flat, a total station and pole was used. Measurements were taken perpendicular to coast at less than 1 m intervals up to the edge of reef flat. Consecutive perpendicular profiles were taken at a distance of approximately 10- 20 m along the north and north-western reef flat of Fuvahmulah covering the *Thundi* beach area as well. These adjacent profiles were later analysed to generate a contour map of the reef flat. The reef flat was mapped during surveys conducted for the feasibility study of the project in the year 2015. To map the steep and deep north-eastern reef edge of Fuvahmulah, a handheld echo sounder together with a GPS was used.

A vessel was driven perpendicular to the coast starting at a depth of 1.5 m. Readings were taken every 2-3 m until the echo sounder was not able to register a reading (up to 75 m). Four reef slope profiles were taken along the north-eastern reef at the locations illustrated in Figure 14.

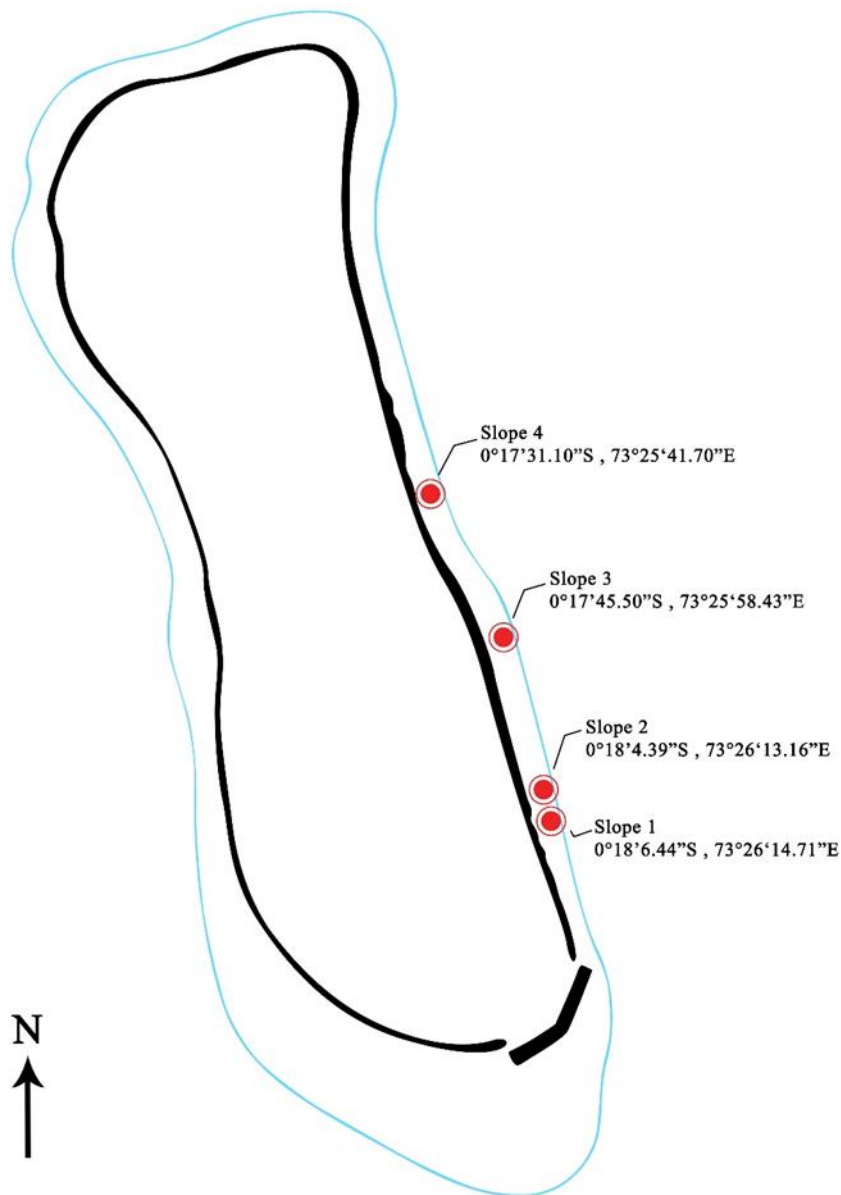


Figure 14: Reef slope study locations

4.6 CURRENTS

Ocean and lagoon current was measured by conducting drogue tests at the north-eastern coast of Fuvahmulah. Drogue tests were carried out using a GPS tracker placed inside purposely built case which was left at the sea for at least 20 minutes. The tracker recorded the speed and position data which was later analysed using software to determine surface current direction and speed at the time of data collection. around the

coastal water to understand the general current movement around the island particularly on locations where sewage outfalls have been proposed. The current data was logged for a few minutes which is a limitation of the study. To obtain more concrete data, measurements need to be taken for a longer period of time.

4.7 WAVES

Long term wave climate at the project area was determined using wave analysis done during the feasibility stage of the project using NOAA long term hindcast data. See (RHDHV, 2015) for feasibility study of the document. Ocean wave data available through NOAA was correlated with local conditions at Fuvahmulah to model the wave dynamics at Fuvahmulah. Validation of the model was done by comparing wave measurements taken during Fuvahmulah harbour construction project: approximately 7 month measurements (Oct 1994 –May 1995). A detailed (numerical) study has been undertaken to assess the local wave conditions (reported by RHDHV, 2016).

4.8 REEF SURVEYS

North-eastern side of the house reef of Fuvahmulah was surveyed as part of the existing environmental study. Reef environment was surveyed to assess and obtain baseline data of the existing reef conditions. Benthic cover composition of the reef-flat and reef slope was studied along with fish communities in each of the survey points. The findings of the surveys were used for impact evaluation and mitigation during the proposed development.

Both quantitative and qualitative methods were used to assess the benthic substrate at the survey sites. Four marine assessment stations were set up along the 2 km length of the north-eastern coast at the locations shown in Figure 15. Three 20 m transects were positioned at each station.

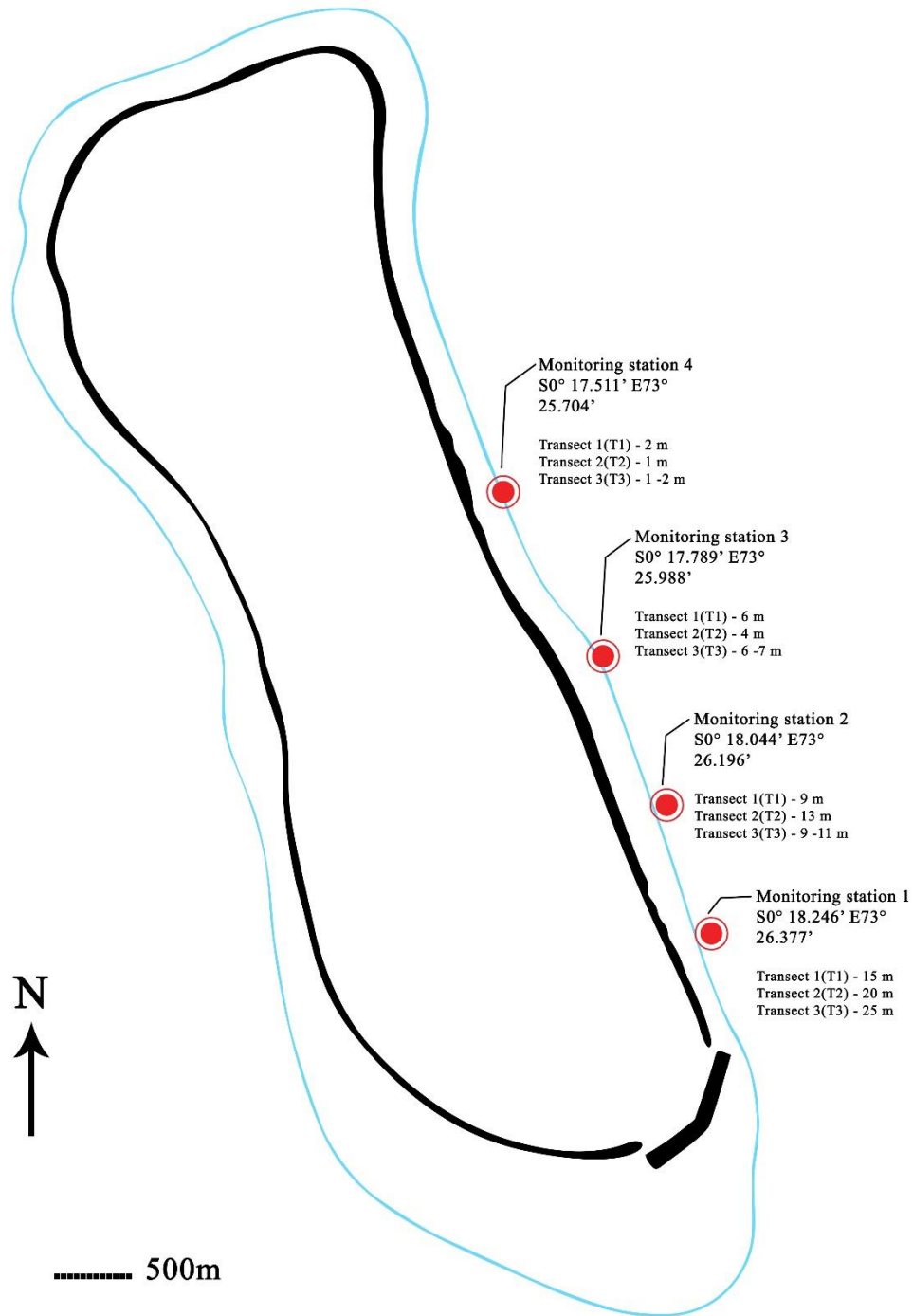


Figure 15: Illustration of marine survey locations

Line Intercept Transect (LIT) surveys were carried out to assess the benthic types and coral species at the survey sites. The assessment was done to identify coral forms which include laminar, encrusting,

free living, columnar, foliaceous, branching, massive, digitate and tabular. The LIT survey done at Fuvahmulah determined benthic cover of north-eastern coast from 25 m up to 1 m. LIT surveys have been proven to be very efficient for studies of benthic coral reef communities (Loya, 1978) English *et al.* 1997), and can be used to evaluate the community structure of corals in terms of species composition and diversity patterns in different zones on a reef. LIT method also provides a rapid estimate of percent cover of corals, algal cover, and cases of other prominent organisms as well as bare substratum. Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. LIT surveys produce valuable data even though they are time consuming and require considerable effort and skills (Segal & Castro 2001).

4.9 FISH STUDY

The fish study was done by taking timed videos at each station at a specific depth. Details of timed swim and depths are given in Table 15 below and for survey locations. The camera was held at a uniform angle during the timed swim.

Table 15: Fish count range at marine survey points

Name	Depth	Duration of Swim
Marine survey point 1	15-25 m	10 min
Marine survey point 2	9 – 13 m	10 min
Marine survey point 3	3- 7 m	10 min
Marine survey point 4	1-2 m	10 min

The photographs and videos obtained from the survey locations shown in Figure 15 were later analysed to identify the type of fish species using (Kuitert, 1988) and (Hafiz & Anderson, 1987).

Fish abundance was assigned by counting, and comparing the count to a selected range which was specific for the area. The count and range is given in Table 16

Table 16: Fish abundance measure

Fish Abundance	Count Range
Rare	0 - 10
Common	10 - 35
Abundant	35+

The method encompasses certain degree of uncertainty. These include:

- Some species may be cryptic in the presence of surveyors; hence these species would not be accounted for in the survey;
- fast moving fishes may not be captured during the timed swim hence these species would also be under estimated;

- some fish may have been captured in the video repeatedly; and
- time of swim may impact observation of certain species as some species are more active at night.

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

4.10 SOCIAL ASSESSMENT METHODOLOGY

Keeping in view of the objective of the social assessment (SA) the study was carried out with a participatory approach that aimed at putting the community at the centre and involved a collective process of reflection, discussion and consultation with all major stakeholders in the Project. As part of the preparatory work, a detailed stakeholder identification exercise was carried out and primary and secondary stakeholders were identified. The primary stakeholders, such as women and youth groups, farmers, shopkeepers, school teachers, and non-government organizations (NGOs) were consulted individually, in homogenous sub-groups and mixed groups to understand the local needs and responses to the proposed subprojects and also to ascertain the impact of the proposed Project on the communities, the area and the overall region.

The SA relied on information from a wide range of documents and interviews, site visits, analysis of statistical data from various sources. The information sources included:

1. Statistical information from the population Census 2014;
2. interviews with key informants including elected local council members, community groups and members of general public through consultative meetings and interviews;
3. field visit to the site of proposed development, Fuvahmulah;
4. detailed public Consultation in Fuvahmulah which is explained in detailed in this report; and
5. review of existing data and related project reports in Fuvahmulah and Southern Region.

5. EXISTING ENVIRONMENTAL CONDITIONS

5.1 INTRODUCTION

This section of the report addresses Task 2 of the TOR and presents the existing environmental baseline conditions at Fuvahmulah. The analysis of existing environment is fundamental for the assessment of the projects feasibility and its impacts. In this Chapter seven core existing environmental parameters were addressed through field work and review of available literature. These parameters include geological, geographical, physiochemical, hydrological, ecological, social and climatic aspects of the environment. This Chapter of the report provides the main findings of the key parameters used to define the existing environment with discussions on the results obtained.

5.2 CLIMATE

5.2.1 Temperature

Maldives experiences a tropical climate throughout the year, where two monsoons namely north east (dry season) and southwest (wet season) govern the climate conditions in the Maldives. The dry season brings less rainfall and higher maximum high temperatures and higher low temperatures. This is evident from maximum high temperature and minimum low temperatures which has been logged for the past 37 year at S. Gan International Airport which is situated approximately 53 km to the southwest of Fuvahmulah.

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

- Temperature gradually increases at the start of northeast monsoon and reaches a peak in around April. (See Figure 16);
- the mean daily maximum temperature was calculated to be 30.9 °C;
- the daily maximum temperature was slightly higher for the southwest monsoon than that of the northeast monsoon;
- The daily average minimum temperature was lower in southwest monsoon compared to the north east (See Figure 16 and Figure 17);
- With the onset of southwest monsoon mean maximum temperature gradually decreases reaching its lowest in around the end of December;
- Temperature fluctuated from the mean in accordance with the monsoons, where highest and lowest registered temperatures were observed during monsoonal transition periods;
- Yearly temperature variance for past thirty-seven years was extremely consistent with 0.4°C;
- The daily average minimum temperature was calculated to be 24.7 °C; and

- The average variance in minimum temperature was found to be 0.8 °C.

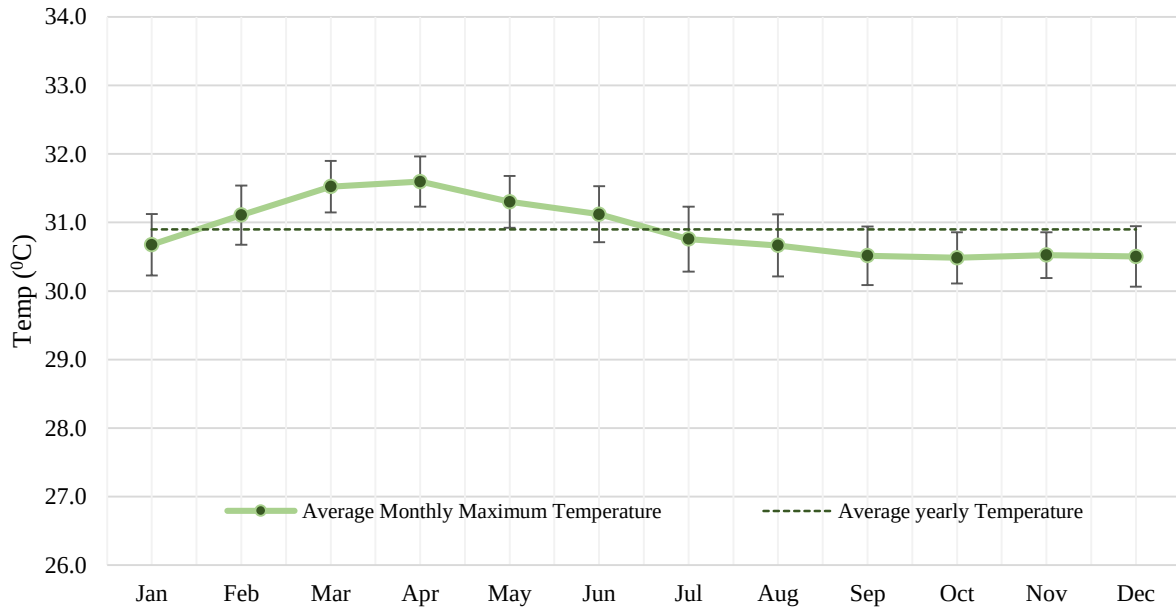


Figure 16: Mean high temperature (1978-2015) (Source: Planning.gov.mv, 2016)

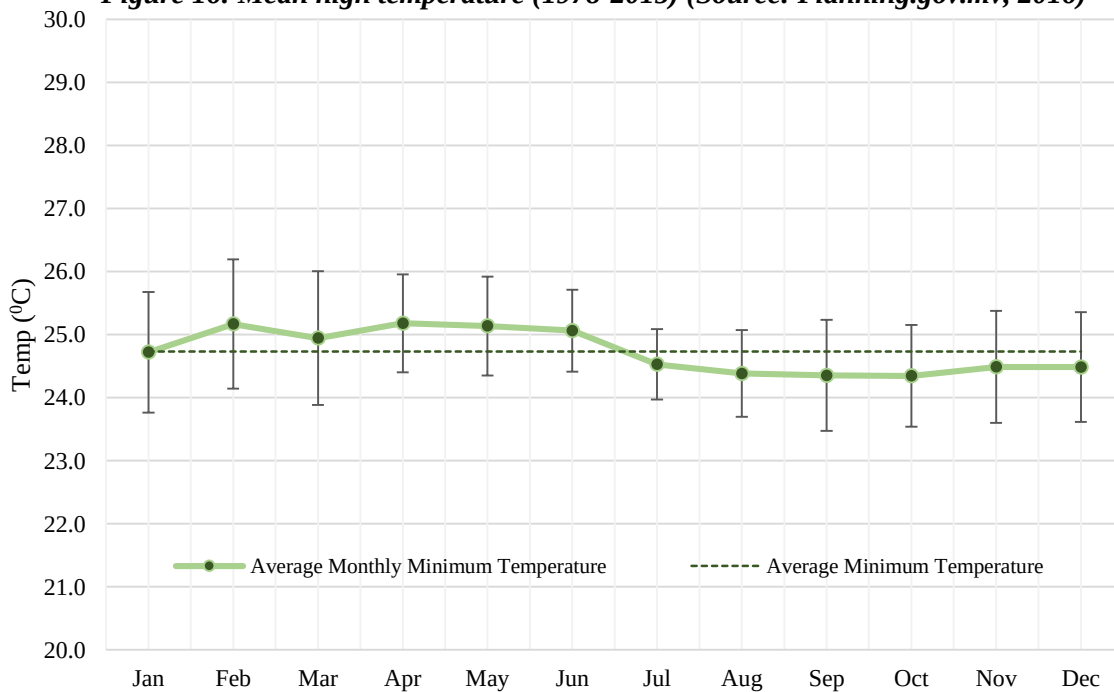


Figure 17: Mean low temperature (1978-2015) (Source: Planning.gov.mv, 2016)

Rainfall was analysed after compiling rainfall data obtained for S. Gan for the past thirty seven years from Yearly Statistics provided by Department of National Planning (DNP). The average of thirty-seven-year monthly

rainfall was calculated from the compiled data. Variance in monthly rainfall was determined through standard deviations. The monthly average for a year was then compared with the mean rainfall obtained for each month. The resulting graph given in Figure 18 showed that.

It was found through historical rainfall data analysis that:

- The total annual rainfall was 2277.5 mm;
- the mean monthly rainfall was 189 mm;
- during the months May-November (southwest monsoon) on average the total rainfall was 74% greater than during the months from December to April (northeast monsoon) ;
- the highest rainfall was observed for the months of October and December where the average rainfall was 227 mm 276 mm and 240 mm respectively;
- the highest variance in rainfall was observed for the months of January, October and September, where the variance calculated was 123 mm, 131 mm and 127 mm respectively; and
- February was found to be the month that received the least amount of rainfall (90 mm) with a least variance in rainfall.

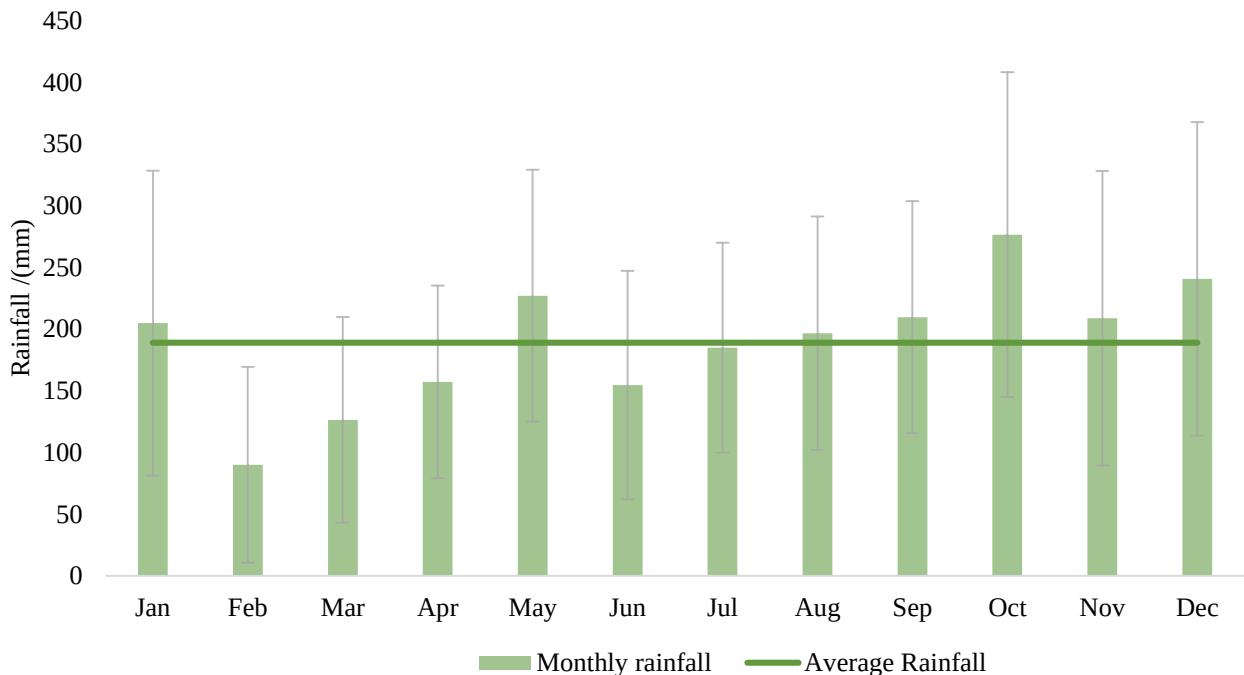


Figure 18: Annual monthly rainfall (1978-2015) compared with average yearly rainfall (1978-2015) (Source: Planning.gov.mv, 2016)

Comparison of the rainfall data obtained for Gan Island with the rainfall data collected for Fuvahmulah (2007 – 2012) showed a total annual mean rainfall of 1843 mm. The month of October receives the highest rainfall and February the lowest (HIDRIA & AQUATICA, 2013).

5.2.2 Wind

The primary wind conditions for the Maldivian islands are dominated by two monsoons. These winds approach with great constancy, primarily from the northeast and southwest directions. Strong winds and gales are infrequent although storms and line squalls can occur, usually in the period from May to October (southwest monsoon).

Wind was analysed after compiling wind data obtained from S. Gan international airport for the past three years. The data was sourced from Yearly Climate Statistics provided by DNP. The average monthly wind speed and direction was derived from the analysis of the collected.

The findings can be summarized as follows:

- Westerly winds were dominant throughout the year (W – 50% and WSW – 16%). (See Figure 19 and Figure 20);
- easterly winds were observed only during the northeast monsoon for the months December, January and February (ENE 33%);
- the yearly average wind speed was 4 ms^{-1} (9 miles hr^{-1});
- lowest wind speeds were recorded during March (7 miles hr^{-1}), April (6.7 miles hr^{-1}) and November (6.7 miles hr^{-1}); and
- The highest and most variable wind speeds were recorded in the month of February, where average wind speeds reached 5 ms^{-1} (12 miles hr^{-1}) with a variance of 3 ms^{-1} (6 miles hr^{-1})

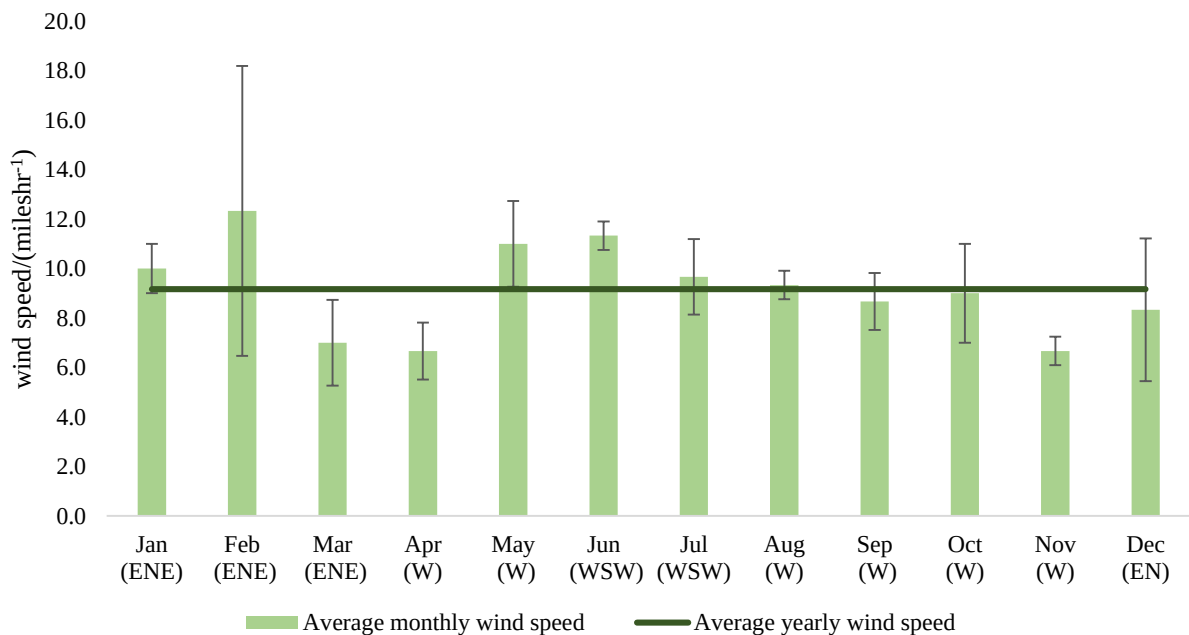


Figure 19: Annual monthly wind speed compared with average yearly wind speed for period 2012-2014

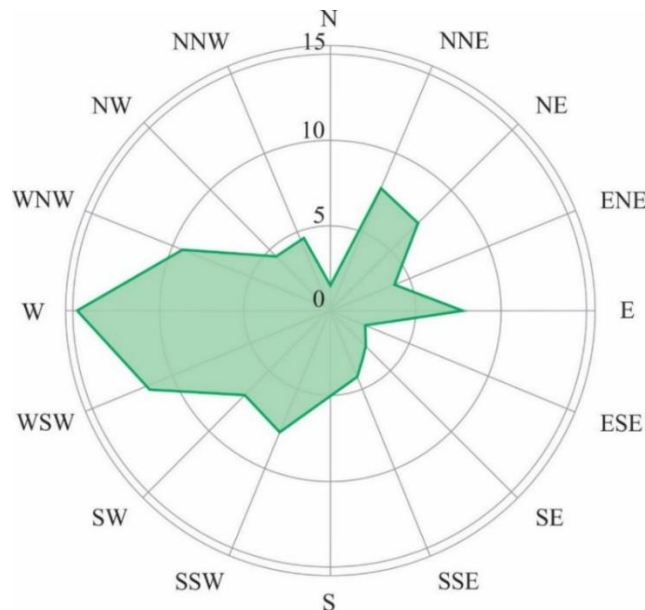


Figure 20: Mean annual wind direction at S. Gan (Source: Windfinder, 2015)

Summary of Weather Analysis

- Northeast monsoon brought winds from the northeast direction for the months of December-March. The wind was dominant from the West for most of the year (April – November). The Project area is expected to be calmer during the southwest monsoon as wind induced waves are expected on the west coast of the island;
- rainfall analysis suggested that, rainfall was extremely variable but was largely concentrated to the southwest monsoon;
- rainfall was lowest during the northeast monsoon, between January – April;
- mean high temperature was mainly found to be consistent throughout the year however, peaks are observed during the latter stages of each monsoon, where end of southwest monsoon recorded the lowest temperatures and vice versa;
- the period between March-April was determined to be the calmest and most stable with the least amount of rain and wind.; and
- during the north-eastern monsoon (December-February) wind direction is mainly from north-west to north-east. During a transition period (March-April) the wind turns to western direction. From the start of the south-western-monsoon the predominant wind direction turns from west towards south-west and south-east. In the second transition period the predominant wind direction is west again.

5.3 PHYSICAL ENVIRONMENT

5.3.1 Island Topography

Three cross sections of Fuvahmulah were taken covering approximately the top, middle and bottom halves of the island. All three profiles show that the elevated ridges sloping down towards the mid-

section of the island. The width of the upper and lower portion of the island were broader compared to the mid-section of the island.

Cross section taken on the upper half of the island showed western side ridge reaching 3m above MSL, while the ridge on the east reaching 2.2m above MSL. Hence, western ridge was here 0.8m higher compared to the eastern ridge. The average elevation of this portion was 1.2m above the MSL.

Cross section taken on the mid half of the island showed western side ridge reaching 3.2m above MSL while the ridge on east reaching 2.2m above MSL. Hence, western ridge was here 1m higher compared to the eastern ridge. The average elevation of this portion was 1.3m above the MSL.

Cross section taken on the bottom half of the island showed western side ridge reaching 2.9m above MSL while the ridge on the east reaching 2.2 above MSL. Hence, western ridge was here 0.7 m higher compared to the eastern ridge. The average elevation of this portion was 1.3m above the MSL.

Hence flat portion of the island was approximately 1.26m above the MSL. The western ridge was raised by 1.77m above MSL while the eastern ridge was elevated by 0.94m above MSL.

The island is elongated or elliptical-shaped with raised ridges at the coastal margin sloping down towards middle where depressions with high water table, swampy areas and two freshwater lakes are formed. Hence the cross-section of the island form a saucer – like shape See Figure 21 for the three cross section profiles in separate drawings and a combined drawing of the three profiles..

The present topographic survey did not cover the water bodies since information on the topographic features of the water bodies and surrounding areas were available from a recent topographic carried out under the Environmental Social Due Diligence for Wetland Conservation Project under the Climate Change Trust Fund (CCTF) (MHI, 2011). Accordingly, near the centre of the water lake in the south the height was measured to be reaching -3m from the MSL. Hence the ground level at Fuvahmulah could be stated to be varying from 4m at the north-eastern coastal ridge to -3m from MSL towards the centre of the freshwater lens on the south. On the one hand the unusually higher ridge on the coastal margin offers protection to the island, once the ridge is breached due to erosion, waves could easily overtop the coastline and flood the central regions of the island. Due to the inward sloping of the island's landform it would also make drainage into the sea a challenge.

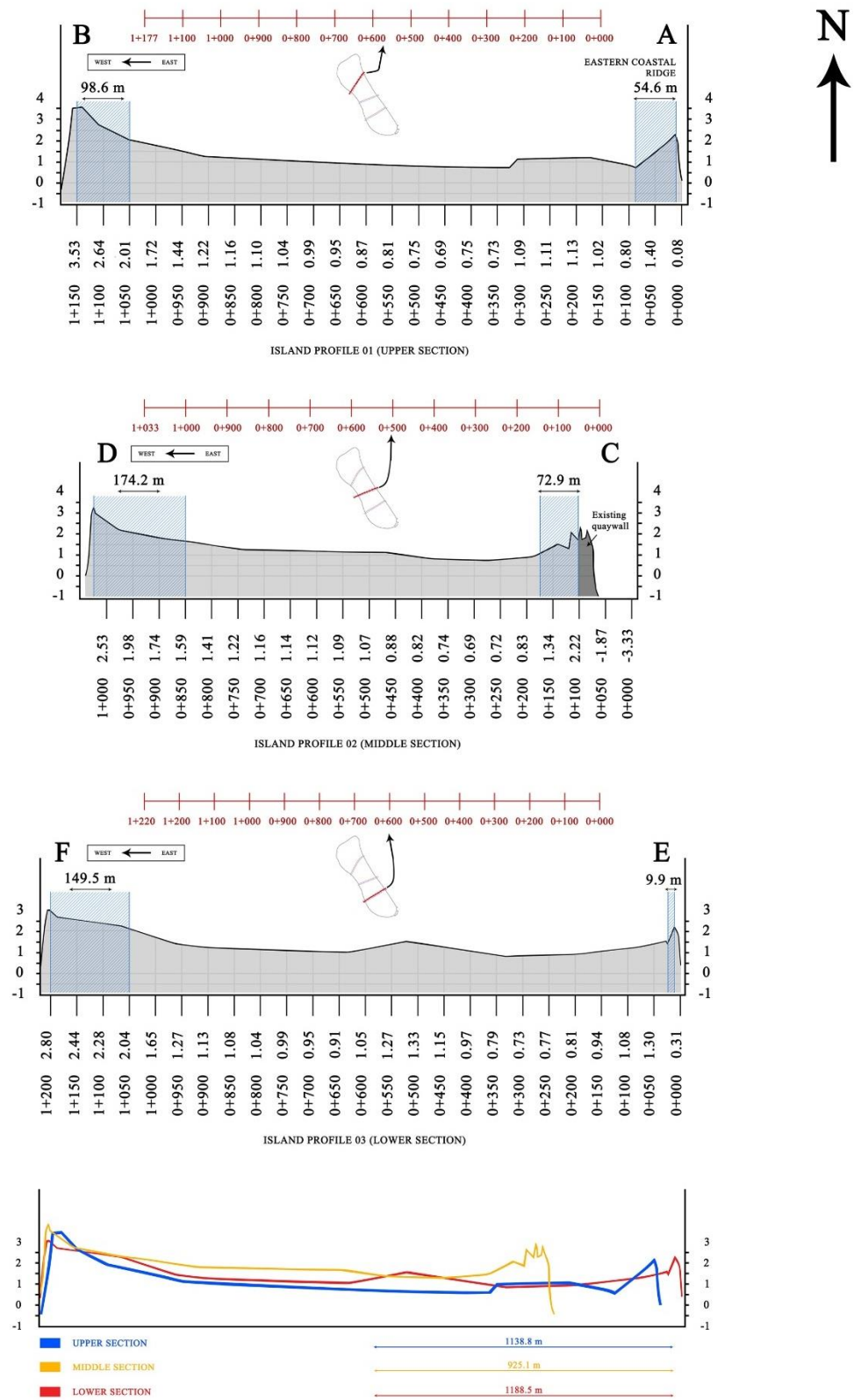


Figure 21: Cross-sectional profiles of Fuvahmulah

5.3.2 Landform and Soil

Fuvahmulah being a relatively large island in the context of the Maldives, the inland soil is believed to be more mature compared to most other islands. In general soil fertility is higher in the middle of the island and poorer towards the coastal margin. The soils found in the swampy areas are found to contain higher levels of organic matter and is found have higher water retaining capacity. The low-lying land of Fuvahmulah was considered to be very good possessing rich black peaty soil (FAO, 1974).

Similar to other coral islands in the Maldives the basis of soil was calcareous material derived from coral rock. In the soil formation process, coral debris gets intermixed with various amounts of plant litter forming a top soil layer which is generally darker in colour. This thin topsoil layer is underlain by a layer of sand before reaching the water lens. Due to the poor silt and clay fractions in the Maldivian soils the holding capacities have been found to be very low. One of the most important physical features to consider is the hydraulic conductivity of the soil which indicates soil's ability to prevent water transport. The lower the figure, the better, since it represents a large resistance to water transport, i.e. transport of possible pollutants into the water table which is generally found a meter below the surface. Hydraulic conductivity tests carried out for soils collected from near coastal areas elsewhere in the Maldives demonstrated low resistance to water transport. The high infiltration capacity of the soils would mean susceptibility of the groundwater lens to ground surface pollution. Hydraulic conductivity for a soil samples taken from 40m from shoreline at 1m depth from the surface of an island was measured to have hydraulic conductivity of $6.8 \times 10^{-6} \text{ ms}^{-1}$ (SWECO, 2009).

The Project boundary does not fall within the areas considered to be of possessing good soil, whereas in the project area the soil comprised of very coarse sand to large pebbled. Soil featured within the project boundary is not considered to be mature but was poorly developed. The loose sandy nature of the soil means high drainage capacity and poor ability to resist contaminants from reaching the groundwater layer

5.3.3 Beaches and Shoreline Changes

Coastal beach composition varied around the island significantly including patches of sandy beaches, white pebble beach (*Thundi*), stony beaches, and areas of beach rock. Beach rock was mainly observed on the southern side of the island. North-eastern beach is thinly spread and in most areas it had disappeared due to erosion believed to be a seasonal shift towards north-eastern side. The island is believed to have the highest coastal ridge among all islands in the country. Regions of severe erosion showed consolidated rocks are overlain by a thin layer of sandy soil. Consolidated bedrock that were exposed due to severe erosion showed disintegration and fracture due to heavy wave action. Weathered and exposed consolidated rocks are extremely vulnerable to wave attack and susceptible to breakaway. As chunks of consolidated rock detaches from the island, it takes with it island's topsoil and uproots trees standing above it (See Figure 26).

Fuvahmulah has a total coastline length of 11km around the island. Much of this long coastline has been experiencing erosion at various levels. Except in a few spots where beach is found. Most notable beach was found on the north – *Thundi*.

During the field survey which was carried out during the southwest monsoon period *Thundi* was found to have shifted from north to north-north-east. Northern coastline had no beach and high tide line was found to be reaching the coastal vegetation in this season. However, it should be noted that the erosion on the northern tip of the Island is a seasonal phenomenon and is not a permanent process. Section 5.3.6 describes *Thundi* Beach in more detail.

Average distance between vegetation line to low tide level was just about 0.5m on the northeast coast. On the north-eastern side approximately 2.6 km of the shoreline was found to be undergoing severe erosion while on the north-western side approximately 1 km of the shoreline was experiencing erosion. Erosion on the western side was observed covering a length of 3.7km, but is less severe than on the north-eastern side. Pebble beach on the south-western side reached a length of nearly a kilometre. This black pebble beach and coarse sandy beach on opposite sides of the island are unique features of Fuvahmulah (see Figure 22).



Comparison of aerial photo of Fuvahmulah taken in 1969 with vegetation and shoreline survey conducted in July 2016 showed, north-eastern coastline undergoing severe erosion and net loss of land from the island. It was observed approximately 15 ha of vegetated land had been lost on the north-eastern side.

Severe erosion and associated permanent loss of land on the north-eastern side has put a number of important buildings at risk. Due to continuous erosion important buildings such as three mosques, cemetery, playground, a house and restaurants are now found to be just within a few metres from the eroding coastline (see Figure 24).

Even though erosion as a serious problem has been reported in numerous reports, very little quantitative information is available on the extent of shoreline erosion that had taken place on Fuvahmulah. According to one assessment approximately 1,900 m (about 51% length of the eastern shoreline and 18% of the entire shoreline of the island) had been eroded from the beach within a time span of six years (2000-2006) and an area of approximately 16,720 m² had been eroded in eastern side of the island (about 10 % of the total beach area surrounding the island). This corresponds to loss of approximately 11,200 m³ of beach materials from the eastern side beach (MEEW, 2006). MEEW (2006) estimated rate of beach erosion on eastern side of the island to be 1.5m per year.

An extreme storm can cause erosion which reduces the integrity of the ridge significantly. When trees are undermined by erosion, roots become exposed to the waves and trees fall. Each tree that gets uprooted detaches approximately 1-2 m² of soil from the island. This in turn weakens the soil and makes other trees susceptible to fall down and makes the underlying rock structure weaker ultimately moving the island's ridge landwards.

Wave attacks and falling down of mature trees has impacted the integrity of the natural coastal defence structure making it structurally weaker and more vulnerable to fracture due to wave impact. On various locations along the north-eastern coastline, sand beneath the coral rock was found to be eroded, and as a result large sections of coral rock were exposed and broken and fragmented.

The cause of the erosion is most probably a combination of human and natural changes in the coastal zone of Fuvahmulah. Some of these causes are summarised below:

- The most significant coastal modification is construction of the harbour, and its associated reef blasting and harbour protection structures in south of the island. These interventions have disturbed the natural longshore sediment transport regime further depriving the eastern coast of sediments;
- Sand and aggregate mining for construction activities, house decoration etc, may have caused increased erosion;
- Access channels were made by blasting the reef flat as in the case of *Rasgefannu* entrance channel which resulted noticeable erosion of the coastline opposite the channel; and
- Natural changes such as increased incidences of storms, sea-level rise may have aggravated erosion.

A combination of the above mentioned human interventions or changes in natural processes have caused disturbance of the natural balance of the sediment supply along the coastline.



Figure 23: North-eastern shoreline erosion of Fuvahmulah from 1969 to 2016



5.3.4 Coastal Ridge and Beach Profiles

Coastal ridge appear to be the main natural defence layer surrounding the island. The width of the ridge of the island was determined using the island cross sectional profiles shown in Figure 21. For the determination of the existing ridge, 1.2 m was considered at the inland mean elevation from MSL. Using this value as the mean elevation the width of the existing western ridge was approximated to be 98.6 m for the western side while on the eastern side, the ridge width was calculated to be 54.6m

In addition to cross-sectional profiles, a total of 21 beach profiles were taken around the island to study coastal ridge characteristics and geomorphological characteristics. Figure 13 shows the locations of the beach profiles. For description purpose, these have been sub-divided as follows: Profiles 1 – 7 (E coast) Profiles 8 – 10 (N coast), Profiles 11 – 18 (W coast) and 19 – 21 (S coast). Details of the profiles are illustrated in detail in Figure 27

Profiles 1 – 7 (Eastern side) show lowest measured elevation was 0.96m, while the highest being 2.01m and the average ridge height on the eastern side was measured to be 1.68m.

Profiles 8 – 10 (North side) showed lowest ridge 2.66m, highest 2.8m and average elevation of the ridge being 2.8m.

Profiles 11 – 18 (West side) showed lowest ridge height of 2.16 m, while the highest was measured to be 3.91m and the calculated average ridge height being 2.85m.

Profiles 19 – 21 (South side) showed lowest ridge height of 2m, and highest of 3.1m while the average ridge height was calculated to be 2.6m.

The comparison of ridge heights based on beach profiles around the island is shown in Figure 25. As the figure depicts on the northern, western and on southern sides the average ridge height was fairly consistent while on the north-eastern side the average ridge height was significantly lower than the rest of the areas. This may be an indication that the highest part of the ridge has been eroded away at this side of the Island. However, that cannot be confirmed based on these data.

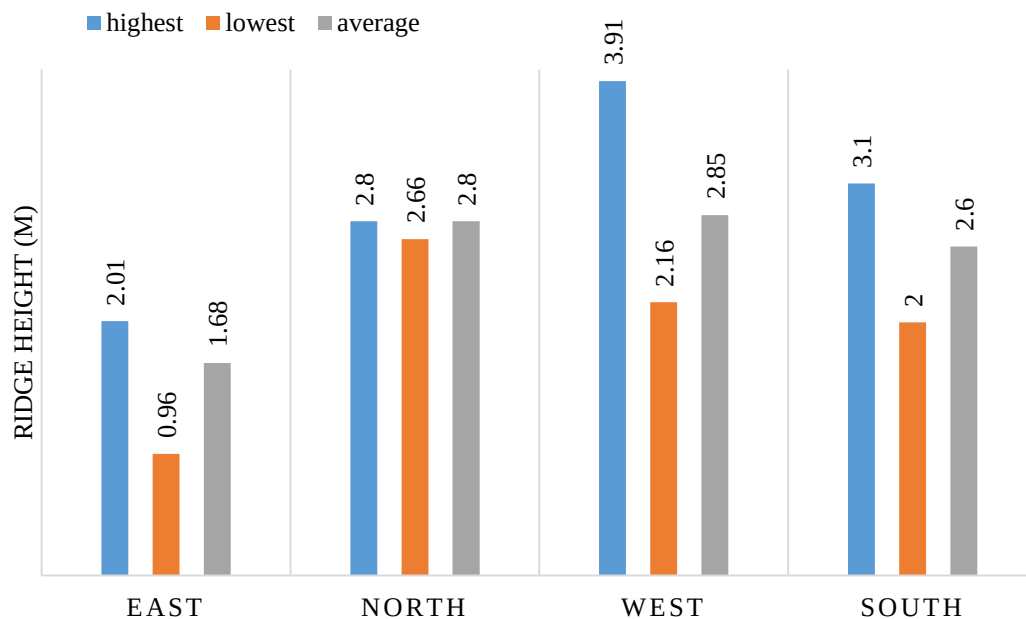


Figure 25: Ridge heights around the coastline of Fuvahmulah

Scouring had taken place from the base of rock foundation and as a result of trees uprooting and wave impacts the ridge foundation had been cracked further at the north-eastern coast as shown in Figure 26. Based on field assessments and analysis of beach and coastal profiles, it was found that the ridge at the north-eastern coast was being eroded (Figure 13 and Figure 27).

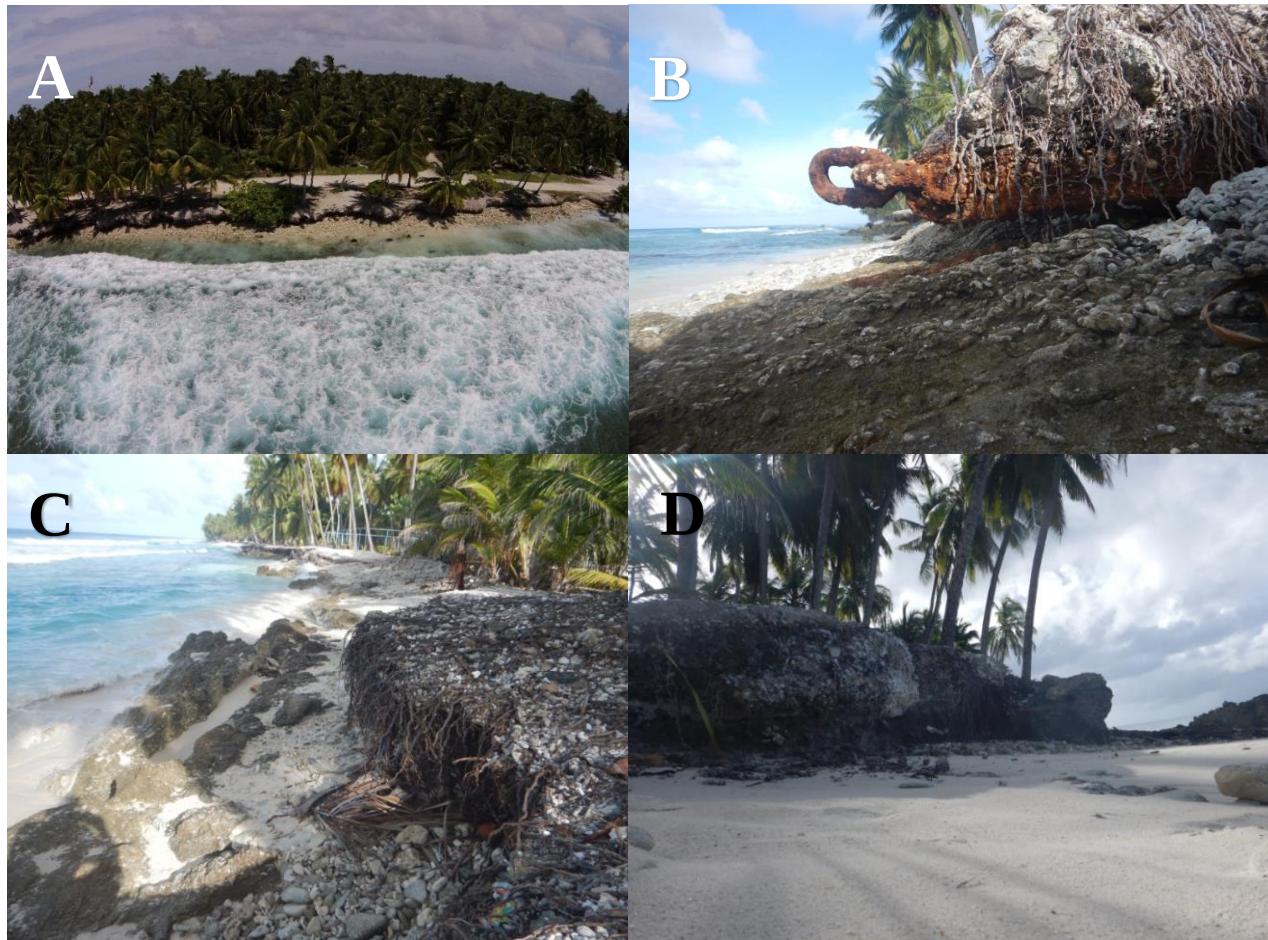


Figure 26: Erosion of the coastal ridge on the north-eastern coast

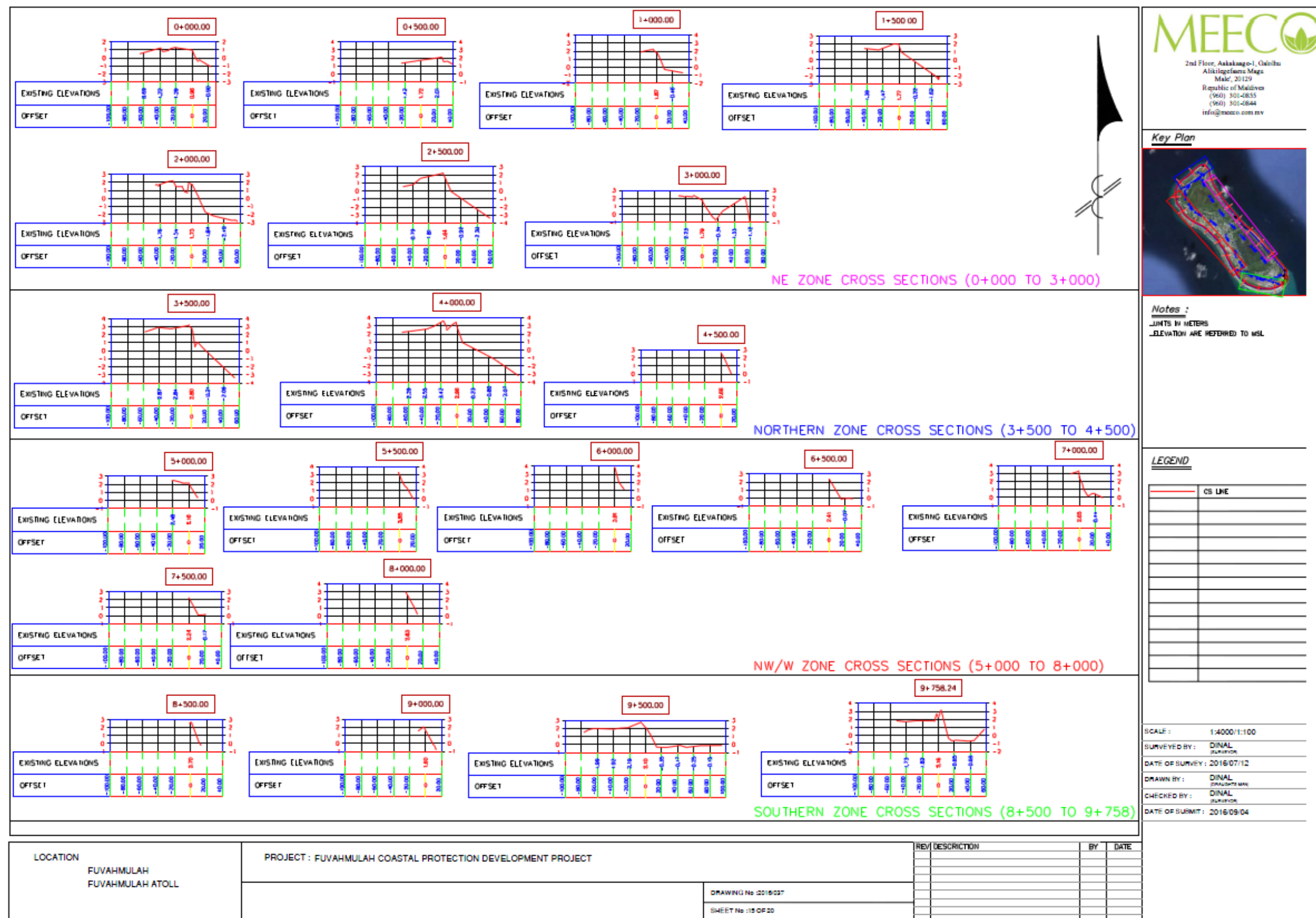


Figure 27: Detailed beach profiles around Fuvahmulah

5.3.5 Digital Terrain Model of Island

The DTM of the island showed that the island was enclosed with a ridge approximately 2- 4 m from MSL. The ridge acted as a protective layer. The ridge was observed to be broader at the southern western side compared to the north-eastern side. The mid-section of the island was observed to be less elevated where the average elevation was between 0.5 – 1 m (Figure 28).

The DTM has quite a detailed accuracy and has been used in further analysis of the current situation and predictions for the future.

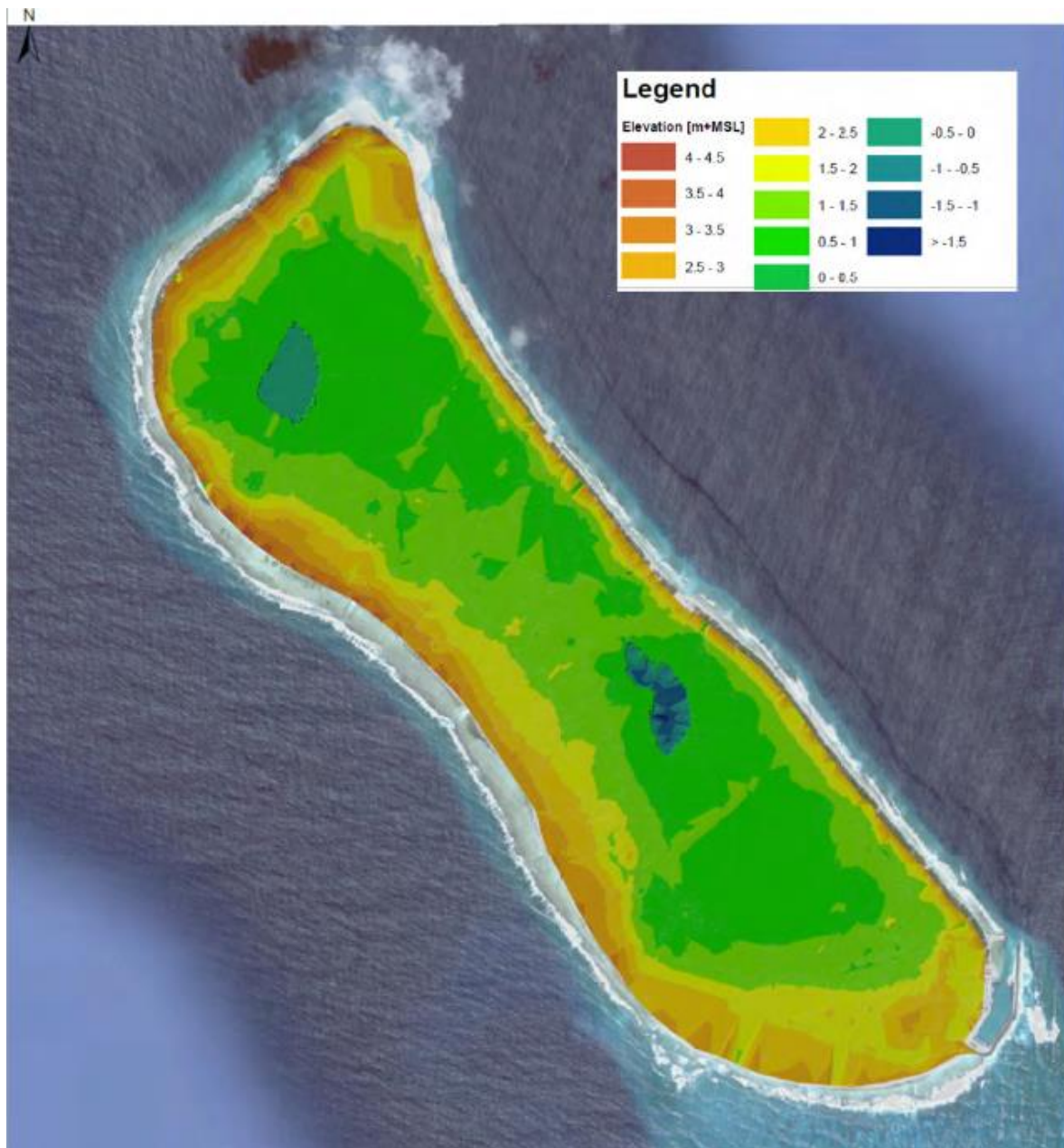


Figure 28: DTM of Fuvahmulah. Source: (RHDHV, 2015)

5.3.6 Thundi Beach Dynamics

Much of the long coastline around Fuvahmulah is devoid of beach. The most dynamic and the most prominent beach – *Thundi* lies on the northern coast of the island. Luthfi (1995) described the dynamic nature of this sand spit and related the movement of the spit to the monsoon reversal. He stated that during the westerly monsoon the spit on the north was reported to extend between 100-150 feet from the vegetation line seawards and during the northeast monsoon, the spit was observed to disappear completely from the northern tip of the island. During the present survey conducted in July 2016, severe erosion was observed on the north-western side of the island while accretion of sand occurred on the northern side of the island. Since the survey was carried out during the westerly monsoon, the observations were found to be consistent with earlier findings.

Although long-term field data on the coastal dynamics for *Thundi* area is not available, based on present and past observations and dialogue with the locals it has become fairly clear that the movement of *Thundi* is restricted to the region between north and northwest of the island. Coastal accretion and erosion is a complex process that may be governed by a number of factors including incident waves and its interaction with the reef platform and associated longshore current regimes. In the case of oceanic coral reef islands such as Fuvahmulah, it is now believed that the shape of the reef platform play even a greater role in monsoonal shoreline changes than wave action (Kench & Brander, 2006). According to the findings of Kench & Brander (2006) shoreline changes in the case of elongate islands' is limited to a narrow region as opposed to circular ones which are more susceptible sediment movement in response to climatic forces. Applying these findings to the case of Fuvahmulah, it can be inferred that the even though monsoonal winds and wind generated waves drive the movement of *Thundi* beach, the beach movement however is limited by the elongate shape of the island. Hence it is assumed that longshore currents along the long stretch of the coastline have limited influence on the behaviour of *Thundi*. Figure 29 shows probable *Thundi* movement over the course of the year based on information collected from satellite images, field observations and literature review.

Thundi beach also showed significant changes in the study of the aerial photographs from 1969 to 2016. Estimates are that *Thundi* beach had diminished by 4 ha in the comparison (see Figure 23). Approximately 64% of sand had been lost from *Thundi* beach based on estimates calculated after comparing survey data obtained during the field trip with historical satellite images taken during 1969, 2004, 2014 and 2016. It was observed that in the past *Thundi* beach greatly extended towards the west. The average area of the *Thundi* beach up until 2004 was approximately 6.4 ha. Since then *Thundi* beach did not extend to the west as much as it used to. The existing sand budget at *Thundi* beach was approximately 2.2 ha. Based on the surveys carried out under the current study it is calculated that the north-eastern shoreline erosion occurred at an average rate of 0.5 to 0.8 m/yr on average over the period 1969 to 2016 (Figure 23).

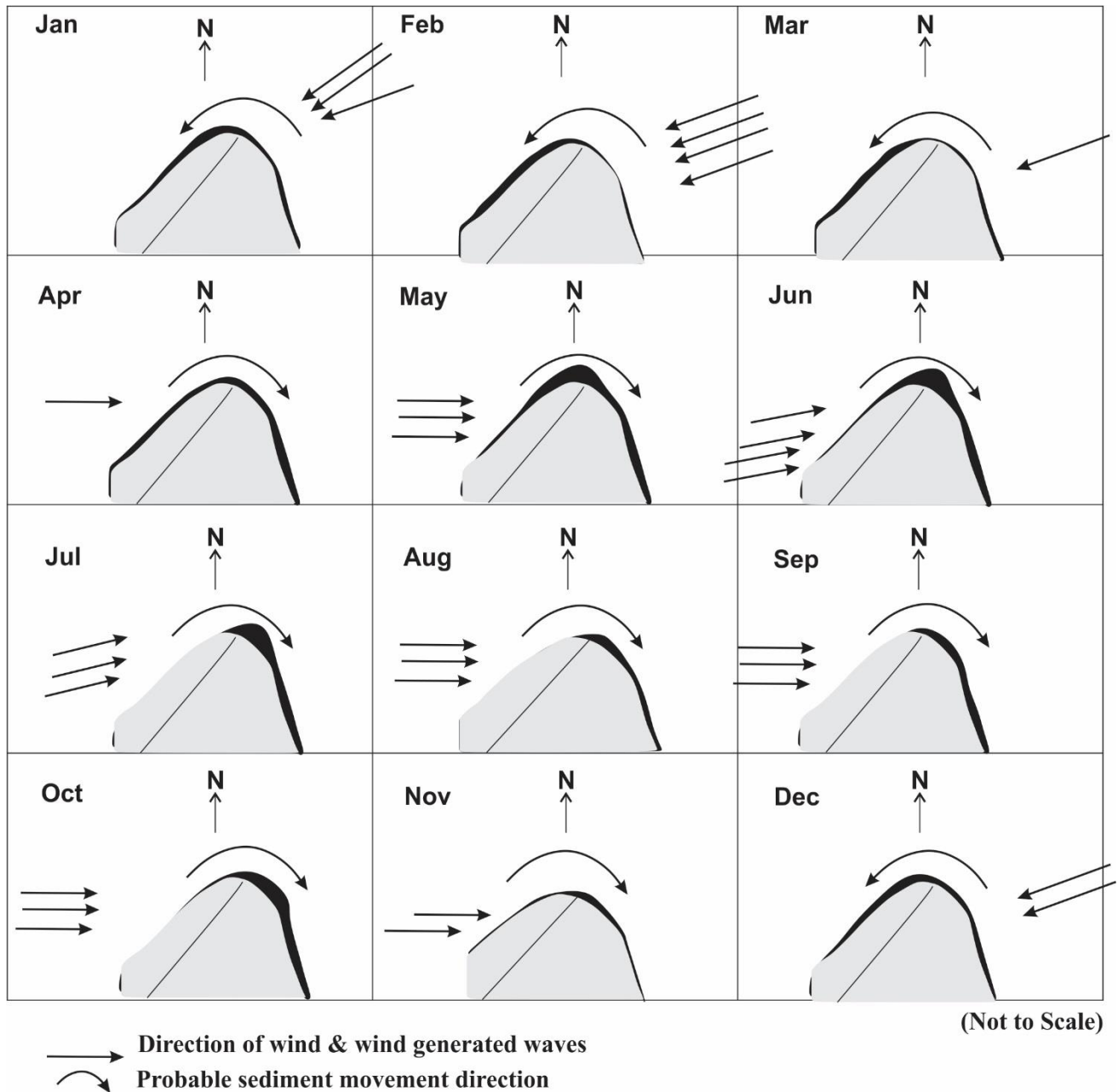


Figure 29: Probable sediment movement around Thundi region

5.3.7 Harbour

The most noticeable modification brought to the coast of the island was construction of the island harbour in 2003, at the eastern side of the island. The harbour basin was approximately 5,300 m². The harbour was protected using armoured rock boulders and tetrapod. Figure 30 shows details of the harbour. A restaurant, boat yard and fishermen's market was built at the harbour which were used very frequently. The harbour was observed to be very hectic, with incoming fishing vessels operating at the harbour throughout the day. See Figure 31 for selected photos of the harbour.

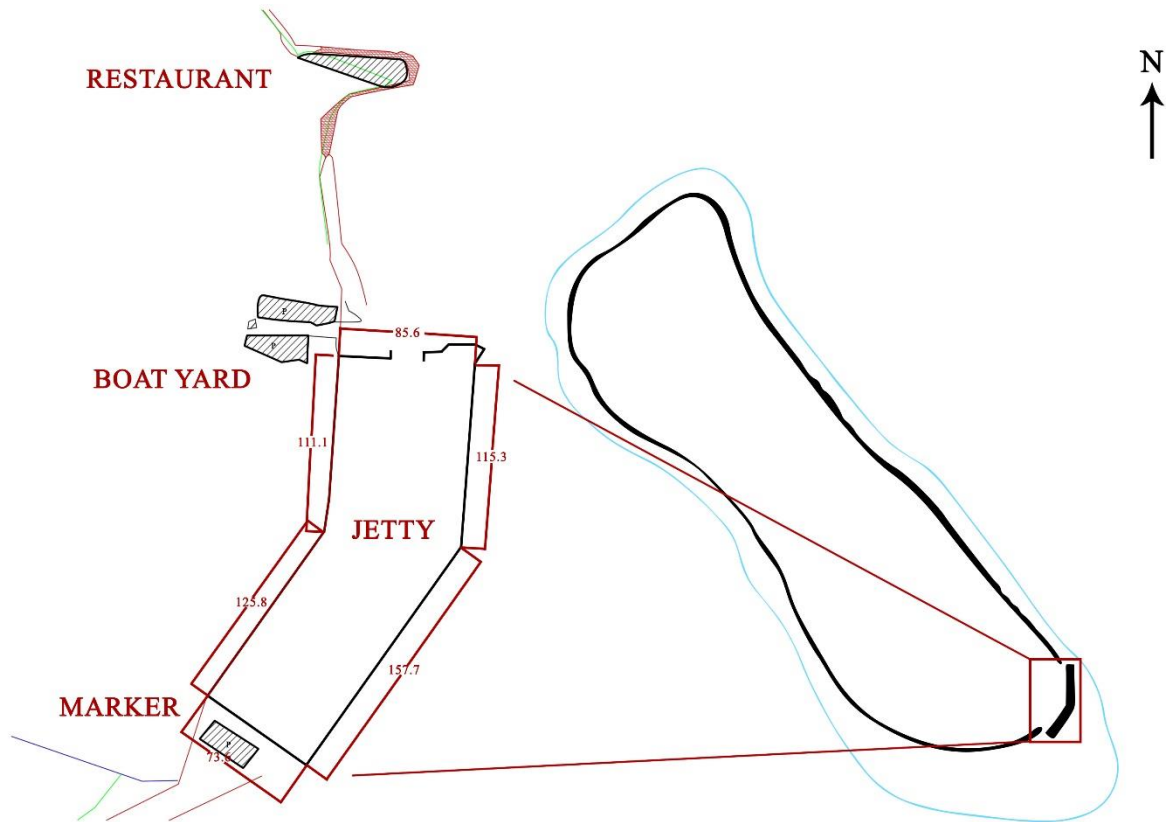


Figure 30: Existing harbour at Fuvahmulah

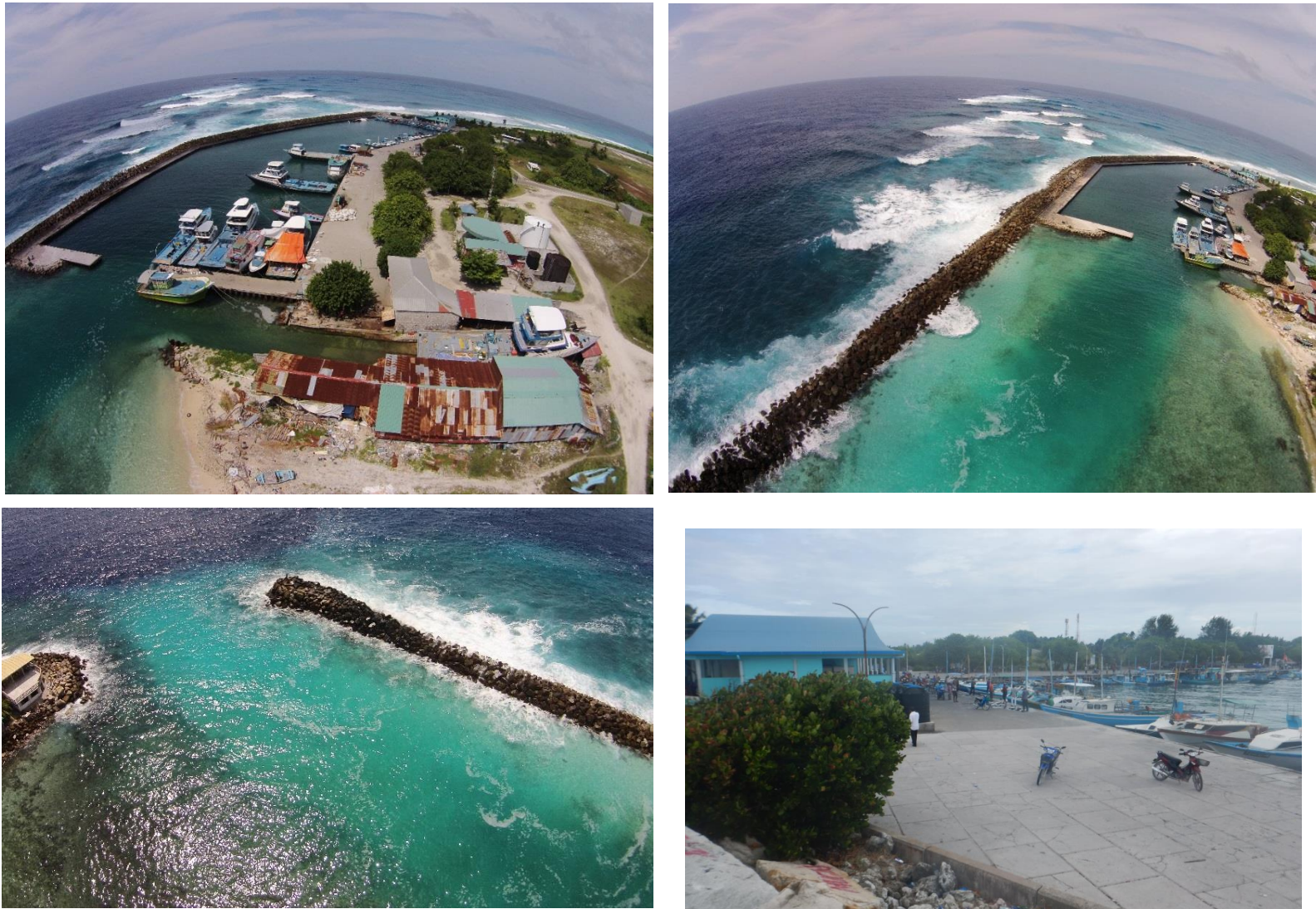


Figure 31: Fuvahmulah harbour and surrounding areas

5.4 HYDRODYNAMICS

5.4.1 Near-shore Currents

Wave breaking at an angle to the shoreline dissipates some of its energy along the shoreline, resulting in longshore currents. These currents move parallel to the shore carrying sedimentation, forming and eroding the beach in the process. Wave energy also gives rise to rip current that move away from the coast carrying sediments with it. Properties of the near-shore currents are shown in figures below. Measurement on the north-eastern coastline of Fuvahmulah to observe the near-shore current properties during the time of the study. Table 17 shows the current velocity and its direction. Average speed and current direction are illustrated in Figure 32. Current propagation direction is shown in Figure 33 .

Table 17: Current data table

Current Measurement	Average Velocity /(m/s)	Standard Deviation /(m/s)	Average Direction
1	0.30	0.16	SE

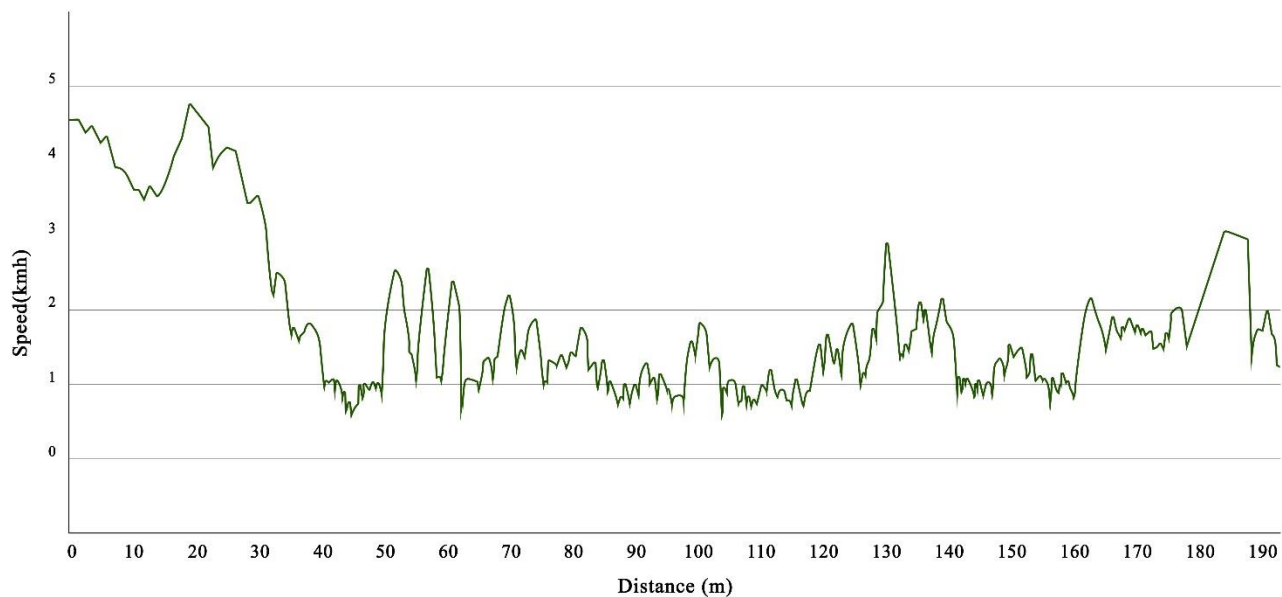


Figure 32: Velocity distance graphs of the tracker

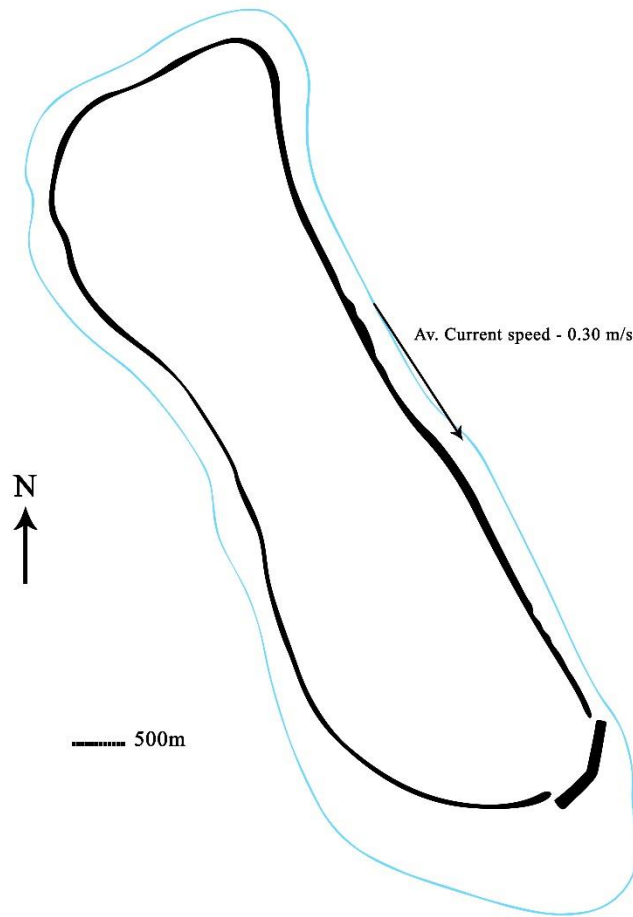


Figure 33: Measured current speed and direction on 14/7/2016

From current measurement it was observed that:

- the currents at the time of the study mainly propagated towards the south – south-eastern direction;
- The average current velocity was moderate with a velocity of 0.30 ms^{-1} ; and
- The currents were believed to be influenced by the direction of the wind (WSW) and resulting wave approach.

In order to determine whether the current velocity would influence sediment transportation current speed calculated was with the Hjulström curve to predict fate of sediment particles based on particle diameter and critical shear stress (See Figure 34).

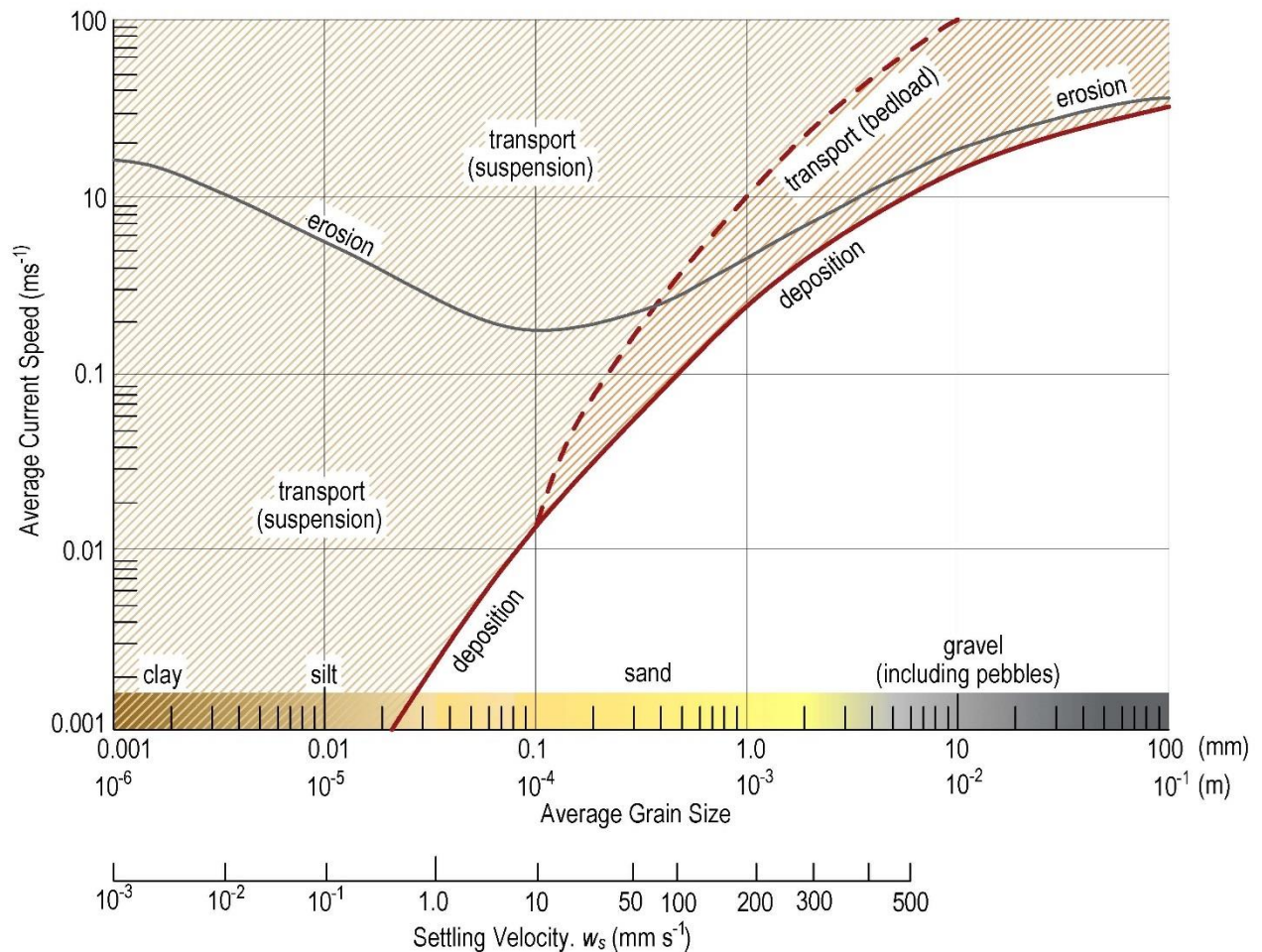


Figure 34: Hjulstrom curve (Source: Goud and Aubry, 1985)

The average current speed observed for the project boundary was 0.30 ms^{-1} . A range of sand types were observed for the area. The project areas consisted of sand ranging from fine to fine gravel (average particle diameter between 0.5-4 mm).

The critical current speed required for particles of coarse sand up to 1 mm would overcome its shear stress above 0.1 ms^{-1} . Extrapolation of both current speed and average grain size suggested that sediments greater than 1 mm were likely to deposit onto the sea bed. Based on surface currents measured, it is concluded that particles up to 1 mm will be readily transported with the measured velocity.

However, the prediction method should be regarded as a simplified model because the methods applied encompass uncertainty as:

- Calculations were based on laminar flow only;
- the mechanism of longshore drift movement of sediments at the swash zone are not addressed in this approach;
- particles were assumed to be complete spheres;
- the effect of a single component of velocity acting upon the particle was utilised, and

- settling velocities and vertical velocities of sediments in still water was used in drawing the graph.

The validity of these models should be concluded based on more intensive data logging and field monitoring, to better manage and understand the relationship, the project is going to have on the sediment transportation and movement. Moreover, currents observed during field surveys were limited to a specific time and monsoon. It is important to measure current data over a longer period of time to better understand the current pattern at the Project area.

5.4.2 Waves

The wave climate at project area has been analysed using long-term hindcast wave data obtained from NOAA for various locations in the vicinity of the project. NOAA hindcast wave and wind data set generated with the WAVEWATCH III model, see Tolman (1997, 1999, 2009). This third generation wave model is developed by the National Oceanic and Atmospheric Administration and the National Centers for Environmental Prediction (NOAA/NCEP). For the entire model domain on a 0.5° by 0.5° mesh, the significant wave height H_s , peak wave period T_p , peak wave direction θ_w , 1-minute average wind speed at a height of 10 m U_{10} and associated direction θ_p is the output made available online. These parameters are available from 1979 onwards as 3-hourly time series. For the purpose of this study, wave data is checked on consistency for six the locations presented in Figure 35. The data from the different locations show similar results, for this study data point LAT- 0.5/LON 73.5 has been used for further analysis. This data point is located 25 km southeast of Fuvahmulah (Figure 35).

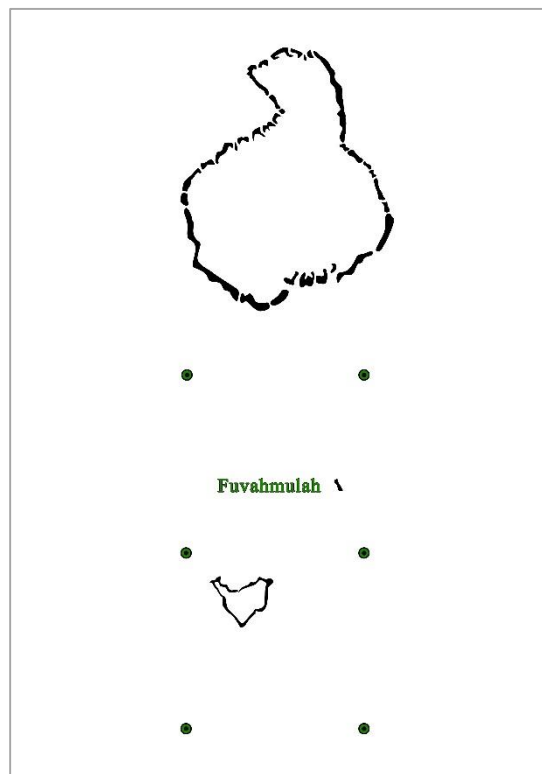


Figure 35: Location (in green) of NOAA output points used for the study

The result shows uniform wave behaviour, with waves mainly coming from south-south-western (SSW) and south-eastern (SE) direction. Waves from SSW have a typical peak period of 10-20 seconds, meaning these are swell waves, generated far out on the ocean. Waves from SE direction consist of a swell component with peak wave periods of 10-15 seconds and a locally wind-driven wave component with shorter wave period of 5-10 seconds.

Those shorter waves are generated by more local storms and can be related to the south-eastern winds as described above. See Figure 36 for annual wave rose for the significant wave height and the peak wave period (T_p)

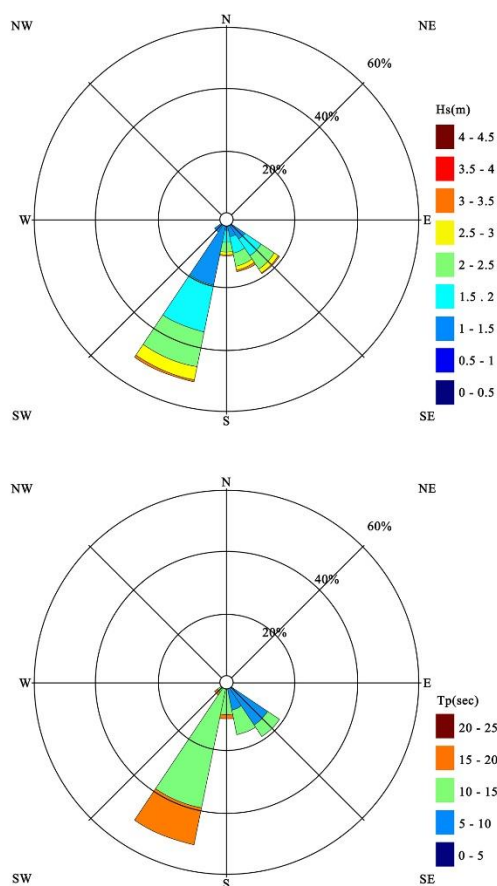


Figure 36: Yearly offshore significant wave height (H_s) and peak wave period (T_p) based on NOAA hindcast data

The wave climate can be assessed in more detail by assessing the wave height and wave periods per month. For this purpose, the monthly wind and wave climate have been included in Figure 37. During the NE-monsoon – from December to February – long swell waves are coming from south-western direction. Typical wave heights are in the range of 1-2 meters and wave periods ranging from 12-24 seconds. Shorter waves with periods ranging 5-8 seconds are coming from the southeast. In the SW-monsoon – from May to September – wave directions are similar to the NE-monsoon, however the distribution and characteristics of the waves differ. Typically, the waves from both south-western and south-eastern

direction are higher in the SW-monsoon compared to the NE-monsoon, ranging 2-4 meters. From June till August the wind direction is predominantly from the south-eastern direction, resulting in more locally generated wind-waves from the southeast in this period (Figure 37).

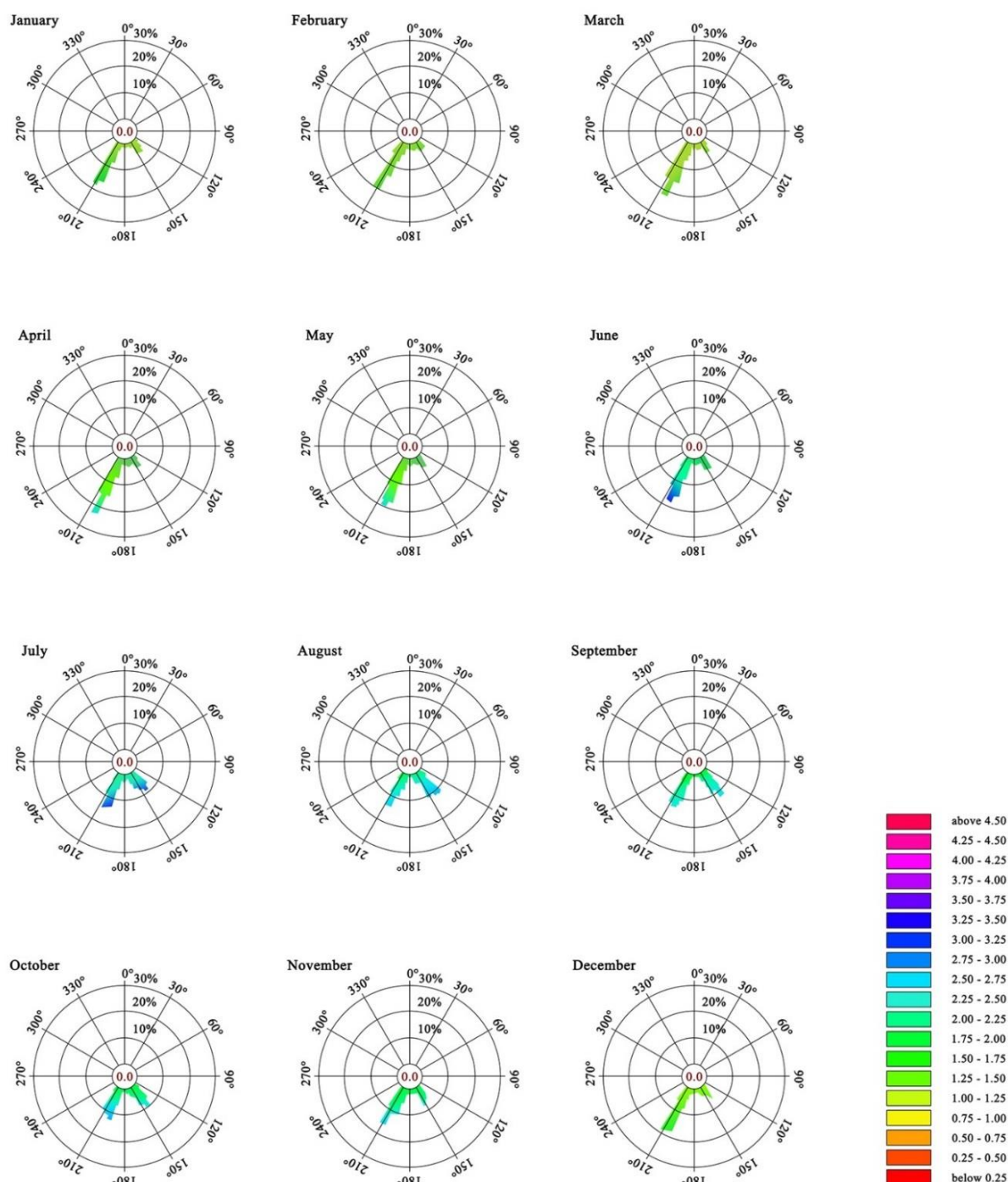


Figure 37: Monthly wave roses at southern Maldives

5.4.3 Summary of Wave Conditions

Wave climate of southern region of the Maldives is summarised in Table 18.

Table 18: Wave height and wave periods based on monsoons (Source: RHDHV, 2016)

Season	Month	Wind	Short Waves	Swell Waves
NE-monsoon (locally called <i>Iruvai</i>)	Dec – Feb	Predominantly from north to NE (up to 7 m/s)	SE H _s 0.5-1.5m T _p 4-8 s	South-west H _s 1-2 m T _p 12-24 s
Transition period 1	Mar - Apr	Predominantly from W (up to 8 m/s)	South-east H _s 0.5-1.5m T _p 4-8 s	South-west H _s 1-2 m T _p 12-17 s
SW-Monsoon (locally called <i>Iruvai</i>)	May - Sept	Predominantly from SE to SW (up to 12 m/s)	South-east H _s 0.5-3m T _p 4-8 s	Southeast to southwest H _s 2-4 m T _p 12-24 s
Transition period 2	Oct - Nov	Predominantly from W (up to 16 m/s)	South-east H _s 0.5-2.5m T _p 4-8 s	South-west H _s 1-3 m T _p 12-17 s

5.4.4 Tides

Tide in the Maldives is characterized by sinusoidal oscillation containing two main cycles per day (semidiurnal tide) combined with a one cycle per day (diurnal tide). The combination of these two tides is referred to as mixed tide. Analyses of tides involve the study of harmonics which represents the period of oscillation of the celestial forcing that give rise to that harmonic.

Tide harmonic analysis by LaMer (2013) in South Huvadhoo Atoll indicated that tide observed had a principle lunar semi-diurnal (M2) tide with a period of 12.42 hours, lunar solar diurnal (K1) with a period of 23.9210 hours. Tide observed had an F ratio of 0.3001 which indicated that the tide observed was, mixed dominantly semi-diurnal tides, where the range of water level calculated was 0.93 m (LaMer, 2013).

Tide data obtained from S. Gan suggested a similar tidal behaviour for Addu region as well with a maximum water range of 1.28 m.

The characteristic tidal levels at Gan are given Table 19.

Table 19: Characteristic tidal levels at S. Gan

Tidal level	Description	Water level [m +MSL]
HAT	Highest Astronomical Tide	+0.63
MHWS	Mean High Water Spring	+0.55
MHHW	Mean Higher High Water	+0.37
MHW	Mean High Water	+0.34
MSL	Mean Sea Level	0.00
MLW	Mean Low Water	-0.34
MLLW	Mean Lower Low Water	-0.40
MLWS	Mean Low Water Spring	-0.56
LAT	Lowest Astronomical Tide	-0.65

5.5 PHYSIOCHEMICAL

5.5.1 Water Quality

Water quality is an essential part of the environment, especially considering that the islands of Maldives has vulnerable and limited fresh water resources and the majority of biodiversity and natural resource available to the island nation depends on the sea.

Due to these reasons, baseline water quality assessments were done for both sea water and ground water. Chemical parameters tested for sea water include, temperature, pH, conductivity, turbidity, total dissolved solids, salinity, specific gravity, BOD and sulphate levels.

Salinization of groundwater lens has been highlighted as a significant outcome of inland flooding of Fuvahmulah as a result of waves. Concerns of saltwater intrusion have been significantly high due to the rapid rate of erosion that has weakened the ridge in the coastline which has been formed as a result of rock consolidation. The quality of aquifer depends on several factors including both natural, human intervention and its geological formation. The quality of groundwater at Fuvahmulah has been tested for its temperature, pH, conductivity, turbidity, total dissolved solids, salinity, specific gravity, BOD and sulphate levels.

Locations were chosen so that water quality testing was carried out along the north-eastern coast and across the island of Fuvahmulah, to determine existing chemical composition of ground water and to determine whether north-eastern coast has been more susceptible to salt water intrusion compared to inland. This approach would also ensure that the samples would be representative of the groundwater quality of Fuvahmulah.

As the groundwater is still being used for purposes such as drinking, washing, and showering in Fuvahmulah, the groundwater quality of samples will be compared with the WHO guidelines for drinking water. WHO guidelines for drinking water are presented in Table 20.

Table 20: WHO guidelines for drinking water

Parameter	Reference Range
pH	6.5-8.5
Physical Appearance	Clear & Colourless
Electrical Conductivity	<1500 μ s/cm
Total Coliforms	0/100ml
Faecal Coliforms	0/100ml
Turbidity	<5NTU
Total Dissolved Solids (TDS)	<1000 mg/l
COD	10mg/l
BOD	6mg/l

The table below summarises water quality assessment results for groundwater and sea water samples taken from Fuvahmulah. (Ground water and seawater sampling locations are illustrated in Figure 12)

Table 21: Water quality assessment results Fuvahmulah

N o.	SITE	Date	Time	Type	Label	Location	Temperature/ °C	pH	Conductivity/(mS/cm)	Turbidity/ (NTU)	Dissolved Oxygen (mg/l)	TDS/(g/L)	Salinity/ (ppt)	BOD	Sulphate	Distance to shore
1	FUVA	14 07 2016	12:00: 21	seawater	SW1	S0° 17.787' E73° 25.970'	29.85	7.89	51.7	0	32.9	31	34	-	-	-
2	FUVA	14 07 2016	12:05: 27	seawater	SW2	S0° 17.688' E73° 25.882'	29.75	7.76	51.8	0	27.48	31.1	34.1	16 mg/L	3300 mg/L	-
3	FUVA	14 07 2016	15:25: 34	seawater	SW3	S0° 17.525' E73° 25.709'	29.74	7.95	51.7	0	27.6	31	34	-	-	-
4	FUVA	15 07 2016	15:36: 21	groundwater	GW1	0°18'24.59"S 73°26'17.31"E	30.01	6.87	0.481	0	30.49	0.313	0.2	-	-	221 m
5	FUVA	15 07 2016	15:55: 10	groundwater	GW2	S0° 17.694' E73° 25.759'	29.14	6.29	0.753	2.2	27.23	0.482	0.4	-	-	45 m
6	FUVA	15 07 2016	16:14: 17	groundwater	GW3	S0° 17.940' E73° 25.405'	29.23	6.47	0.458	0	30.9	0.295	0.2	-	-	262 m
7	FUVA	15 07 2016	16:28: 38	groundwater	GW4	S0° 17.664' E73° 25.541'	29.81	6.86	0.385	5.3	19.31	0.25	0.2	-	-	310 m
8	FUVA	15 07 2016	16:38: 38	groundwater	GW5	S0° 17.731' E73° 25.360'	27.82	7.2	0.468	6.7	14.96	0.304	0.2	-	-	293 m

5.5.1.1 Physical and Chemical Parameters

Groundwater Temperature

Temperature is an important physical characteristic of water and it affects the rate of reaction and the solubility of gases in water. Moreover, high temperature of water decreases its palatability due to the increase in taste, odour and colour. It can also promote the growth of microorganisms while causing corrosion problems (WHO, 2006).

The mean temperature of groundwater tested Fuvahmulah was 29.23 °C. The highest temperature recorded was 30.01 for sample GW1. These changes are observed in part due to location of wells that were tested as once which were uncovered and in the open had a higher temperature compared to enclosed wells. There are no guidelines set by WHO for the temperature of drinking water, although WHO states that higher temperatures can impact the acceptability of inorganic and chemical contaminants in the water. (See Figure 38 for average temperature).

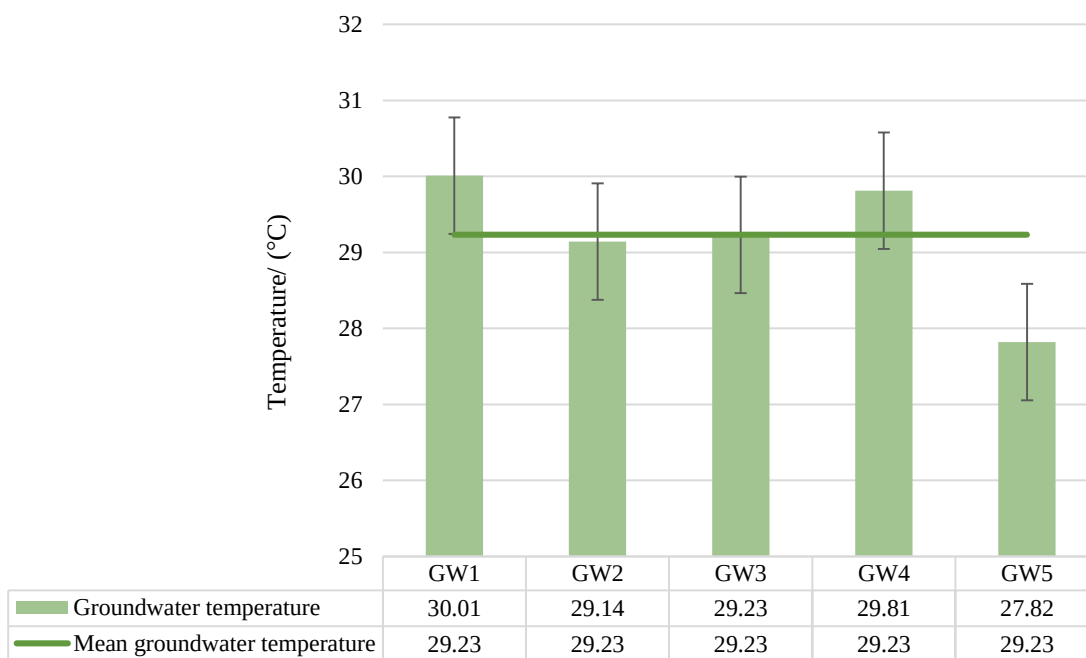


Figure 38 Groundwater temperature measurements

Seawater Temperature

Reef-building corals cannot tolerate water temperatures below 18° Celsius. Many grow optimally in water temperatures between 23°–29°Celsius, but some can tolerate temperatures as high as 40° Celsius for short periods (Figure 39).

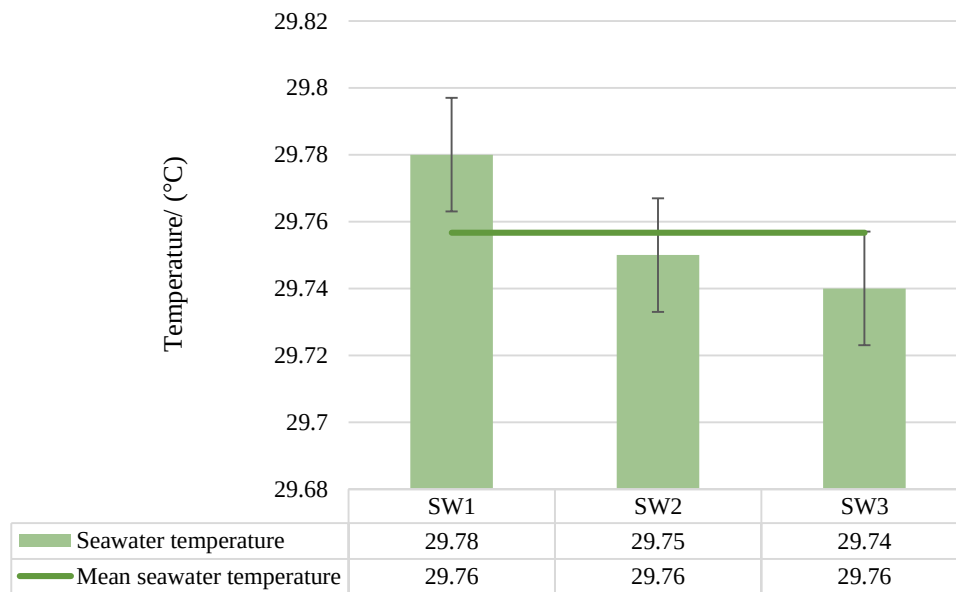


Figure 39: Seawater temperature

The mean surface temperature of seawater tested was 29.76 °C. A very small deviation of 0.02 °C was observed for seawater temperature, which suggested that the surface temperature was constant. The mean seawater temperature logged at Fuvahmulah was close to the upper limit of the optimum temperature.

Groundwater pH

pH is a measure of the acidic or alkaline condition of the water. The pH has no unit and is measured through a scale ranging from 0-14, where pH = 7 is neutral, pH < 7 is acidic and pH > 7 is alkaline. The ideal pH for drinking water is 6.5 to 8.5 as given in the WHO guidelines (Figure 40).

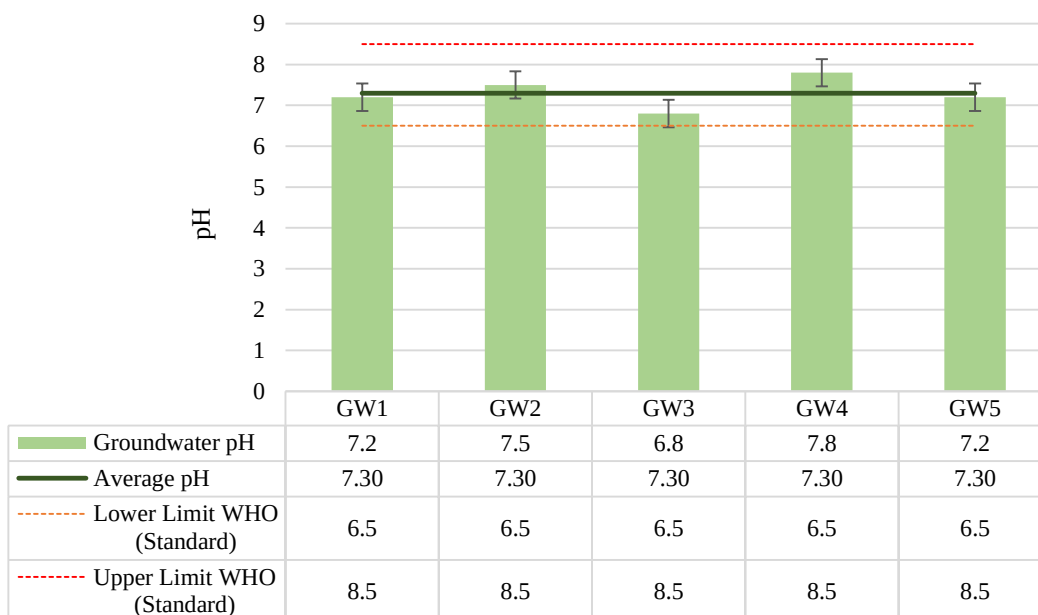


Figure 40 pH, Groundwater Quality Tests

The mean pH of the groundwater Fuvahmulah was is 7.30. Therefore, the pH of the groundwater tested in the project islands was neutral to alkaline. These values were within the given range of acceptable values for drinking water as set by WHO.

Seawater pH

Much of the carbon dioxide that enters the atmosphere dissolves into the ocean. In fact, the oceans have absorbed about 1/3 of the carbon dioxide produced from human activities since 1800 and about 1/2 of the carbon dioxide produced by burning fossil fuels (Sabine *et al*; 2004).

With ocean acidification, corals cannot absorb the calcium carbonate they need to maintain their skeletons and the stony skeletons that support corals and reefs will dissolve (Figure 41).

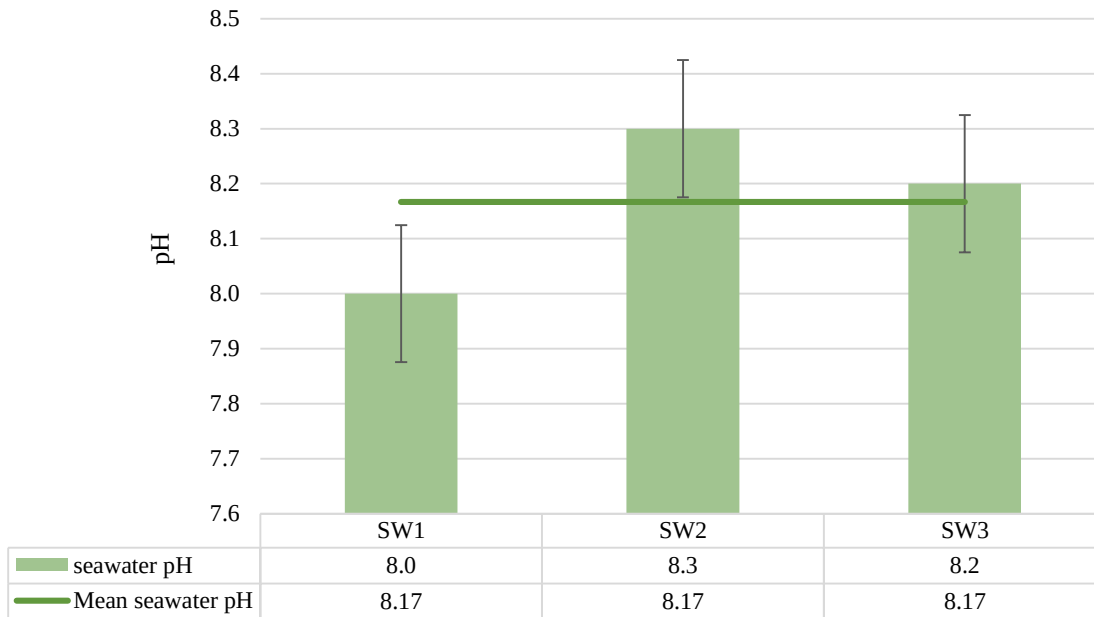


Figure 41: pH, seawater quality tests

The mean pH of the seawater was 8.17. With ocean acidification, corals cannot absorb the calcium carbonate they need to maintain their skeletons and the stony skeletons that support corals and reefs will dissolve. The mean pH measured was slightly basic and corresponds to oceanic pH determined by SCOR (2009).

Groundwater Turbidity

It is a measure of water clarity; how much the material suspended in water decreases the passage of light through the water. Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity and other sources. The turbidity depends on the fineness and concentration of particles present in water (Figure 42).

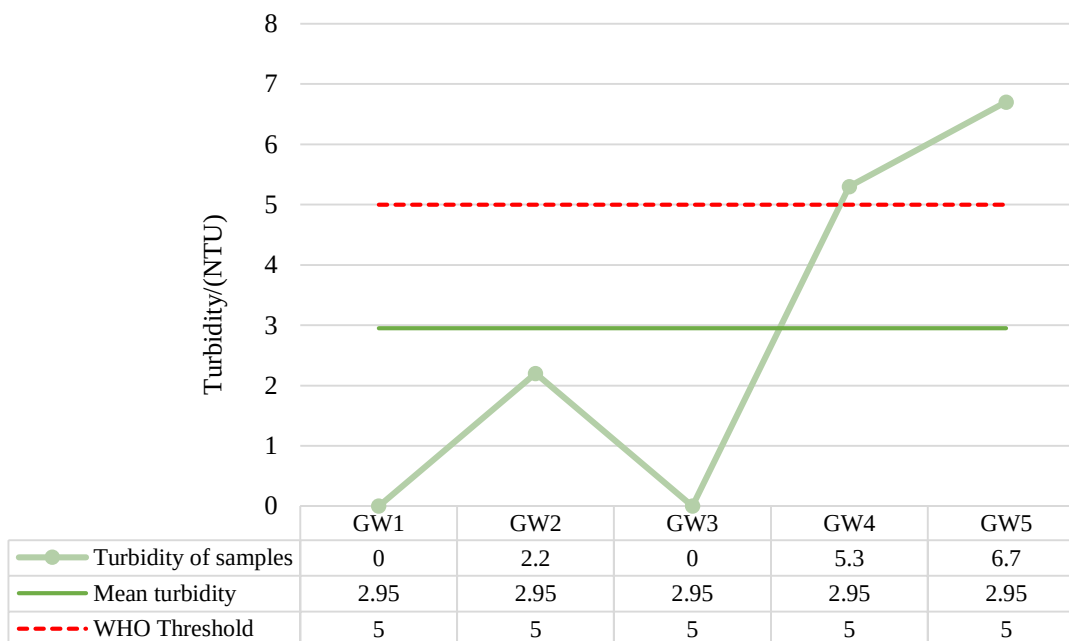


Figure 42 Turbidity, Groundwater Quality Tests

The turbidity in the groundwater tested show an average of 2.95 NTU which is below the WHO recommended level. However, turbidity of groundwater tested at sites GW4 and GW5 were higher than WHO recommended levels; this was mainly because these wells had been contaminated with debris.

Seawater Turbidity

The seawater had a turbidity of 0 NTU. (See The table below summarises water quality assessment results for groundwater and sea water samples taken from Fuvahmulah. (Ground water and seawater sampling locations are illustrated in Figure 12)

Table 21 and Figure 12 for sample locations).

Groundwater TDS

Dissolved particles in the water, along with ionic species, are referred to as dissolved solids. These solids pass through a water filter and are usually less than 1 micron. Dissolved solids can include materials such as organic materials, salts, nutrients and toxins.

In considering waters for human consumption or other uses, it is important to know the concentrations of both suspended and dissolved solids. Dissolved solids such as nitrogen and phosphorus at optimum amounts can foster the growth of aquatic life in the waters. It can also increase the turbidity of the water. WHO sets a maximum of 1000mg/l for the amount of TDS, with levels higher than that increasingly becoming unpalatable. For palatability, a value of 600mg/l is considered acceptable (WHO, 2006) (Figure 43).

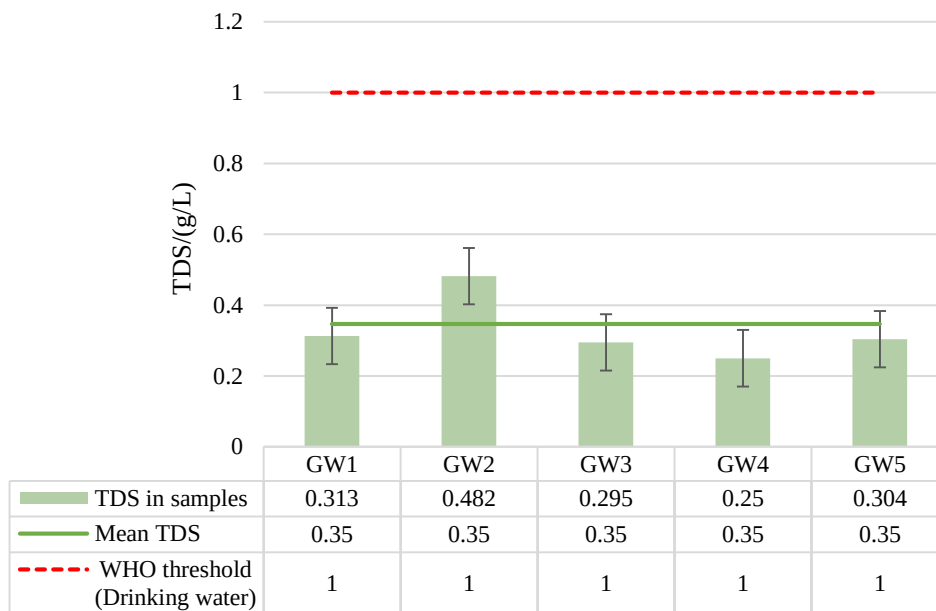


Figure 43 Total Dissolved Solids in groundwater

High TDS can cause gastro intestinal irritation and laxative effects (WHO, 1997). The mean TDS level for Fuvahmulah was measured at 350 mg/l. All samples were found to be acceptable as they were less than the maximum TDS value set by WHO at 1000 mg/l (Figure 43).

According to Rabinove *et al*; (1958) salinity of the tested samples can be classified using the TDS values obtained in Table 22.

Table 22 Salinity Classification (Source: Rabinove *et. al*, 1958)

Classification	TDS (mg/l)
Non-Saline	<1000
Slightly-Saline	1000~3000
Moderately Saline	3000-10,000
Very Saline	10,000

Referring to these classifications, the samples tested at all three islands can be deemed to have non-saline groundwater.

Seawater TDS

TDS measurements of seawater showed a very constant reading with little variation. The mean TDS for seawater was 31 g/l which is the normal TDS measurements for seawater (Figure 44).

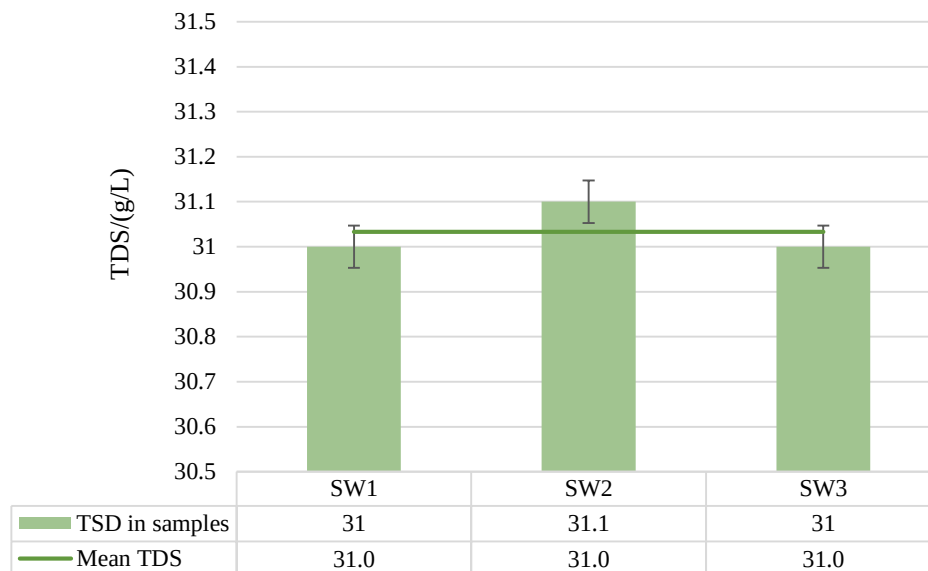


Figure 44: Total Dissolved Solids, Seawater

Groundwater Electrical Conductivity

Electrical conductivity can show an indication of the materials dissolved in the tested water. The WHO guidelines for drinking water states that the electrical conductivity of the water should be less than 1.5 ms/cm for the water to be acceptable for drinking purposes (Figure 45).

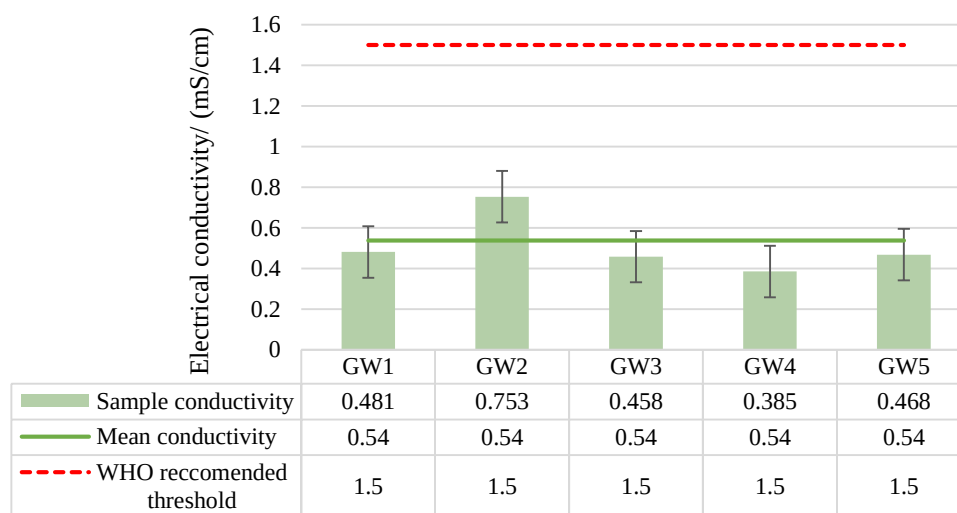


Figure 45: Groundwater Electrical Conductivity

The mean electrical conductivity of the groundwater measured at Fuvahmulah was highest, at 0.75 ms/cm. samples were found to be below the threshold set by WHO (see Figure 45).

Seawater Electrical Conductivity

Electrical conductivity of seawater was very constant with a mean conductivity of 51.7 mS/cm, which was normal for electrical conductivity of seawater (Figure 46).

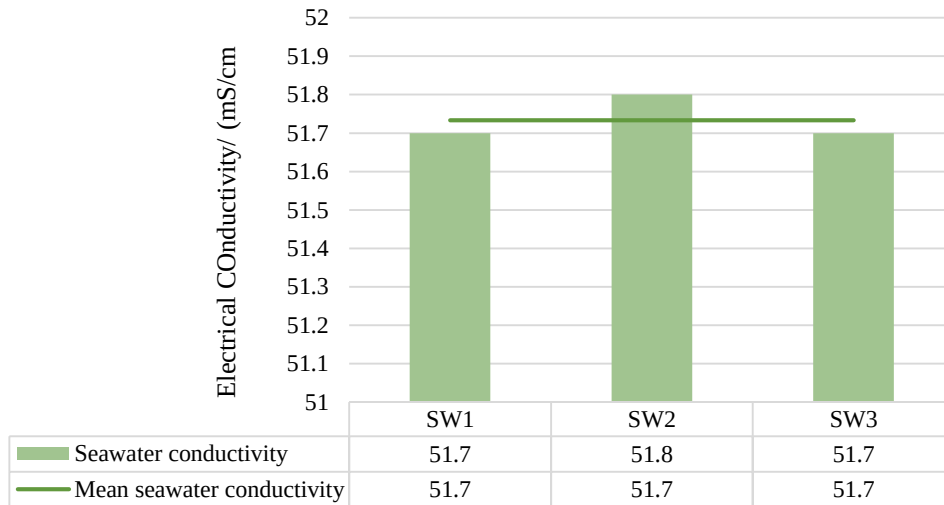


Figure 46: Electrical conductivity of seawater

Groundwater Salinity

The salinity of water shows the total amount of non-carbonate salts present. This mostly consists of NaCl. Salinity is measured in parts per thousand, where 1 ppt = 1000mg/L. Salinity of tested water can also be determined comparing the values of TDS with the salinity classification of Rabinove *et. al*; (1958) (Figure 47).

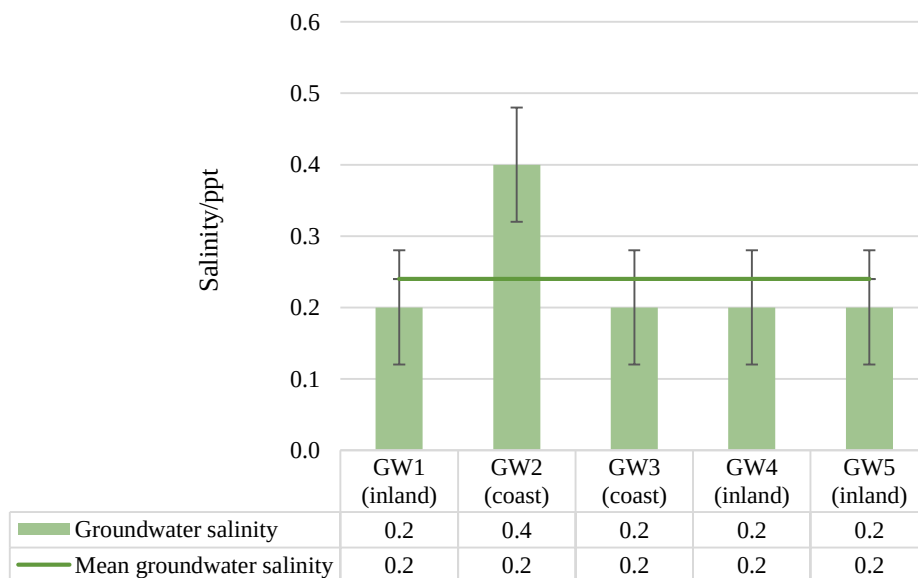


Figure 47: Groundwater salinity

The tested samples show a mean of 0.2 ppt salinity in Fuvahmulah. The highest recorded salinity was observed in sample GW2 which was taken close to the north-eastern coast of Fuvahmulah. These results show the groundwater of the project islands had a low amount of Na^+ and Cl^- ions.

In order to determine whether distance from coast had any significant influence on the salinity of ground water samples that were tested, a linear regression analysis was done between TDS and distance from shore the samples were tested from. TDS was used in this case as salinity of the samples were derived from TDS measurements. The distance of samples from the shore are tabulated in The table below summarises water quality assessment results for groundwater and sea water samples taken from Fuvahmulah. (Ground water and seawater sampling locations are illustrated in Figure 12)

Table 21.

The linear regression analysis below showed that there was negative correlation between distance from the shore and TDS of samples. The correlation coefficient of the analysis was 0.97, which can be considered as a very strong indicator that groundwater samples tested near the shore were more saline than groundwater tested within the island. This could be due to salt water intrusion near the shore as a result of waves frequently toppling inland. However, these results are based on a few data points and in order to come to a more conclusive result, more samples shall be tested.

5.5.2 Linear Regression (Groundwater salinity compared to distance from coast)

Linear regression of data, where observed values are compared against theoretical and experimental values, was performed. Standard deviation analysis of experimental data, are compared against theoretical linearity equation to determine the correlation between distance from the coast and TDS measurement of the samples. (See Table 23). The statistical and regression data are provided in

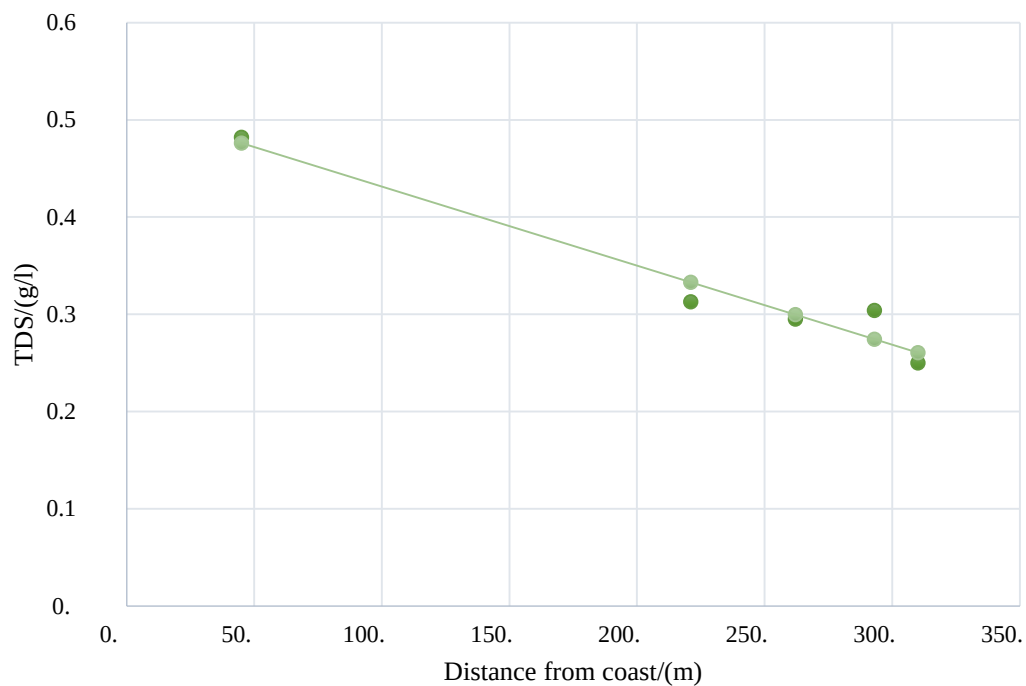
Table 24 and the linearity graph is illustrated in Figure 48.

Table 23: TDS readings and distance from coast

ID	TDS/(g/l)	Distance from coast/(m)
GW2	0.482	45
GW1	0.313	221
GW3	0.295	262
GW4	0.304	293
GW5	0.25	310

Table 24: Statistical and regression data

Statistical Data	
Mean of X	226.2
Mean of Y	0.3288
S_{xx}	45626.8
S_{x^2}	301459
S_{yy}	0.0316868
S_{y^2}	0.572234
S_{xy}	-37.1478
Correlation Coefficient (r)	-0.976976
Slope (b)	-0.0008142
Intercept (a)	0.5129644
Residual StdDev ($S_{y/x}$)	0.1469874

**Figure 48: TDS against distance from coast**

BOD

Biochemical Oxygen Demand or BOD, is a widely used test to obtain the concentration of organic matter in samples of water. The basic concept of BOD is that if there is sufficient oxygen available in a sample of water, aerobic biological decomposition will occur until all the organic waste is consumed. This process occurs through the action of the microorganisms present in the sample.

Organic materials such as those from rainwater runoff, dead organisms, leaves, fallen trees, and animal wastes have a significant contribution to the BOD levels of water. As the amount of organic materials increase, aerobic microorganisms will decompose the organic materials, using up oxygen. Seawater samples close to the north-eastern coast of Fuvahmulah was tested for BOD. The results suggested that BOD of seawater at the project site was 16 mg/L. This suggested that seawater at the project site had not been contaminated.

Sulphate

Sulphate ions constitutes to about 7.75% of major ions in seawater and is the third most common ion in seawater following sodium and chloride. The sulphate level in tested seawater was 3300 mg/L

5.5.3 Summary of Water Test Result

In general, the seawater quality of the project site was satisfactory. The water was slightly alkaline with an average of 8.2 pH. The average salinity and conductivity were 34 ppt and 51.7 mS cm^{-1} , respectively, characteristic of normal sea water. No sudden changes in conductivity was observed between sites that could suggest pollution.

Total dissolved solids (TDS) combine the sum of all ion particles that are smaller than 2 microns (0.0002 cm). This includes all of the disassociated electrolytes that make up salinity concentrations, as well as other compounds such as dissolved organic matter. The TDS readings were normal with an average of 31 gL $^{-1}$. The TDS reading were close to the salinity of water body, which suggested that sea water hadn't been polluted by non-ionic hydrocarbons.

Sedimentation is determined to have an impact to the natural marine environment as result of the proposed shore protection project. Sedimentation and its impact on the marine biota is further discussed in the marine environment Section 5.6. The baseline turbidity levels at the project site was 0 NTU.

5.6 MARINE ENVIRONMENT

5.6.1 Bathymetry

A bathymetry of the north-eastern reef flat covering the *Thundi* area is demonstrated in *Figure 49* and reef slope profiles are shown in *Figure 50*.

Bathymetry Analysis

Reef Flat:

- The average depth of the north-eastern reef flat area was between -0.6 to -3 m from MSL. The area was observed to be moderately shallow.
- The shallowest area was -0.6 m from MSL and was adjacent to the coast up to 5 m from the shoreline.
- The width of reef flat measured from low tide mark to the reef edge was approximately 140 m across.

Reef Slope:

- The reef edge was mapped perpendicular to shore at 4 locations along the north-eastern coast of Fuvahmulah.
- Reef slope profiles of the four locations are illustrated in *Figure 50*.
- The profiles suggested a very steep slope at the reef edge. The bottom half slope (Profile 3) was less steep at – 72% compared to the top half (Profile 1 and 2) where the slope was -90%.



Figure 49: Bathymetry drawing of the north-eastern reef flat of Fuvahmulah

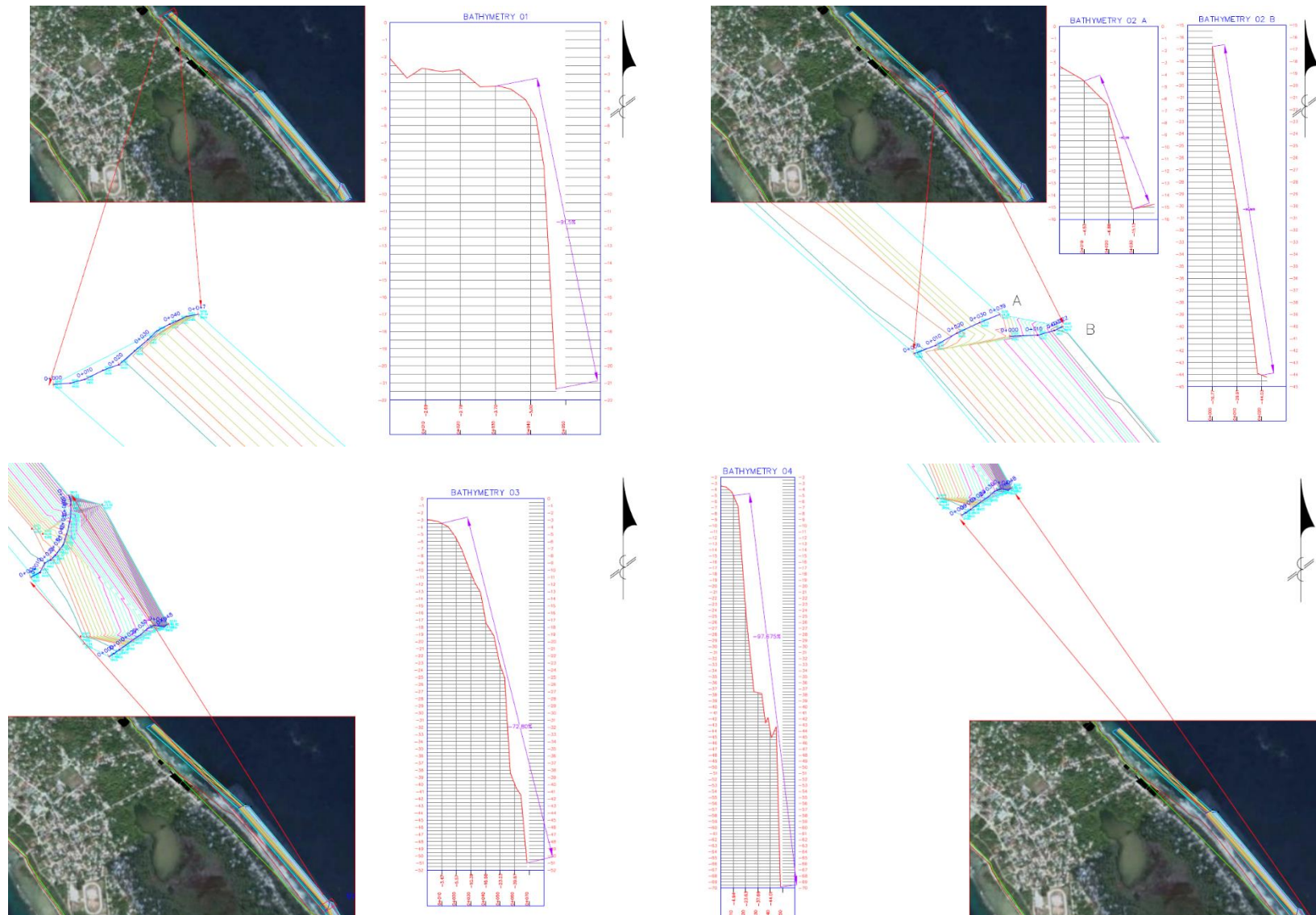


Figure 50: Reef slope profiles at the northern coast

5.6.2 Benthic Cover and Fish Study

The benthic cover was assessed after setting up 4 monitoring station within a span of two kilometres. Monitoring stations were set up every 500 m. (Figure 15 gives locations of monitoring stations). Three 20 m transects were laid at each monitoring station where the depth of each transect was noted. The marine survey showed the growth form in the following categories:

1. Laminar (plate-like)
2. Encrusting
3. Free living
4. Columnar
5. Folioseous
6. Branching
7. Massive (ball-shaped or boulder-like)
8. Digitate (like fingers with no secondary branches).

Marine Analysis Station 1

In general, the highest coral cover was observed at this station where transects were taken from 15 – 20 m. The combined live coral cover at this depth of Fuvahmulah house reef was 16 %. (See details of each individual transect below). A large percentage of massive and free living corals were observed at the station more than 50% of live corals were found to be effected by bleaching. This zone mainly comprised of dead corals followed by rubble.

Transect 1

The first transect laid at a depth of 15 m on the 13/7/2016 at 10:42 am. The percentile benthic cover of transect is illustrated in Figure 51.

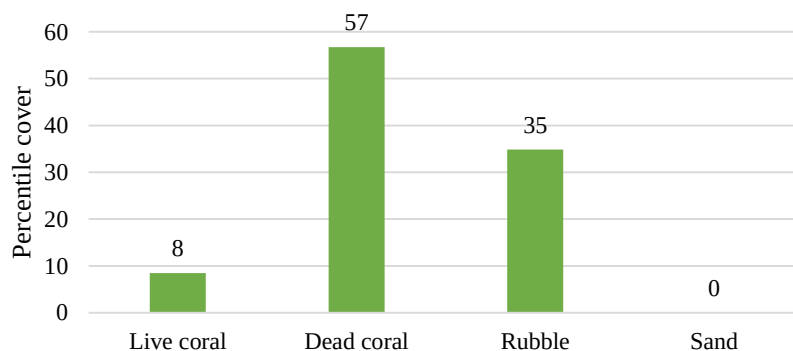


Figure 51: Benthic Substrate cover MAS 1_Transect 1 (15 m)

Observations:

The main benthic substrate observed at the site was dead corals followed by rubble. Live corals covered the least percentage at the transect zone.

The main coral species identified at the site were:

- Porites (Massive)
- Pocillopora (Branching)
- Fungia (Free living)

Other common species found at the site include:

- Sea urchins
- Algae

The most common coral species observed at the site were Massive and free living. Approximately 55% of corals analysed at the transect were bleached. Figure 54 shows some of the selected photos of the transect site.

Transect 2

The second transect was laid at a depth of 20 m on the 13/7/2016 at 10:42 am. The percentile benthic cover of transect is illustrated in Figure 52.

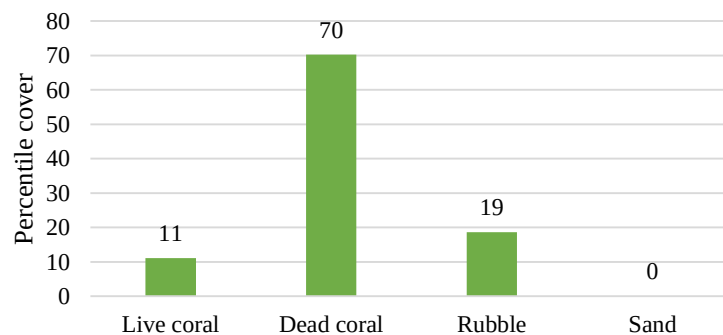


Figure 52: Benthic Substrate cover MAS 1_Transect 2 (20m)

Observations:

The main benthic substrate observed at the site was dead corals followed by rubble. Live corals covered the least percentage at the transect zone.

The main Coral species identified at the site were:

- Porites (Massive)
- Pocillopora (Branching)
- Fungia (free living)

The most common coral species observed at the transect site were Massive and free living. Approximately 45% of corals analysed at the transect were bleached. Figure 54 shows some of the selected photos of the transect site.

Transect 3

The third transect laid at a depth of 25 m on the 13/7/2016 at 10:42 am. The percentile benthic cover of transect is illustrated in Figure 53.

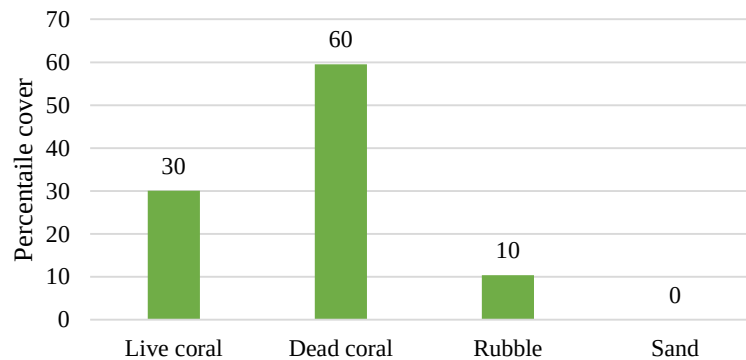


Figure 53: Benthic Substrate cover MAS 1_Transect 3 (25m)

The main benthic substrate observed at the site was dead corals followed by live corals. Rubble covered the least percentage at the transect zone.

The highest coral cover (30%) was observed for this site. Live coral cover was highest at 25 m based on all transects analysed during the study.

The main Coral species identified at the site were:

- Porites, Favites (Massive)
- Pocillopora (Branching)
- Plate and mushroom corals were observed at this zone.

The most common coral forms observed at the transect site were Massive and free living. Approximately 45% of corals analysed at the transect were bleached. Figure 54 shows some of the selected photos of the transect site.

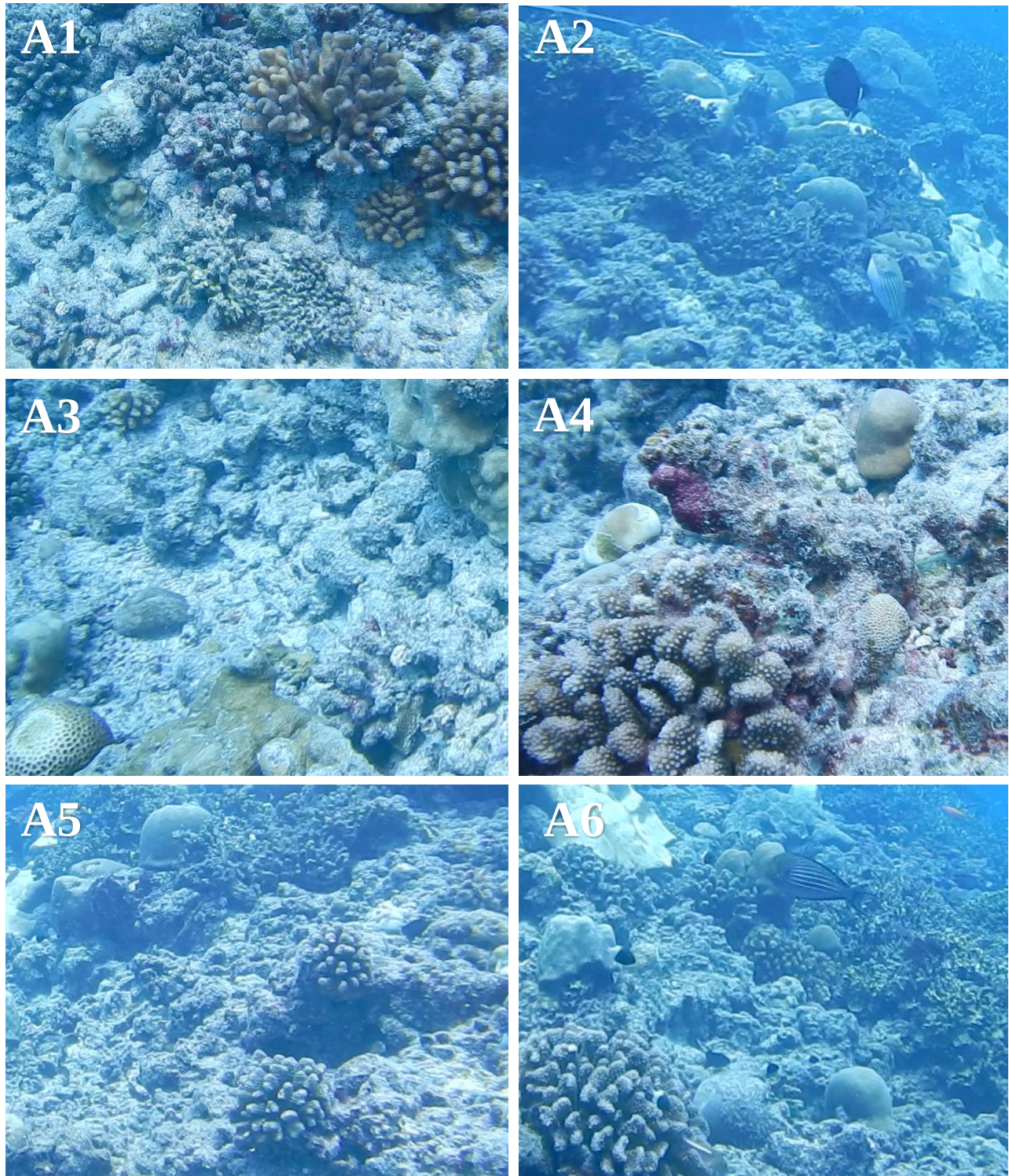


Figure 54: Selected photos of marine monitoring station 1. Depth 15-25 m Average combined live coral cover at the zone was 16%. Most common benthic substrate was dead corals.

Fish Study at Marine Analysis Station 1

A timed swim of 10 minutes was conducted at the transect sites and Table 25 below shows that types of fishes observed with their relative abundance.

Table 25: Types of fishes and abundance Marine Monitoring Station 1

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

The fish study showed a diverse range of species at this zone. The biodiversity at this zone was significantly greater compared to the shallower zones of the reef. The most common families observed at this station include *Pomacentridae*, *Caesionidae* and *Balistidae*. The most abundant reef fishes observed include two tone chromis, Indian trigger fish and yellow back fusiliers other common reef fishes observed at the station were mimic surgeon fish, lined surgeon fish and striated surgeon fish. These were common between depths 15- 25 m. Orange striped triggerfish was however observed more commonly at 15 m while it was encountered less frequently during the timed swims at 20-25 m.

Marine Analysis Station 2

Coral cover was low between 9- 11 m at the reef edge. The combined live coral cover at this depth of Fuvahmulah house reef was 4.5 %.

Transect 1

The first transect at Marine Analysis Station 2 (MAS2) was laid at a depth of 9 m on the 13/7/2016 at 03:00 pm. The percentile benthic cover of transect is illustrated in Figure 55.

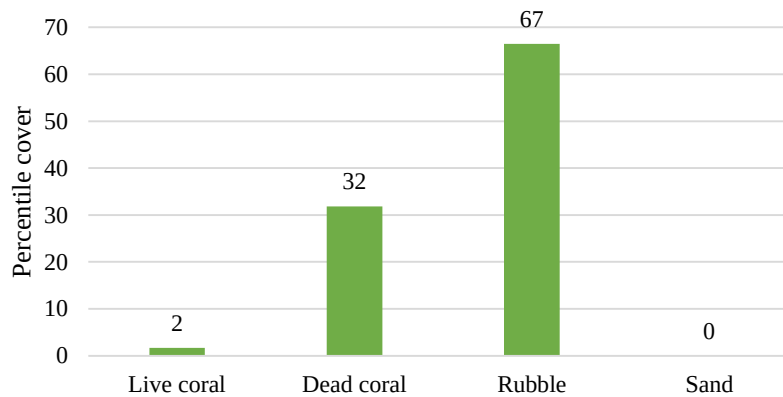


Figure 55: Benthic Substrate cover MAS 2_Transect 1 (9m)

The main benthic substrate observed at the site was rubble followed by dead corals. Live corals covered the least percentage at the transect zone with a cover of 1.7%. The main coral species identified at the site was Pocillopora (Branching), including algae as well. The most common coral species observed at the transect site were massive corals. Approximately 50% of corals analysed at the transect were bleached. Figure 58 shows some of the selected photos of the transect site.

Transect 2

The third transect was laid at a depth of 13 m on the 13/7/2016 at 03:15 pm. The percentile benthic cover of transect is illustrated in Figure 56.

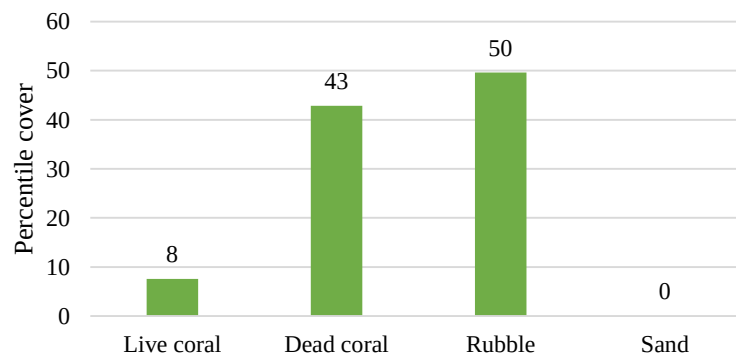


Figure 56: Benthic Substrate cover MAS 2_Transect 2 (13m)

The main benthic substrate observed at the site was rubble followed by dead corals. The difference between these forms were fairly even at the zone. Live corals covered the least percentage at the transect zone with a cover of 1.7%. The main coral species identified at the site was massive Porites and to some extent algae as well. The most common coral species observed at the transect site were massive corals. Approximately 55% of corals analysed at the transect were bleached. Figure 58 shows some of the selected photos of the transect site.

Transect 3

The third transect laid at a depth of 9-11 m on the 13/7/2016 at 03:45 pm. The percentile benthic cover of transect is illustrated in Figure 57.

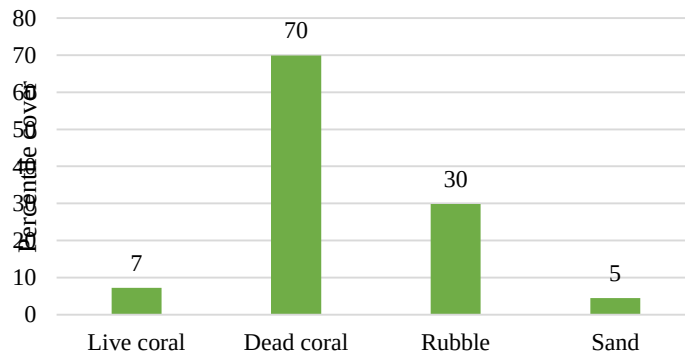


Figure 57: Benthic Substrate cover MAS 2_Transect 3 (9-11m)

The main benthic substrate observed at the site was rubble followed by dead corals. Live corals covered the least percentage at the transect zone with a cover of 1.7%.

The main coral species identified at the site was Pocillopora (Branching) Porites, Favites (Massive) and to some extent algae as well. The most common coral species observed at the transect site was branching Pocillopora. Approximately 50% of corals analysed at the transect were bleached. Figure 58 shows some of the selected photos of the transect site.

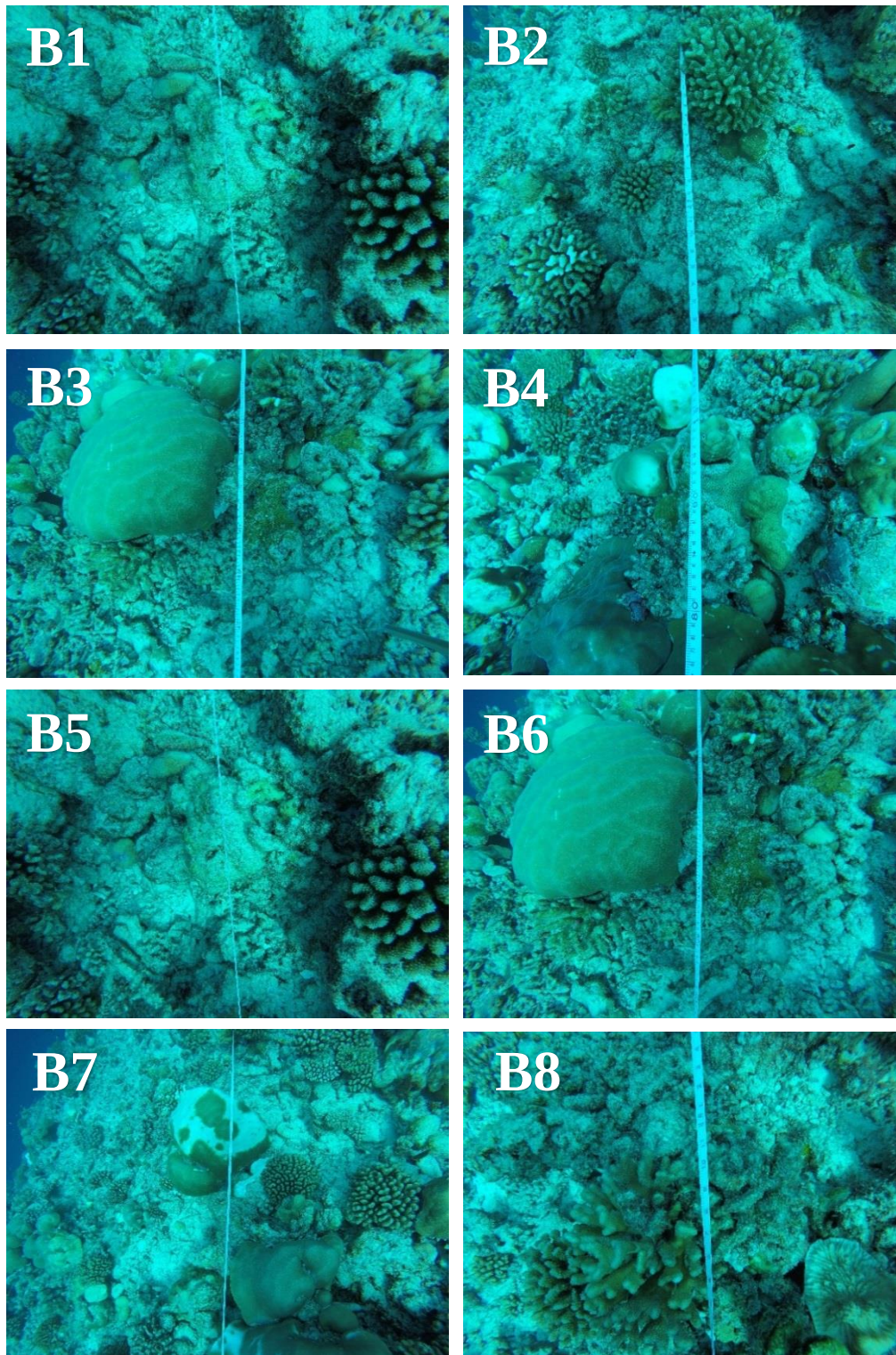


Figure 58: Selected photos of marine monitoring station 2. Depth 9- 13 m. Average combined live coral cover based on three transects was 4.5%. Dominant cover was a combination of dead corals and rubble.

Fish Study at Marine Analysis Station 2

A timed swim of 10 minutes was conducted at the transect sites. Table 26 shows that types of fishes observed with their relative abundance.

Table 26: Types of fishes and abundance Marine Monitoring Station

Scientific name	Common name	Relative abundance
Family: Acanthuridae		
<i>Acanthurus Lucosternon</i>	Powder-blue surgeon fish	Common
<i>Acanthurus Lineatus</i>	Lined surgeon fish	Common
<i>Zebrasoma xanthurum</i>	Yellowtail tang	Rare
<i>Zebrasoma scopas</i>	Brown tang	Common
<i>Ctenochaetus striatus</i>	Striated surgeonfish	Common
Family: Pomacentridae		
<i>Chromis dimidiata</i>	Two tone chromis	Abundant
<i>Chromis vridis</i>	Blue-green puller	Abundant
<i>Abudefduf Vaigiensis</i>	Sergeant major	Common
<i>Amblyglyphidodon indicus</i>	Maldives damselfish	Rare
Family: Scaridae		
<i>Scarus scaber</i>	Five saddle parrot fish	Rare
<i>Chlorurus strogilocephalus</i>	Steephead parrotfish	Rare
Family: Ballistae		
<i>Melichthys indicus</i>	Indian triggerfish	Abundant
Family: Labridae		
<i>Labroides dimidiatus</i>	Bluestreak cleaner wrasse	Common
<i>Thalassoma hardwickle</i>	Six-bar wrasse	Rare
<i>Hemigymnus fasciatus</i>	Banded thicklip wrasse	Rare

The fish study showed a diverse range of reef fish species at the zone. The most common family of fish at this zone was Acanthuridae, Pomacentridae and Ballistae. Most common fish species found included Powder-blue surgeon fish lined surgeon fish, brown tang, striated surgeonfish, two tone chromis, blue-green puller, Indian triggerfish and blue streak cleaner wrasse.

Marine Analysis Station 3

Coral cover was low to moderate between 6- 8 m. The combined live coral cover at this depth of Fuvahmulah house reef was approximately 7%. Analysis of three transects taken at MAS3 are described below.

Transect 1

The first transect at MAS3 was laid at a depth of 6 m on the 14/7/2016 at 10:42 am. The percentile benthic cover of transect is illustrated in Figure 59.

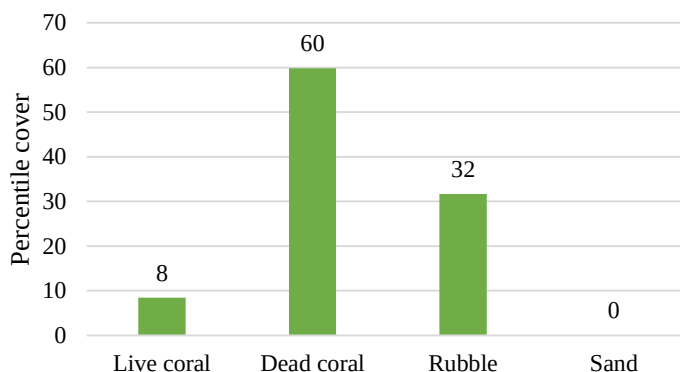


Figure 59: Benthic Substrate cover MAS 3_Transect 1(6m)

The main benthic substrate observed at the site was dead corals followed by rubbles. Live corals covered the least percentage at the transect zone with a cover of 8.45%.

The main coral species identified at the site was Pocillopora (Branching), Acropora (Branching) and Porites (Massive) and algae. The most common coral forms observed at the transect site were massive and free living. Approximately 45% of live corals analysed at the transect were bleached. Figure 62 shows some of the selected photos of the transect site.

Transect 2

The second transect was laid at a depth of 3-4 m on the 14/7/2016 at 10:50 am. The percentile benthic cover of transect is illustrated in Figure 60.

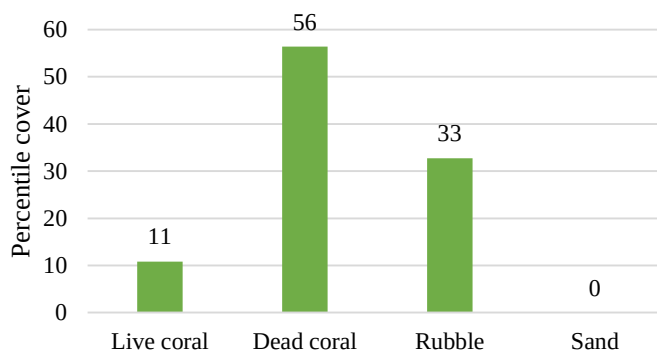


Figure 60: Benthic Substrate cover MAS 3_Transect 2 (3-4m)

Observations:

The main benthic substrate observed at the site was dead corals followed by rubbles. Live corals covered the least percentage at the transect zone with a cover of 10%.

The main coral species identified at the site was Pocillopora (Branching), Acropora (Branching) and Porites (Massive) and algae.

The most common coral form observed at the transect site was massive corals. Approximately 55% of live corals analysed at the transect were bleached. Figure 62 shows some of the selected photos of the transect site.

Transect 3

The third transect laid at a depth of 6-7 m on the 14/7/2016 at 11: 10 am. The percentile benthic cover of transect is illustrated in Figure 61.

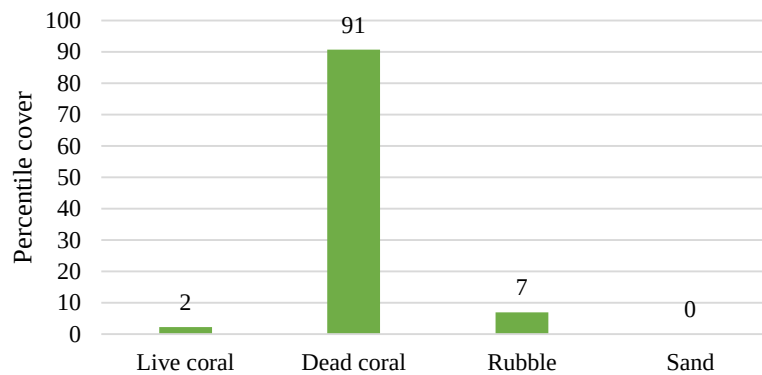


Figure 61 Benthic Substrate cover MAS 3_Transect 3 (6-7m)

The main benthic substrate observed at the site was dead corals followed by rubbles. Live corals covered the least percentage at the transect zone with a cover of 2.5%.

The main coral species identified at the site was Porites, Favites (Massive), Pocillopora (Branching) and algae.

The most common coral form observed at the transect site was massive corals. Approximately 45% of live corals analysed at the transect were bleached. Figure 62 shows some of the selected photos of the transect site.

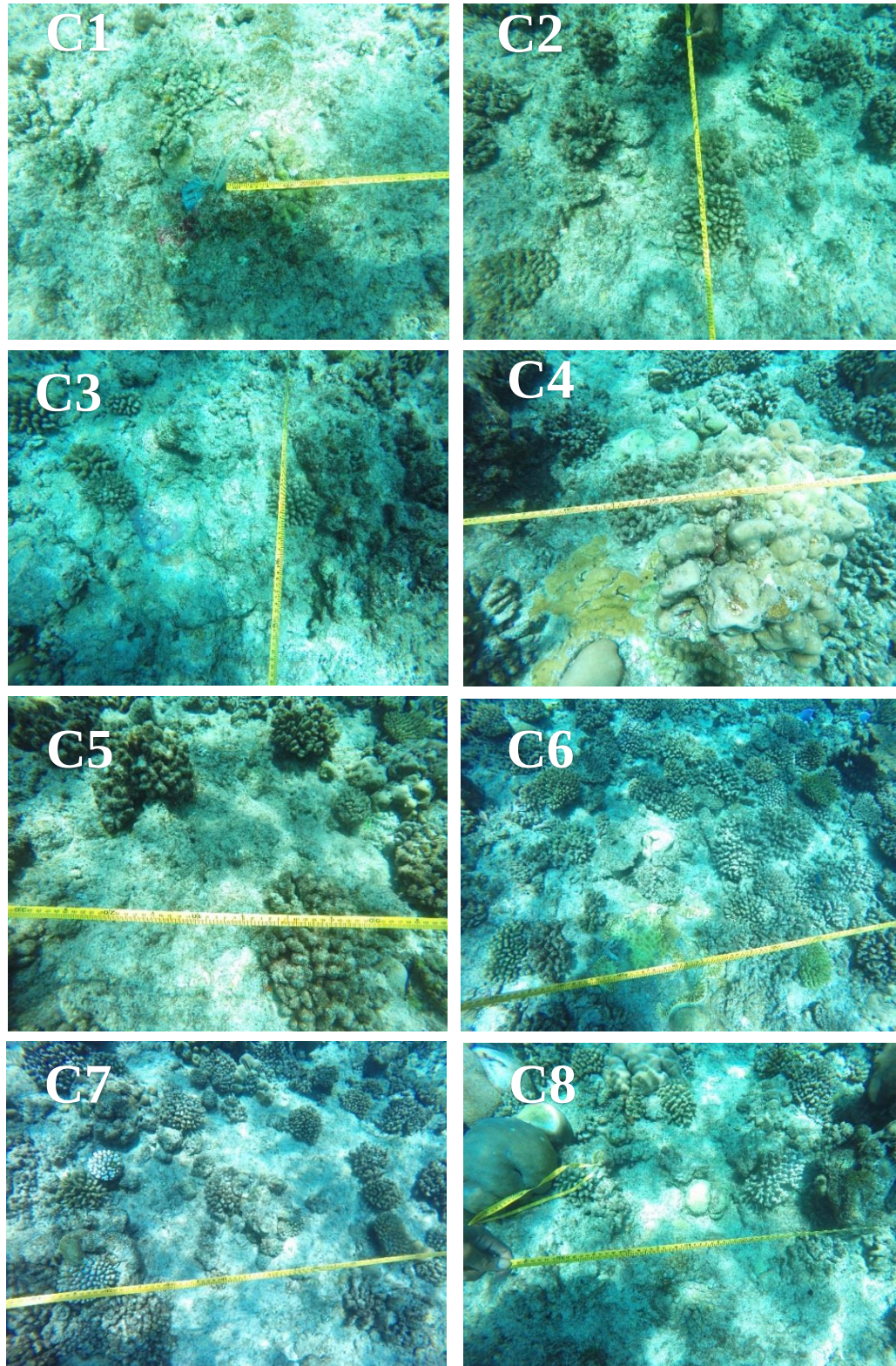


Figure 62: Selected photos of marine monitoring station 3. Depth 3- 6. The average combined live coral cover based on the three transects was 7%. Dominant cover at MM3 was dead corals.

Fish Study at Marine Analysis Station 3

A timed swim of 10 minutes was conducted at the transect sites and Table 27 below shows that types of fishes observed with their relative frequency.

Table 27: Types of fishes and abundance Marine Monitoring Station 3

Scientific name	Common name	Relative abundance
Family: Acanthuridae		
<i>Acanthurus lucosternon</i>	Powder-blue surgeon fish	Abundant
<i>Acanthurus lineatus</i>	Lined surgeon fish	Common
<i>Zebrasoma scopas</i>	Brown tang	Rare
<i>Ctenochaetus striatus</i>	Striated surgeon fish	Common
Family: Pomacentridae		
<i>Abudefduf vaigiensis</i>	Sergeant major	Rare
<i>Amblyglyphidodon indicus</i>	Maldivian damselfish	Rare
<i>Dascyllus aruanus</i>	Humbug dascyllus	Rare
Family: Blennidae		
<i>Aspidontus taeniatus</i>	False cleaner fish	Rare
Family: Labridae		
<i>Thalassoma hardwickie</i>	Six-bar wrasse	Rare
<i>Thalassoma quinquevittatum</i>	Five stripe wrasse	Rare
Family: Chaetodontidae		
<i>Chaetodon trifasciatus</i>	Oval butterfly fish	Rare
Family: Haemulidae		
<i>Plectorhinchus vittatus</i>	Oriental sweetlips	Rare

The fish study showed moderate amount of reef fishes at the station and transect zones. The most common family of fish at this zone was *Acanthuridae*. Most common fish species found include Powder-blue surgeon fish, Lined surgeon fish and Striated surgeonfish.

Marine Analysis Station 4

Transect 1

The first transect at MAS4 was laid at a depth of 2 m on the 14/7/2016 at 2:45 pm. The percentile benthic cover of transect is illustrated in Figure 63.

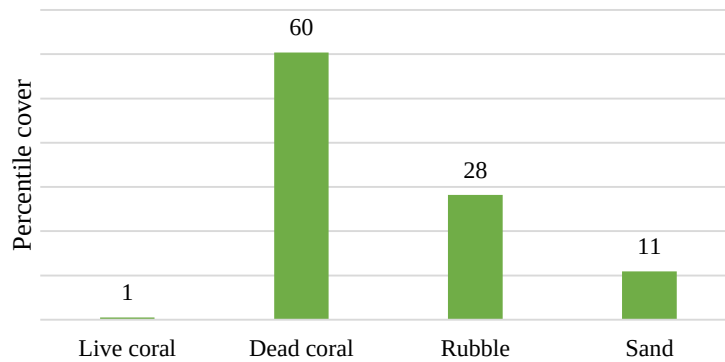


Figure 63: Benthic Substrate cover MAS 4_Transect 1(2m)

The main benthic substrate observed at the site was dead corals followed by rubbles and sand. Live corals covered the least percentage at the transect zone with a cover of 0.5%.

The main coral species identified at the site was Porites. However live coral cover at the zone was negligible. See Figure 66 for selected photos of the transect zone.

Transect 2

The second transect was laid at a depth of 1 m on the 14/7/2016 at 3:15 pm. The percentile benthic cover of transect is illustrated in Figure 64.

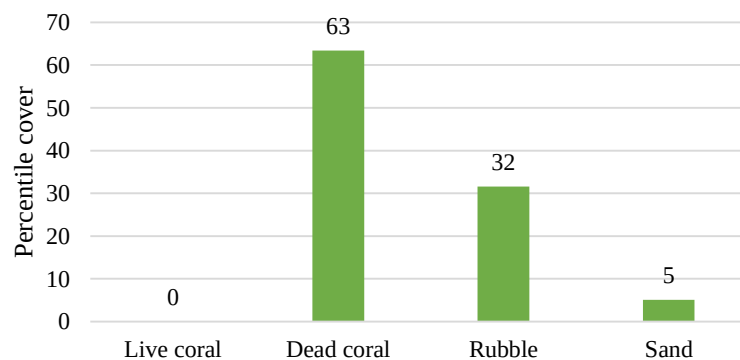


Figure 64: Benthic Substrate cover MAS 4_Transect 2 (1m)

The main benthic substrate observed at the site was dead corals followed by rubbles and sand. Live corals were not observed at the transect zone.

Transect 3

The third transect was laid at a depth of 1-2 m on the 14/7/2016 at 3:30 pm. The percentile benthic cover of transect is illustrated in Figure 65.

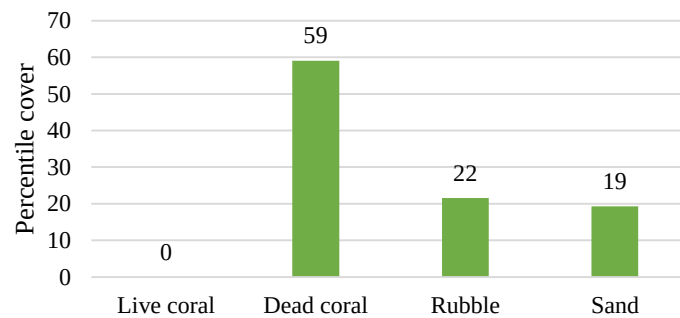


Figure 65: Benthic Substrate cover MAS 4_Transect 3 (1-2m)

The main benthic substrate observed at the site was dead corals followed by rubbles and sand. Live corals were not observed at the transect zone. Selected pictures from this transect is given in Figure 66.

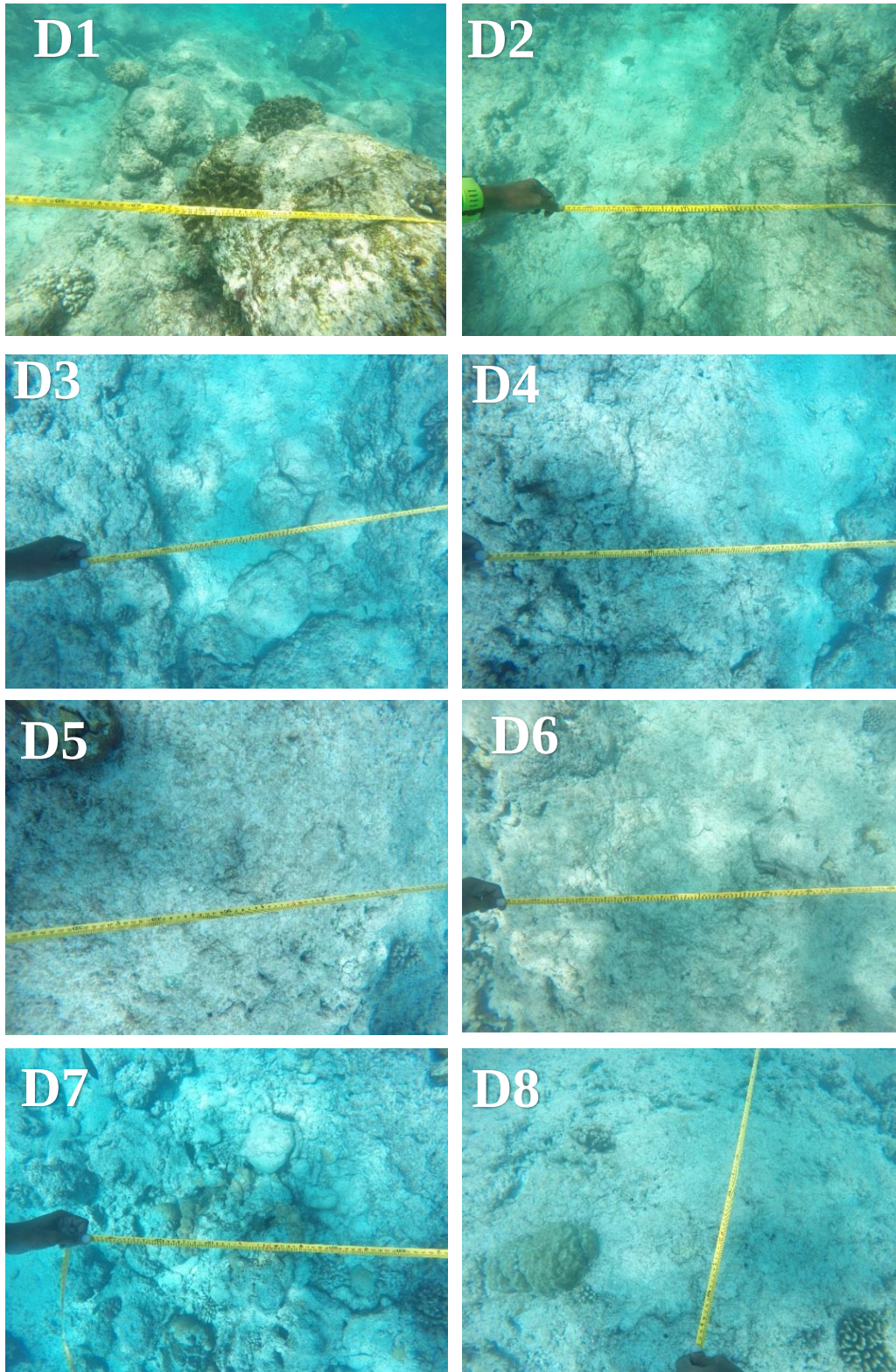


Figure 66: Selected photos of marine monitoring station 3. Depth 1- 2 m. Live coral cover was negligible based on data from three transects. Dominant cover at this zone were sand and rubble.

Fish Study at Marine Analysis Station 4

A timed swim of 10 minutes was conducted at the transect sites and Table 28 below shows that types of fishes observed with their relative frequency.

Table 28: Types of fishes and abundance Marine Monitoring Station 4

Scientific name	Common name	Relative abundance
Family – Acanthuridae		
<i>Acanthurus lucosternon</i>	Powder-blue surgeon fish	Common
<i>Acanthurus lineatus</i>	Lined surgeon fish	Common
Family – Pomacentridae		
<i>Abudefduf vaigiensis</i>	Sergeant Major	Rare
<i>Dascyllus aruanus</i>	Humbug Dascyllus,	Rare
Family – Labridae		
<i>Thalassoma hardwickle</i>	Six-bar wrasse	Rare
Family – Chaetodontidae		
<i>Chaetodon trifasciatus</i>	Oval butterflyfish	Rare
<i>Chaetodon triangulum</i>	Triangular butterflyfish	Rare

The combined live coral cover at this depth of Fuvahmulah house reef was negligible. This zone mainly comprised of rubble followed by dead coral. The fish study showed not many species of reef fishes were observed at this depth. The most common family of fish at this zone was the *Acanthuridae*. Most common fish species found include Powder-blue surgeon fish and Lined surgeon fish.

5.6.3 Benthic Cover and Fish Study Result Summary

Monitoring station 1 (T1, T2 and T3)

- The highest coral cover was observed at depths between 15 – 20 m.
- The combined live coral cover at this depth of Fuvahmulah house reef was 16 %.
- A large percentage of massive and free living corals were observed at these depths.
- More than 50% of live corals were found to be effected by bleaching.
- This zone mainly comprised of dead corals followed by rubble.
- Plate and mushroom corals were observed at this zone.

General observation was that live species cover gradually increased with the increasing depth of the water body above the transect. Near shore areas were dominated by rubble and dead corals (See Figure 67)

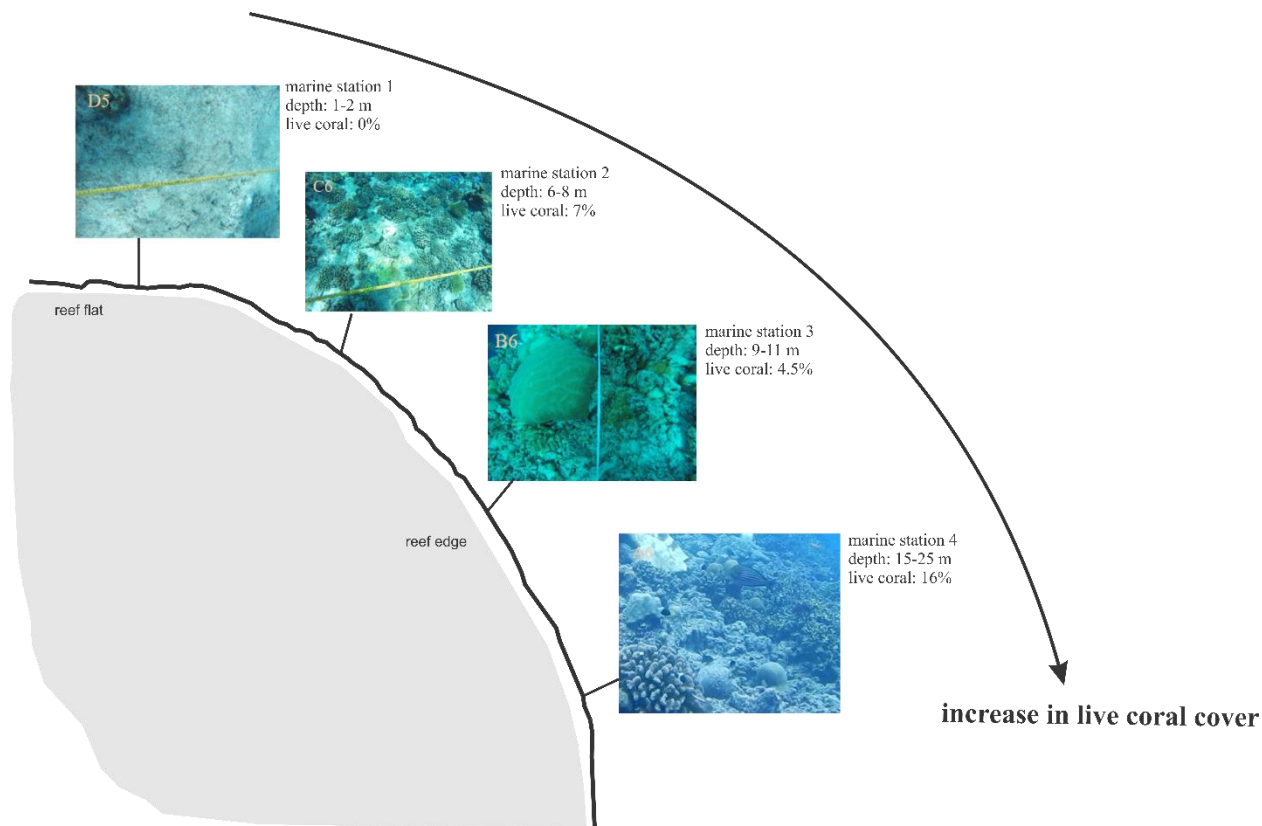


Figure 67: Increase in diversity and abundance moving further away from coastline and deeper into the reef slope at Fuvahmulah northeastern house reef (in the vertical)

- The fish study showed a diverse range of species at this zone. The biodiversity at this zone was significantly greater compared to the shallower zones of the reef.
- The most common families observed at this station include Pomacentridae, Caesionidae and Balistidae.
- The most abundant reef fishes observed include Two tone chromis, Indian trigger fish and yellow back fusiliers
- Other common reef fishes observed at the station were mimic surgeon fish, lined surgeon fish and striated surgeon fish. These were common between depths 15- 25.
- Orange striped triggerfish was however observed more commonly at 15 m while it was encountered less frequently during the timed swims at 20-25 m.

Monitoring station 2 (T1, T2 and T3)

- Coral cover was low between 9- 11 m at the reef edge.
- The combined live coral cover at this depth of Fuvahmulah house reef was 4.5 %.
- Massive corals and branching Pocillopora were found to be most common forms of live corals at this depth range.
- More than 50% of live corals were found to be bleached.

- This zone mainly comprised of rubble followed by dead coral.
- The fish study showed a diverse range of reef fish species at the zone.
- The most common family of fish at this zone was *Acanthuridae*, *Pomacentridae* and *Ballistae*
- Most common fish species found included Powder-blue surgeon fish Lined surgeon fish, Brown tang, Striated surgeonfish, Two tone chromis, Blue-green puller, Indian triggerfish and Bluestreak cleaner wrasse.

Monitoring station 3 (T1, T2 and T3)

- Coral cover was low to moderate between 6- 8 m.
- The combined live coral cover at this depth of Fuvahmulah house reef was approximately 7%.
- Massive corals were found to be most common forms of live corals at this depth range.
- More than 50% of live corals were found to be bleached.
- This zone mainly comprised of rubble followed by dead coral.
- The fish study showed moderate amount of reef fishes
- The most common family of fish at this zone was *Acanthuridae*
- Most common fish species found include Powder-blue surgeon fish, Lined surgeon fish and Striated surgeonfish

Monitoring station 4 (T1, T2 and T3)

- Coral cover was negligible between 0.5- 2 m.
- The combined live coral cover at this depth of Fuvahmulah house reef was negligible.
- This zone mainly comprised of rubble followed by dead coral.
- The fish study showed not many species of reef fishes were observed at this depth
- The most common family of fish at this zone was the *Acanthuridae*.
- Most common fish species found include Powder-blue surgeon fish and Lined surgeon fish.

5.7 PROTECTED AREAS

Ministry of Environment and Energy has declared three areas in Fuvahmulah Island as Protected Areas since 2012. These areas include the “*Bandaara Kilhi*” and its associated wetlands which covers an area of 52 ha, “*Dhandi Magu Kilhi*” and its surrounding wetlands covers an area of 63 ha and the unique *Thundi* beach and its associated reef located on the north end of Fuvahmulah Island covers a total area of 165 ha. (See Figure 68 for protected areas). The *Thundi* beach area is a very significant geographic location in the Maldives. Apart from being a pristine white pebble beach, it is the highest elevated point in the Maldives at approximately 4 m from MSL. The area is famous for its marine wildlife, where dolphin and whale shark sightings are common according to locals.

Due to the wave conditions at the *Thundi* beach area it has also become a surfing point in recent years. The beach attracts a lot of locals and tourist alike. It has become famous over the past years

due to its geographic significance A management plan for these areas are being developed under Climate Change Trust Fund (CCTF) by the MEE.

As illustrated in the figure 68, the onshore revetment does not directly affect any of the protected sites although the north end of the planned onshore revetment will be within 100m from the boundary of the *Thundi* area.

As the onshore revetment will be at the interphase between the land and the sea, the structure is expected to have some impact on the sediment transport along the northeast coastline of the island. There is no clear evidence available to indicate that sediment from *Thundi* moving too far into southwards during seasonal changes. Whereas it is believed that *Thundi* oscillation is limited to a relatively narrow region between part of the northern coastline and north-eastern coastline as demonstrated in the Figure 29. It is also believed sediment transport along north-eastern coastline has been limited by the harbour constructed on the southern end of the island. Although it is hypothesised that the impact of onshore revetment will not be significant, due to lack of clear understanding of the near-shore current regime and sediment dynamics, a long – term coastal monitoring program has been proposed in this report to assess any changes that may take place as a result of the revetment. It is also suggested that the monitoring of *Thundi* beach be incorporated into the on-going formulation of management plan under the CCTF project. Figure 68 shows the protected areas of Fuvahmulah and Figure 69 shows aerial pictures of *Thundi* area.



Figure 68: Protected areas map of Fuvahmulah

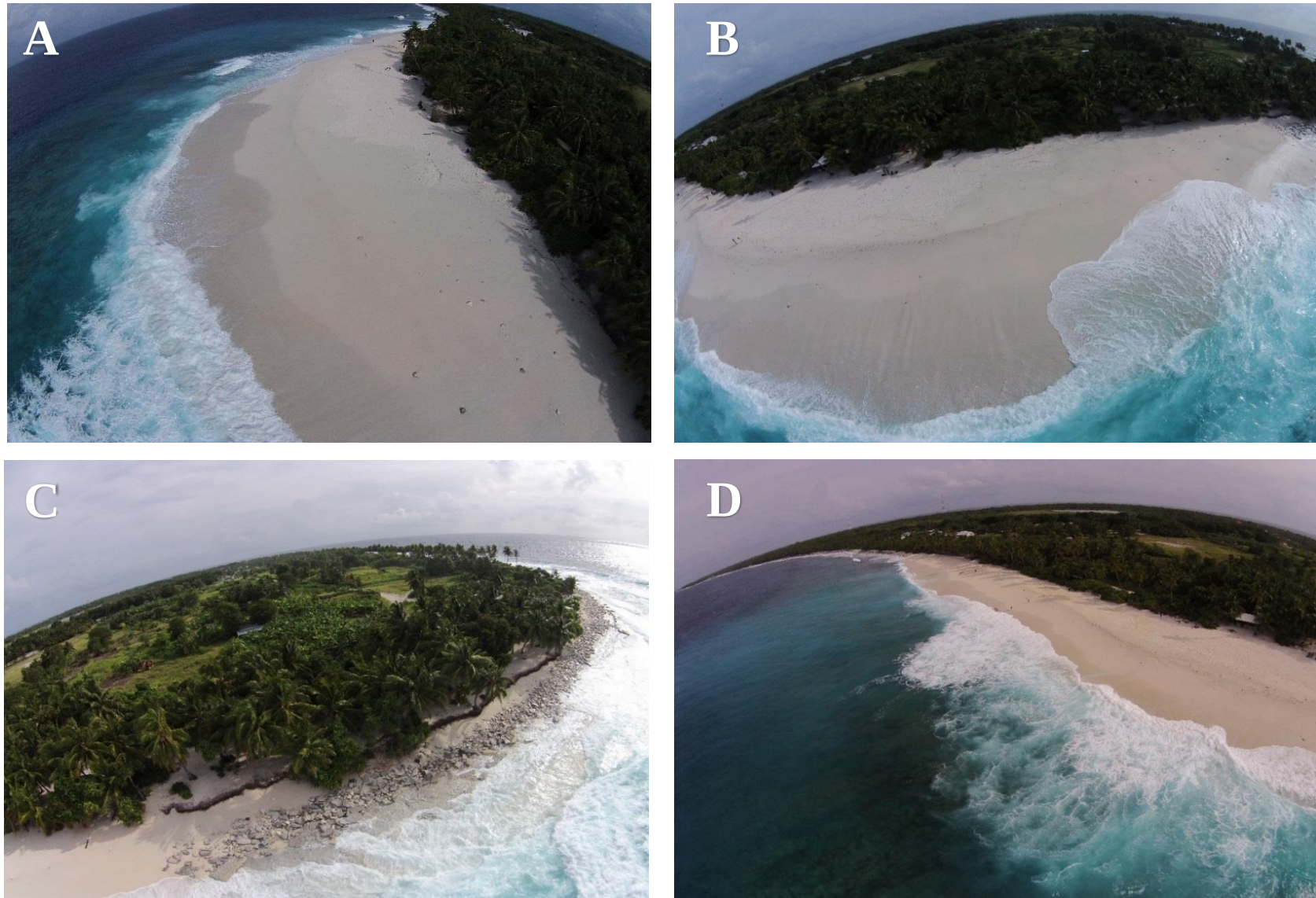


Figure 69: Thundi beach area during the southwest monsoon (A, B and D) accretion on northeast (C) erosion on the northwest

5.8 MARINE WILDLIFE

Some of the unique marine wildlife that are found in Fuvahmulah include:

- Thresher sharks which are encountered at the south eastern side of the island during the north east monsoon according to locals. According to local divers two species of thresher sharks which include the bigeye thresher (*Alopias superciliosus*) and common thresher (*Alopias vulpinus*) are observed at this area.
- Tiger sharks which are encountered at the eastern reef of Fuvahmulah according to local divers.
- Dolphins (*Tursiops aduncusare*) have been sighted from the open sea to the north of *Thundi* both by the people visiting *Thundi* and traveller around that area.

Literature shows that the near shore ecosystem of Fuvahmulah is home to *katteylhi* (*Promethichthys prometheus*) – a unique large-toothed deep-sea fish (snake mackerel) that is only caught off the coast of Fuvahmulah at a depth ranging between 100 – 700 m. According to locals, *katteylhi* fishing ground is located on the western side approximately a kilometre off the reef edge. Figure 70 illustrates common locations for these species around Fuvahmulah coastal area.



Figure 70: Illustration of notable marine wildlife around Fuvahmulah

5.9 TERRESTRIAL FLORA AND FAUNA

The outpost zone vegetation close to the proposed project location was dominated by *Cocos nucifera* (Coconut palm) (Figure 71). Occasionally other coastal species that have widespread occurrence throughout the Maldives such as *Hibiscus tiliaceus* (Sea hibiscus) and *Cordia subcordata* (sea trumpet) were also observed (Table 29).

Table 29: Common tree species found at project site

Local name	Scientific name	Common Name	Genus	Frequency
Dhivehi ruh	<i>Cocos nucifera</i>	Coconut palm	Arecacea / Palmae	Abundant
Dhiggaa	<i>Hibiscus tiliaceus</i>	Sea hibiscus	Malvaceae	Common
Kaani	<i>Cordia subcordata</i>	Sea trumpet	Ehretiaceae	Common



Figure 71: Vegetation cover at the project boundary. A – aerial view -B – ground level view – shows the outpost zone was mostly consisted of coconut palms.

Even though the Project site was found to be rather impoverished of biodiversity, Fuvahmulah is known for relatively rich diversity compared to most other islands in the country (MEE, 2011). The island is unique for its two protected wetlands. The wetland areas of Fuvahmulah are mostly made up of dense vegetation ranging from ferns to reeds traditionally used for weaving mats to taro fields, an abundance of water spinach and plant varieties such as *Syzygium cumini* (Jambu), Pond-apple, Mango, Pineapple, Screw pine, Tropical almond, Cheese fruit, Ambarella, Banana trees and others. The marsh land is surrounding the two fresh water ponds in Fuvahmulah, which is the habitat of the protected Common Moorhen, (*Olhuvalu Kanbili*) (Figure 72), is locally only found in some southern atolls of Maldives. According to local wetland management unit, the wetlands are frequented by numerous migratory bird species during the north east monsoon including terns and frigate birds



Figure 72: Protected common moorhen in Fuvahmulah

5.10 HAZARDS AND VULNERABILITY

Natural hazards that occur in Maldives can be broadly distinguished into geological and meteorological hazards. Based on the DIRAM (UNDP, 2008) the following hazards are relevant to the project location.

- Wind storms;
- Swell waves and wind waves;
- Flooding due to heavy rainfall/storms;
- Gravity waves (sea swells and *udha*); and
- Tsunami.

DIRAM report stated that major natural hazards in the Maldives are strictly controlled by the geophysical and climatic settings and shows quite different patterns in their distribution, as shown in Figure 73.

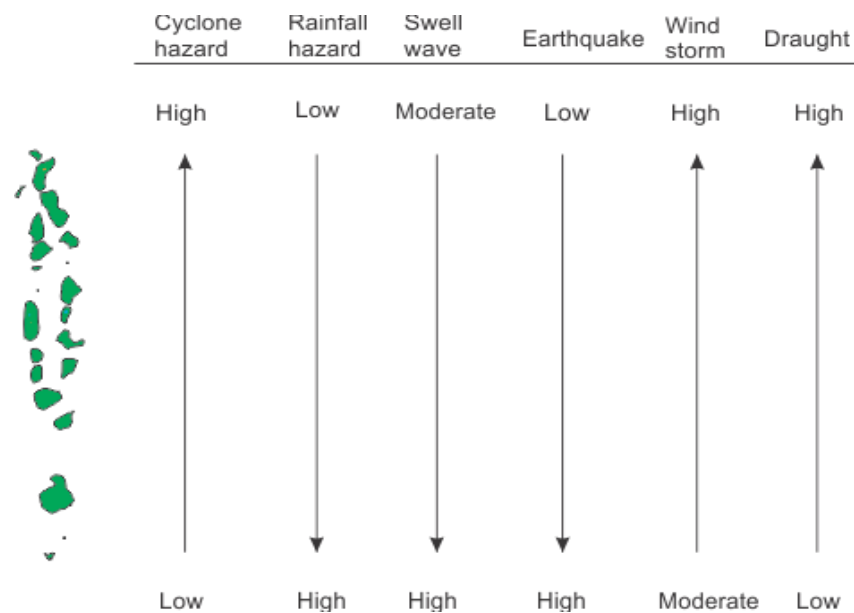


Figure 73: Exposure to hazards based on geographic location of atolls (Source: UNDP, (2008))

The damage potential based on frequency of natural hazard to the Maldives is summarized in Table 30.

Table 30: Damage potential based on frequency of hazard (Source: UNDP, 2009)

Hazard	Tsunami	Swell waves or storm surges	Rainfall flooding	Strong winds
frequency	Once in 200 years	Occasionally every year	Once every year	Several times a year
Potential damage	Very high	high	moderate	low

Maldives being located within the equatorial region of the Indian Ocean is generally shielded from cyclonic activity (UNDP, 2005). There have only been a few cyclonic strength depressions that have tracked through the Maldives, all which occurred in the northern and north central regions. Only 11 cyclones crossed the islands over the entire span of 128 years. None of them passed the southern (project) islands.

The northern atolls are at a greater risk from being effected by cyclonic winds and storm surges compared to southern atolls as depicted in Figure 74 (UNDP, 2009).

Based on (UNDP, 2005) and (UNDP, 2009) studies it was observed that Southern atolls including Fuvahmulah was more susceptible to swell waves. Swell waves may cause or accelerate erosion of islands. This will in turn lead to weakening of the island ridge formed from consolidated rocks.

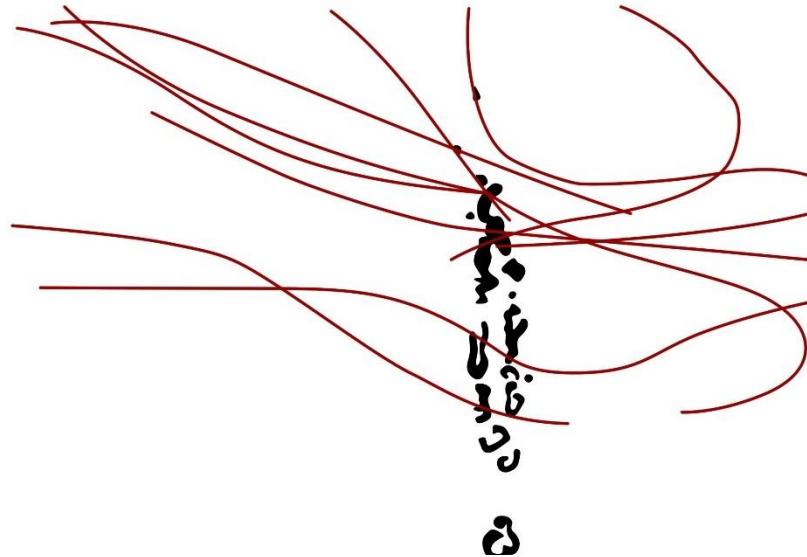


Figure 74: Tracks of cyclones affecting Maldives, 1877 - 2004 (Source: UNDP, 2009)

Failure and weakening of island ridge may lead to inland flooding. Inland flooding and the energy of waves would have numerous negative environmental and social impacts.

These include:

- Damage to coastal structures such as mosques and restaurants
- Salt water intrusion into the ground water lens of island.

A detailed feasibility study carried out for the Fuvahmulah coastal protection project highlighted and studied the main risks Fuvahmulah faced, based on different climate change and sea level scenarios.

The feasibility study by RHDHV (2015) stated that Fuvahmulah faced three main coastal vulnerabilities. All three threats were related to flooding of the island as determined by the feasibility study.

Threat 1. Erosion-induced flooding of the island due to a breach in the ridge, caused by either:

- a) Ongoing erosion of the coastline which can ultimately lead to breaching of the ridge and flooding of the island.

In an erosion survey of the Fuvahmulah coastline Ministry of Environment (2006) average erosion rates of 1.5 m per year was observed, the study concluded that with the ridge width of 40 meters in 2006 could lead to breaching of the ridge in 27 years from 2006.

A single severe storm event can accelerate the erosion and breaching process. Such storm erosion of the ridge can cause palm trees to fall down, taking roots and large fragments of soil away from the ridge. This will lead to large gaps in the ridge and can cause rapid breaching of the ridge.

b) Threat 2. Overtopping:

High water levels and waves cause overtopping of the ridge resulting in flooding of the coastal area. This can happen during high water in combination with large swell waves. Mainly the lower parts of the ridge are threatened and already face overtopping problems causing nuisance to houses and agriculture.

c) Threat 3. Seepage:

Erosion of the coastal ridge increases the seepage of salt water into the fresh water lens under the island. Events have been recorded where groundwater has become saline and cause damage to crops. These events are generally related to storm events with high water levels.

Climate change and sea level rise is expected to worsen the coastal stresses in Fuvahmulah due to long term sea-level change, resulting in increasing water depth over the reef allowing greater wave energy to propagate across the reef. Changing wave regime associated with climate change such as larger waves or change in angle of approach and change in intensity may exacerbate the erosion and overtopping problems.

Climate change and sea level rise is expected to worsen the hazards in Fuvahmulah due to long term sea-level change resulting in increasing water depth over the reef allowing greater wave energy to propagate across the reef. Changing wave regime associated with climate change such as larger waves or change in angle of approach and change in intensity may exacerbate the erosion problem leaving the coast and island more vulnerable.

It was estimated that waves reaching the Maldives would increase by 5% in the span of 50 years based on the RCP 2.6 scenario taking into account a sea level rise of 50 cm (RHDHV, 2015).

Although no complete records of the events of coastal erosion and wave incidents are available, from the information that was collected from reliable sources show at least 13 incidents involving coastal flooding and damages to the natural coastal defence of the island. Table 31 summarises some of these historical events obtained from various sources.

Table 31: Recent historical records of coastal flooding & erosion

Year	Month/day	Incident
1977	August, 18-13	Coastal flooding caused by high surf and storm surge was reported
1980	August, 27	Coastal flooding caused by high surf and storm surge was reported
1987	June, 3	Coastal flooding caused by high surf and storm surge was reported
1991	May 30 – June 12	Severe weather events and high waves that lasted for the period affected the island
2005	October	severe weather and high waves affected the island
2007	May	Swells caused flooding and salinization of groundwater in wells used for watering the agricultural plots. According to records it took about 15 days for the water salinity to improve to enable farmers to use it.
	July, 6	The island office recorded 34×16 ft beachrock detached and broken from the east coast. The incident also resulted in falling down of 2 coconut palms in the area
	October	An area between Rasgefannu and <i>Bandahelafannu</i> a lump of beachrock got separated and fell apart due to wave action.
2008	May	A large chunk of beachrock measuring 37×5 ft was reported to have detached from the coast in the beginning of the month. The area affected was on the eastern side between Rasgefannu and <i>Bandahalufannu</i> .
	July, 28	Farmers growing crops in the northern area of the island complained that the groundwater wells used for watering the farmlands became saline and were unable use it for their crops. After waiting for up to 4 days for the water to improve, they had to dig new wells further inland. The wells that became saline were dug 150 ft inland from the shoreline and the new wells were located 700 feet from the shoreline. Salinization of the groundwater occurred at a crucial time when the peak season for watermelon was approaching. The incident was caused by the tidal inundation of waves that affected 200 ft inland. North area which got affected is extensively used for growing vegetables and water melons.
	August, 4	Local media reported a large portion of beachrock cut off from the east coast believed to be due to wave action. The detached block measured to be 30×9.5 x 4 ft.
	December, 22	The island experienced severe wave attacks on the eastern coastal areas with resulting fracturing and damaging the beachrock from three different regions, loss of land and falling down of coconut palms from the coast was also recorded. Beachrock blocks measuring 25×10 ft, 25×8 ft and 13×8 ft fell off as a result of this event.
2009	January, 15	high waves affected north-eastern coastal areas of Fuvahmulah. It was reported that waves reached 159 feet inland. Waves overtopped the seawall constructed at Rasgefannu to protect the shore. The incident affected the groundwater quality of the wells used in the houses in the affected area. This high wave episode also flooded the drainage system. The incident lasted for a few days.
2011	August, 6	Flooding caused by the ocean swells was recorded. The affected areas were mostly on the western side and the seawater reached up to 100 feet inland. Some sweater flooding occurred near the existing airport area. According to the information provided by the National Meteorological Centre (NMC), the incident was caused by a strong storm formed on the southeast of the Maldives. Wave heights reached 9-10 feet according to NMC. No major damage to the infrastructure was reported.
2013	February, 13	<i>Malegan</i> area on the eastern side of the island affected by swells affecting up to 90 feet inland from the coast. Beach erosion and loss of vegetation was also reported. No property or houses reported damage.

5.10.1 Flooding

Based on the UNDP (2005, 2009) reports and the Feasibility Study (RHDHV, 2016), the main threat to the island remains to be flooding of the islands as a result of coastal degradation and waves. Inland flooding is perceived to occur through degradation of the island ridge formed as a result of the high energy environment created at the coast. The ridge acts as a protective shield and is significantly elevated compared to the mean elevation of the island. (See section 5.3 for description of coast). When a breach will develop in the island ridge, the low-lying centre of the island will be flooded and will destroy agriculture, nature, infrastructure and other assets. If no measures are taken, the ridge can breach in the future due to either ongoing erosion (case A) or sudden breaching due to a severe storm event (case B). A combination of both processes is most likely.

In either case, inland flooding occurs when the breaching process of the ridge is initiated by incoming waves. The extent of breach will depend upon the water level, wave height, currents and condition of the ridge. The duration of the flooding event will be governed by the extent of storm conditions in combination with the tide level. Typically, high water and swell waves can last for long periods at the region where Fuvahmulah is situated. At the end of high tide water inflow stops however saline water which had entered the island would flow down the elevation gradient and remain at the lower parts of the island. The predicted island flooding is demonstrated in Figure 75.

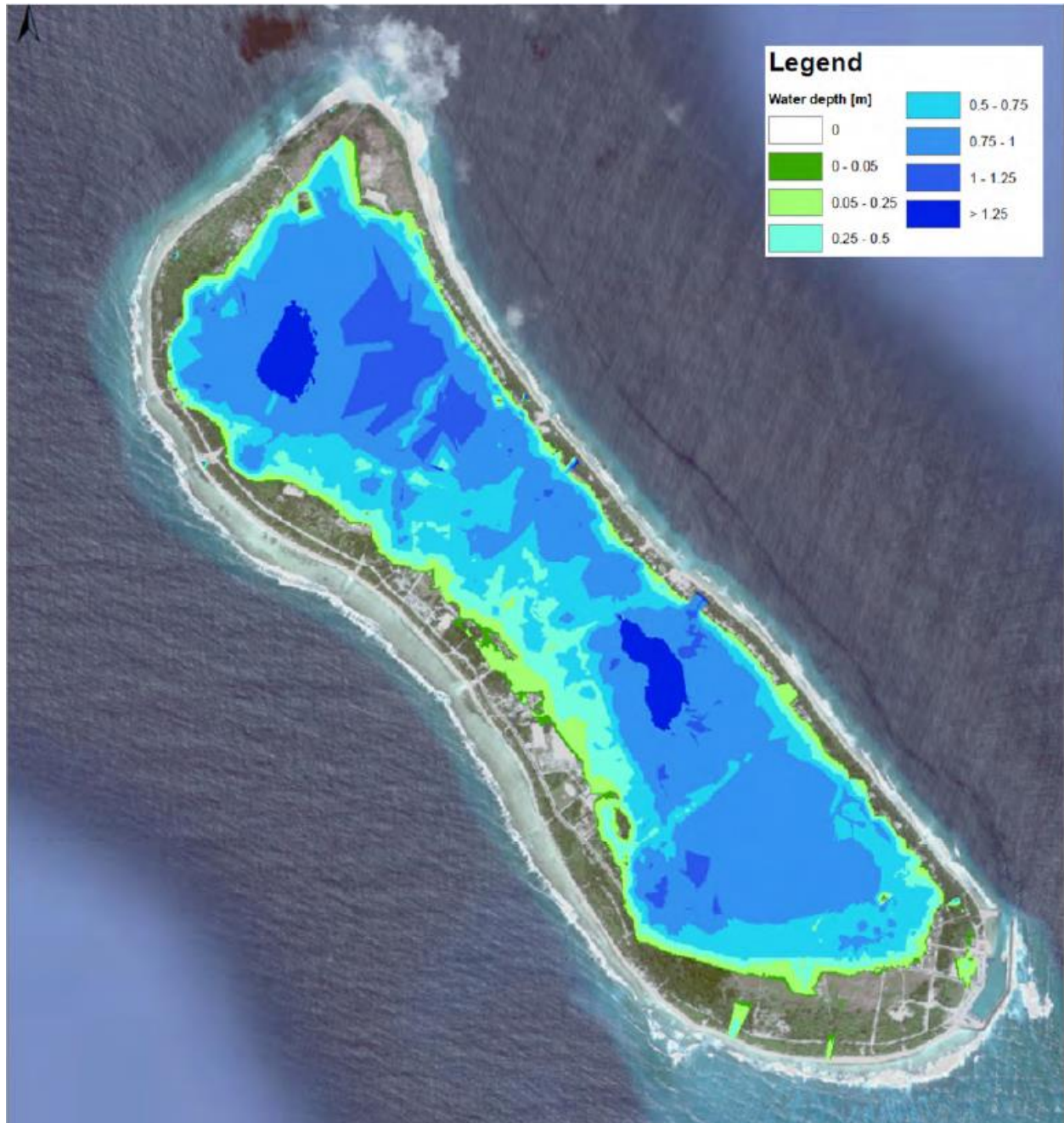


**Figure 75: Potential flooding at Fuvahmulah due to a 1/10 per year flood event, +0.2 m sea level rise
(Source: RHDHV, 2015)**

6. EXISTING SOCIO-ECONOMIC CONDITIONS

6.1 INTRODUCTION

This Chapter covers socioeconomic environment of Fuvahmulah as required in the ToR for the EIA study. The demographical, economic situation, land use planning, natural resource use, accessibility, transport services, basic infrastructure services such as water supply, wastewater disposal, solid waste disposal, energy supply and social services (health, education, security and recreation) and community needs of the local population is covered in the following Sections.

Fuvahmulah is one of the largest urban centers of Maldives with a relatively large population and relatively good economic and social infrastructure and services.

The island is need of a sustainable coastal protection system to prevent erosion and flooding for the social well-being of the community.

Therefore, the proposed project would decrease the community vulnerability to uncontrolled erosion and would increase the resilience and opportunities of the community to build on a stable and healthy development of the island.

6.2 HISTORICAL OVERVIEW

The island has been inhabited since 1,500 years. There is a belief that Fuvahmulah once had a lagoon in the centre of the island with a channel connecting the lagoon to the sea. The channel closed by natural processes and the lagoon areas turned into the present two freshwater lakes, known as *kilhi* (Luthfy, 1994). This theory has also been reported by (Woodroffe, 1989). However, there is no physical evidence to validate this claim. The island community believes that Fuvahmulah was a small coral atoll whose southern end was open at a spot called *Diyarehifaando* and the inside of the island was a saltwater lagoon forming a natural harbour. There is a spot on the southern end known as *Kudhuheraival* (forest of a small islet), which indicates there was a small separate islet there in ancient times. The community believes the channel connecting the lagoon with the ocean was closed by massive coral boulders in the past.

Settlements were initially located on the rim of the island, but difficulties in farming due to the hard subsurface led to the gradual encroachment into low-lying wetland areas (Luthfy, 1994). H.C.P Bell (1940) in his Monograph has identified Fuvahmulah as the most beautiful island in the Maldives, because it is a one-island atoll rich in ecological diversity. Fuvahmulah is also unique for its cultural and heritage value. There is a Buddhist stupa (burial mound) locally known as Fuvahmulah *Havitta*. H.C.P. Bell in his 1922 expedition observed two *Havitta*, the big *Havitta* about 40 feet in height and a smaller mound, about 15 feet in height that was located nearby. The heights and shapes of these have been modified by excessive and unauthorized digging for artefacts during the 1940s, but still the ruins look like a hill. The island also contains monuments of the Islamic period, mosques built from coral stones. The oldest important mosque is called Gemmiskiy, which also include an ancient graveyard and a well. There is also an ancient circular bath with stone steps, locally known as *Vasho-Veyo*.

Fuvahmulah is the third largest inhabited island of the Country, in terms of its land boundary with 484 Hectares. The habitable land is estimated at about 300 Ha. Fuvahmulah is a relatively urbanized island. The island has all the required facilities in terms of paved roads and other modern infrastructure. The settlement footprint covers 65-70% of the total habitable area. The population density of Fuvahmulah (excluding the non-habitable wetland area) is 22 persons per ha, which is low compared to most islands of Maldives. Fuvahmulah has 2300 allocated land plots, of which 1700 are in use for houses.

6.3 RELATIVE IMPORTANCE OF THE PROJECT ISLAND

Protecting the eroding coastline, preventing further loss of land to erosion and safeguarding the community to the results of the erosion is a critical requirement for the community of Fuvahmulah. Protection of Fuvahmulah coastline has been in the government priority for nearly a decade and the small scale attempts implemented so far to curb erosion have proven unsuccessful.

Although coastal erosion is experienced by many other islands in the Maldives, Fuvahmulah has become the priority island for a number of reasons as summarised below:

- The island of Fuvahmulah, one of the biggest and most populated island in the Maldives;
- Dhivehi Language dialect spoken in Fuvahmulah, which is unique to the island;
- Fuvahmulah is the only island which is administratively considered as an atoll in the Maldives;
- Fuvahmulah has always been considered as special by the Maldivians, mainly due to its natural beauty from the rich biodiversity. It supports a diverse range of habitats including tropical woodlands, inland fresh water wetlands, fresh ground water, back yard fruit and vegetable trees, land, beach and a dense coastal vegetation belt;
- Fuvahmulah also contains the largest wetland in the Maldives (legally protected under Environment Law) with an estimated area of over 141 Hectares comprising about 33% of the island;
- The livelihood and food security of the island is very much dependent on agriculture, which is exceptional for the Maldives. Major products, like coconut (70 percent of national production in 2006), taro, mango and banana come from Fuvahmulah;
- Fuvahmulah has the infrastructure for education, health, transport and security. The island has one higher secondary school and three schools which teach from primary to secondary grades. There is one atoll hospital, and one power station with 3 generators. The island also has a police station and one fire and rescues station operated by Maldives National Defence Force (MNDF). The island has an airport and a harbour facility;
- The GoM has recently accorded city status to Fuvahmulah making it the third City in the Maldives (Male' and Addu Atoll are the other two cities). The city status will draw further investments to the island; and
- The GoM is investing in the island, future projects such as the sewerage system and treatment, a ring road and housing. The improvements in infrastructure will also enhance businesses which will enhance the economic value further. Though not quantified, it is

clear that these developments can be regarded as very beneficial to the economic viability of the proposed coastal protection measures.

Fuvahmulah is considered one of the envisaged growth centre islands in the Maldives for the future. The Government of the Maldives is further investing in infrastructure and development of the island through several ongoing projects, and has the intention to develop Fuvahmulah as a safe island with a concentration of population and facilities that will attract people both from smaller less populated islands as well as offer an alternative for migration to Male'.

6.4 LAND USE

Fuvahmulah can be considered as a highly urbanized island with a high population density. The settlement footprint covers 65-70% of the total habitable area.

A large portion of the land in Fuvahmulah is locked as it is declared protected as wetland areas. Within this settlement footprint the population density excluding the wetland area is 22 persons/ha.

Since the construction of harbour, major changes have been brought to the island structure. Hence, a large portion of the land available is currently being used for housing and infrastructure, economic establishments and public infrastructure such as schools, offices and health facilities. The harbour area is considered as the industrial and commercial zone of the island. The fish market, boat building yards and some engineering workshops and garages are located in this area. The atoll council has plans to lease more land for commercial activities in this area. The other economic establishments such as restaurants and shops are distributed along the main road that runs around the island. The southern side of the island holds the airport infrastructure and the runway. This area also has land allocated for a city hotel.

Fuvahmulah has 8 administrative wards, which vary in housing concentrations. The highest spatial concentration is in the central area of the island. Future housing requirements pose a challenge to the island and particularly to some wards. Some members of the public are of the view that more housing plots are needed to be given from the buffer zones around the protected wetland areas to cater for additional housing requirements.

Geomorphological characteristics of the island limits the areas of the island that can be used for building purposes. As the existing land use map given in Figure 76 shows the outpost zone of the island consisting of mixed littoral vegetation has been reserved for environmental protection and set aside as the environmental protection zone (EPZ). In most areas adjacent to the project boundary the undergrowth has been cleared as coconut palms dominate the littoral vegetation. Several openings in the EPZ provide easy access to the beach and sea.

The eastern peripheral land being significantly narrower than the land available on the western side, relatively fewer buildings are found bordering with the Project site. In addition to a number of residential plots, a number of institutional and community facilities have been located between the main road running from north to south of the island and the eastern coast – *Bahaaru Magu*.

These include seven mosques, a cemetery, two social centres, a historical site, and football field. According to the Atoll Council, the cemetery on the east coast is not in use anymore and so is the mosque adjacent to it. The mosques at Rasgefannu, the social centre and the football pitch at Rasgefannu have been exposed to the island's coast due to erosion with no barrier vegetation offering protection. The close proximity of important community facilities such as mosques will have to be taken into account when planning for the Project implementation so as to avoid sensitivities of the public. The existing land use plan of the island is given in Figure 76 and social and institutional facilities within the impact zone have illustrated in Figure 77. In terms of social leisure acuties *Thundi* is the most popular spot for the locals as well as for the visitors. It is frequented for picnicking, swimming, surfing and enjoying nature. No social or institutional facilities included in the impact zone will have a significant direct impact of the Project whereas they are likely to experience indirect effects of the Project all of which have been predicted to be temporary and reversible. *Thundi* area included in the impact zone will not be closed off during the construction period. The only facility that may need temporary closure is the football pitch at Rasgefannu which may require to be kept out of bounds for safety reasons during the construction of the breakwater segment opposite to it. *Anbule*, *Bandahafannu*, *Rasgefannu*, and *Bodufannu* are occasionally used for swimming during fine weathers and are not considered common swimming spots. These areas will have to be closed off during the construction period for safety concerns. These temporary measures are not expected to be of significant social impacts as alternatives are available for the locals.

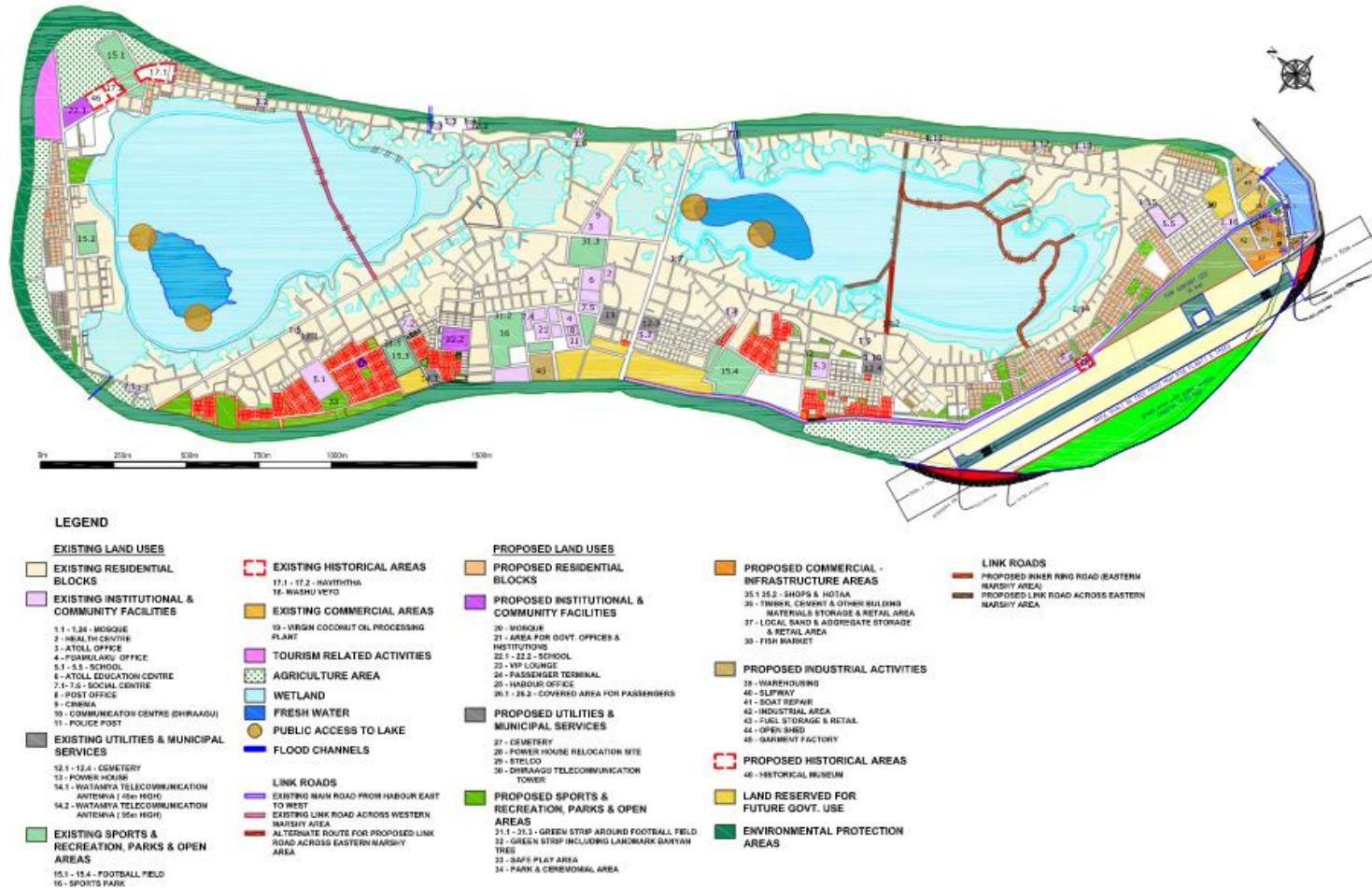


Figure 76: Land use plan of Fuvahmulah



Figure 77: Social and institutional facilities in the impact zone

6.5 POPULATION AND MIGRATION

According to Census 2014, the total population residing in Fuvahmulah is 8510, with 4085 males and 4425 females. Of the resident population, locals account for 7984 of which 3612 are males and 4372 are females. 526 persons are registered as foreigners of which 473 are males while 53 are females. It has a sex ratio of 83:100 (male to female), with an increasing population at an annual rate of 0.63% over the period 2006 till 2014, which is less compared to some other atolls in Maldives. The population density of Fuvahmulah is 22 persons per Ha which is very low compared to most islands of Maldives. The low density is attributed to the fact approximately one-third of the island is occupied by wetlands and hence not suitable for housing. According to census 2014 Fuvahmulah population contributes 2.36% to the total population of Maldives. Population data of Fuvahmulah from 1990 to 2014 are shown in Figure 78.

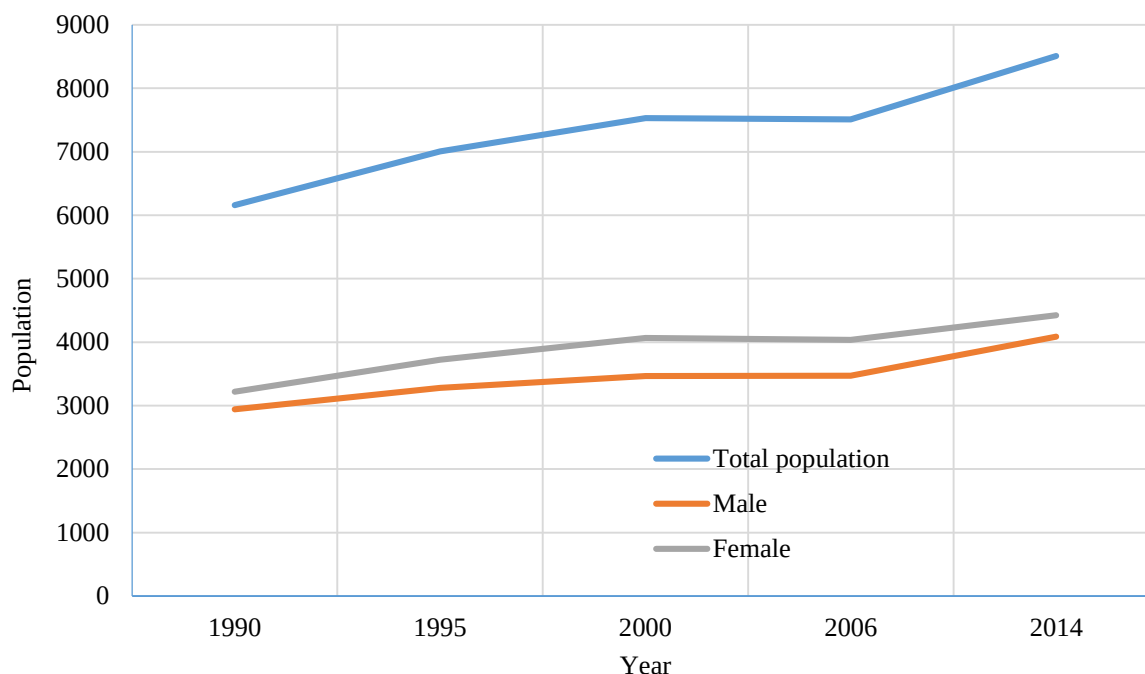


Figure 78: Population of Fuvahmulah 1990 – 2014 (Source: DNP, 2014)

According to the Atoll Council, the registered population of the island in May 2015 is 12,224, out of which 8510 are residing in the island. This means that 30.4% of the island population has migrated to other atolls and to Male'. According to census 2014, 25% of the residents migrated from the island which means that the number of people migrating to other atoll has been increasing. Recent data on the distribution of the out migration of Fuvahmulah population and the reasons for migration is not available. 17% live in the capital city of Male'.

The main reasons for migration according to Census 2014 were for the purpose as for education (4%), for employment opportunities (6%), return migrant to live in the island (55%), family

migration (18%), Marriage (8%), as parent/ guardian (0.7%) & medical (0.2%). According to these statistics 55% of the people preferred to live out of Fuvahmulah in another island. Majority of the people living in Fuvahmulah were registered and native to Fuvahmulah, however, 5% of people residing in Fuvahmulah were registered in other atolls.

Furthermore, with the increasing development of the island it is also noted that number of foreign workers residing in the island is increasing. According to 2014 Census, 6.2% (526) of the population residing in the island are expatriates. However, this is less compared to some other atolls in Maldives. The main sectors in which the foreign workers are employed includes health sector, education field, construction area, agriculture and as house maids.

In the Maldives, population consolidation really depends on the political agenda and there are no detailed policies with regard to this. Fuvahmulah residents have always had a strong sense of belonging to their island socially and culturally. There is no expectation that residents of Fuvahmulah would be relocated to another island. However, the concentration of population to larger islands concept, could apply to Fuvahmulah, whereby populations from other atolls could be moved into the island, increasing its population in the near future. While this may be a possibility at this stage it is not clear if that would happen in a near future. Such a policy to bring people from another small island to Fuvahmulah can also strain the island's resources in particular suitable land for housing.

The population of Maldives is ethnically homogenous with no recognized sub-categories. It can therefore be stated with confidence that there are no "indigenous minority" groups which need to be separately considered for the purposes of this study. In view of this, it is clear that there is no need to evaluate any impact on indigenous people.

6.6 HOUSEHOLD AND FAMILIES

Generally, in Maldives, most households are based on extended families. But recent developments show that the numbers of nuclear families are increasing. According to the 2006 census, the total number of households in Fuvahmulah is 1,332 and average household size is 5.7. This is less than the average household size of 6 in 2000. No recent official data are available. The total number of houses as given in table 32 in Fuvahmulah Island is 1,827.

Table 32: No of Houses belonging to administrative wards

Ward	No of Houses
Dhandimagu	263
Dhiguvaadu	205
Hodhadu	252
Maadhadu	183
Miskiymagu	292
Funad	229
Malegan	126
Doodigan	277
Total	1,827

6.7 GENDER

The 2014 gender development index (GDI) puts the Maldives in 104th place out of the 188 countries ranked (UNDP, 2015). The GDI measures differences between male and female achievements in three basic dimensions of human development: health, measured by female and male life expectancy at birth; education, measured by female and male expected years of schooling for children and female and male mean years of schooling for adults ages 25 and older; and equitable command over economic resources, measured by female and male estimated earned income. The Maldives has particularly strong performance on female educational attainment.

The Gender Empowerment Measure (GEM) is an index designed to measure of gender equality puts Maldives in 95th place out of the 135 countries ranked, ahead of India at 105 but behind Sri Lanka at 39. It was introduced at the same time as the Gender-related Development Index (GDI) but measures topics like empowerment that are not covered by that index.

The Government's policy to provide education to all children, and exclude no one is the most accomplished policies of the Government. As a result, equal opportunities to education for male and female child is available from primary to secondary education. As education is the most vital instrument for women's empowerment, this paves the way for more opportunities for women in high-paying positions with economic power and decision making.

Fuvahmulah is one of the few atolls in Maldives where higher secondary and tertiary education is available. These opportunities are equally available for males and females in the island. As a result, family members do not have to be separated for education and leads to social impacts experienced by women being very positive. This reduces the work load on women in maintaining the home and increases family cohesion.

As the same as education, there is universal and equal health care services provided to male and female population in Fuvahmulah through the Fuvahmulah Atoll Hospital. The state provides medical insurance to both the gender. The islands also have pharmacies which is covered under national medical insurance scheme Asandha. Pregnant women are provided pre-natal care and

births are attended by skilled health care professionals, as a result maternal deaths are rarely occurring in the island.

The Vulnerability and Poverty Assessment conducted in 2004 shows that there is disparity between males and females when it comes to employment. The percentages of employed males (89%) are more than that of employed females (71%). Similarly the percentages of unemployed females (29%) are more than unemployed males (11%) (UNDP, 2005).

In addition to this, gender differences are clearly visible in the sectors men and women are employed. In Fuvahmulah, no women are elected to the Atoll Council, mainly due the fact that no woman had contested in the election. As mentioned above there are no official data available but according to the island records more women engage in agricultural practices such as growing vegetables and household level small-scale catering services such as preparation of “short eats”, which they sell to their immediate communities. As a result, women directly benefit from increased income generation opportunities and, in most cases, from control of what they earn. More men engage in fishing sector, transportation industry and construction industry.

Gender differences can be seen in the employment sector. In 2004 (most recent available data) there are more employed men (89%) than women (71%). Accordingly, there are also more unemployed women (29%) than men (11%). In addition, gender differences are visible in the sectors where men and women are employed. According to the island records more women are engaged in agricultural, such as cultivating taros and vegetables and more men engage in fishing sector.

There are a number of female headed households in the island, but the exact number is not known. As per the atoll council, there are many men from the island, who are working in resorts and in Male’ and these houses are headed by females with the men working outside the island. The gender disparities in the main activities of the island are shown in Figure 79.

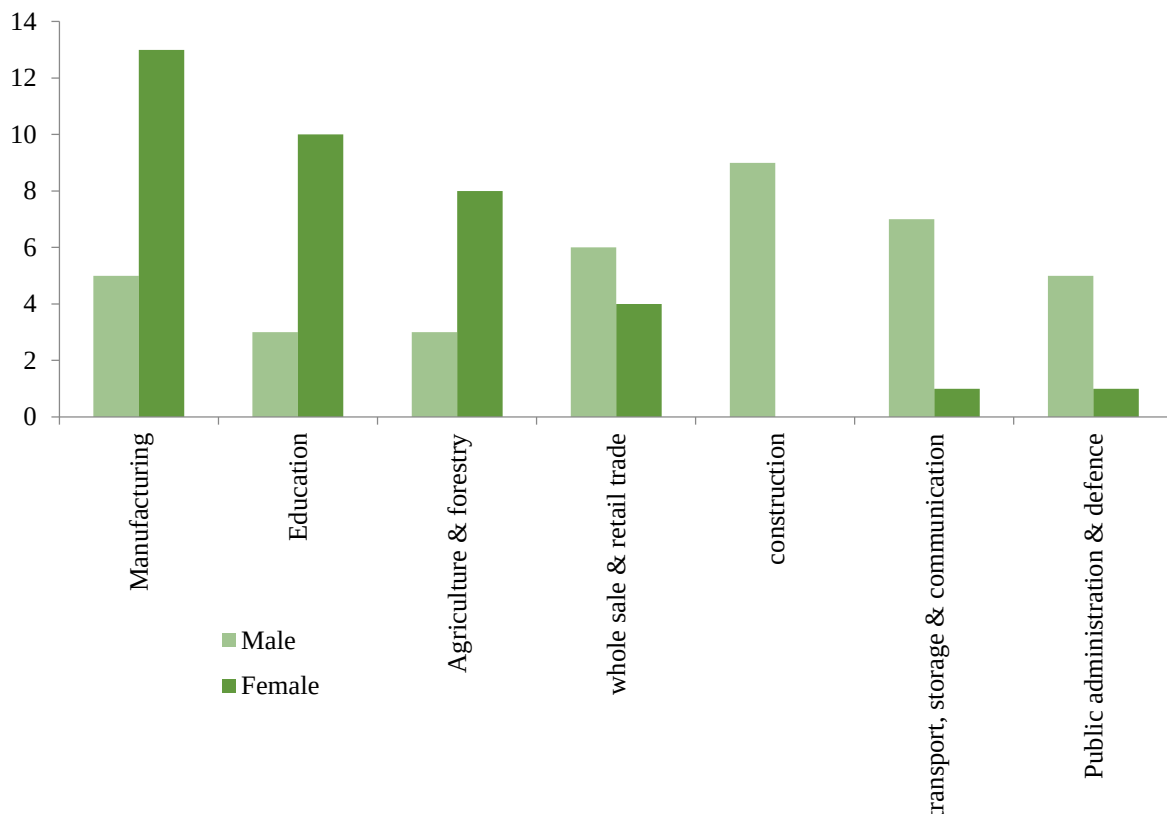


Figure 79: Gender disparities in economic activities in Fuvahmulah
 (Source: Ministry of Planning and National Development, Census 2006)

6.8 ECONOMY AND EMPLOYMENT

Fuvahmulah is the third largest island in area in the Maldives and the third most populous. According to the 2006 Census, the total economically active population is 2,914, the labour force participation rate is 62%, and the unemployment rate is 25%. Most of the employment is in public administration (25%), manufacturing (19%) and agriculture (11%). Fishing occupies 7% of the working population. As on other islands, employment opportunities are limited on Fuvahmulah, resulting in significant emigration to other islands to seek work (especially Male' and the resorts). One of the major problems challenging the people of Fuvahmulah, especially youth, is lack of employment opportunities.

Existence of several government offices and services makes the public sector the largest employer of the island. In addition to government offices various service providers, numerous retail shops, teashops, transport and telecommunication services, agriculture, construction and other small industries provide numerous job opportunities for the people of Fuvahmulah.

Agriculture is a traditional sector and in 2006 11% of the working population was involved in it. Both men and women participate actively in agriculture. Products including mangoes, watermelon, coconuts, pumpkins, bananas butternut, and yams are grown, and some traded in Male'. In 2009

agricultural products brought from Fuvahmulah and traded in Male were valued at over Rf 6 million. Taro is a major crop grown in the wetlands and consumed locally. Island-grown cucumber, capsicum, fresh beans, tomatoes, lemon and passion fruit contribute to the island's food self-sufficiency.

According to the 2006 Census, 7% of the working population is involved in the fishing industry. Some 145 people are involved in tuna fishing in the island, with 19 vessels regularly going out. This is relatively less than other atolls. The main type of fishing is with pole and line (trolling, with outriggers) using live bait. Fishing is conducted throughout the year except Fridays and religious holidays. The best fishing season is the north-east monsoon from December to March, with March the best month. Fishing continues through the south-west monsoon, April to November.

Over the last years, especially since the celebration of the SAARC Summit on the island and the construction of the airport, easy access to the island has been enabled and therefore initial steps for tourism development have been taken. Since 2008 it is possible to develop guest houses on inhabited islands. This fact has also provided new opportunities for the island.

A number of restaurants and guest houses have been developed since and in August 2013 the first guest house registered to receive tourists was opened. Currently, there are a number of enterprises related to tourism (food providers, accommodation providers) that already have an adequate level of quality to receiving tourists and they are promoting tourism on the island.

The tourism offer is in the initial stages but the presence of a Dive Centre (recently opened) increases the attractiveness of the island.

6.9 EDUCATION

Fuvahmulah is one of the few islands where higher secondary and tertiary education is offered in the Maldives.

As of July 2016, according to Atoll Council, there are 2808 students and 245 teachers working in 10 educational facilities on the island. Gn. Atoll Education Centre, the only secondary and higher secondary school serving in the island and is also the largest education facility in the island. Inaugurated on April 20, 1982, it currently serves more than 1000 students. The 3 primary schools of Fuvahmulah include Fuvahmulaku School (FS), Madharusathu-Sheik Mohammed Jamaaluddeen (MJM) and Hafiz Ahmed School (HAS). There are also 8 preschools in the island managed by the governments as well as private parties. From 2012 onwards Villa College Fuvahmulah campus is offering degree courses in the island which gave opportunities for many students who complete their secondary and higher secondary in the island, to pursue higher education. The island has a literacy rate of 95% (DNP, 2006).

According to Census – 2006, 47% of the people who have attained education, over the age of 6 has obtained primary education. However, there is a lesser number attending secondary education and further. The percent of population who have received secondary education is 12% with 10% completing GCE Level examination. Added to this, 6% completed certificate level education, only 0.3% of this population completed GCE A 'Level examination. 0.5% of the population have attained Diploma level, Degree and Masters Level ((DNP , 2006) (Figure 80).

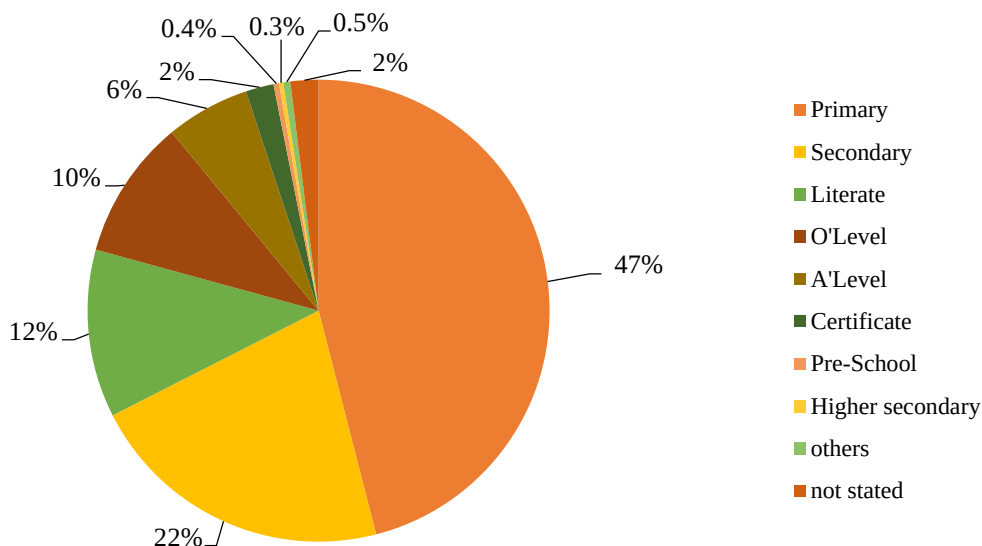


Figure 80: The levels of education attained by Fuvahmulah population in percentage over the age of 6 (Source: DNP, 2006)

6.10 HEALTH

The health services provided for people in Fuvahmulah are generally well compared to other atolls in the Maldives.

Health facilities are one clinic and two pharmacies operated by residents. Traditional medical practitioners also provide medical services.

The first Health Centre of Fuvahmulah officially started its services on May 12, 1973. Because of the geographical isolation of the island and rapid increasing population, the government had upgraded the health centre to a hospital on June 11, 2001. The hospital operates for 24 hours with 2 general practitioners, 4 specialists, 1 radiographer and 36 nurses. Medical tests like blood tests and urine tests can be done in the hospital.

Most commonly reported diseases are acute respiratory infections, viral fever, and diarrhoea. Other diseases rarely reported in the island include dengue fever, typhoid and scrub typhus.

No particular health related issue specific to the island had been recorded. Since late 1980s, all the children has been vaccinated as per WHO guidelines and diseases like TB, Polio has been completely eradicated from Fuvahmulah. The most common ailment is acute respiratory infections, with other significant diseases including dengue fever and diarrhea see (Table 33 and Figure 81). Cases too serious for the regional hospital in Fuvahmulah are transferred to Male". Other health facilities are one clinic and two pharmacies operated by residents. Traditional medical practitioners also provide medical services. The first Health Centre of Fuvahmulah officially started its services on May 12, 1973. Since its establishment, many developments have taken place in the health sector of the island. New infrastructure had been built and varieties of services were offered. Because of the geographical isolation of the island and rapid increasing population, the government had upgraded the health centre to a hospital on June 11, 2001. The hospital operates for 24 hours with 2 general practitioners, 4 specialists, 1 radiographer and 36 nurses. Medical tests like blood tests and urine tests can be done in the hospital ((DNP, 2016).

Table 33: Showing the total number of reported cases by selected diseases in Fuvahmulah in 2012
(Source: DNP, 2016)

Acute respiratory infection		Viral fever		Diarrhoea		Scrub Typhus		Dengue fever		Typhoid	
Under 5years	Above 5years	Under 5years	Above 5years	Under 5years	Above 5years	Under 5years	Above 5years	Under 5years	Above 5years	Under 5years	Above 5years
1863	2960	331	653	236	299	-	4	1	12	-	1

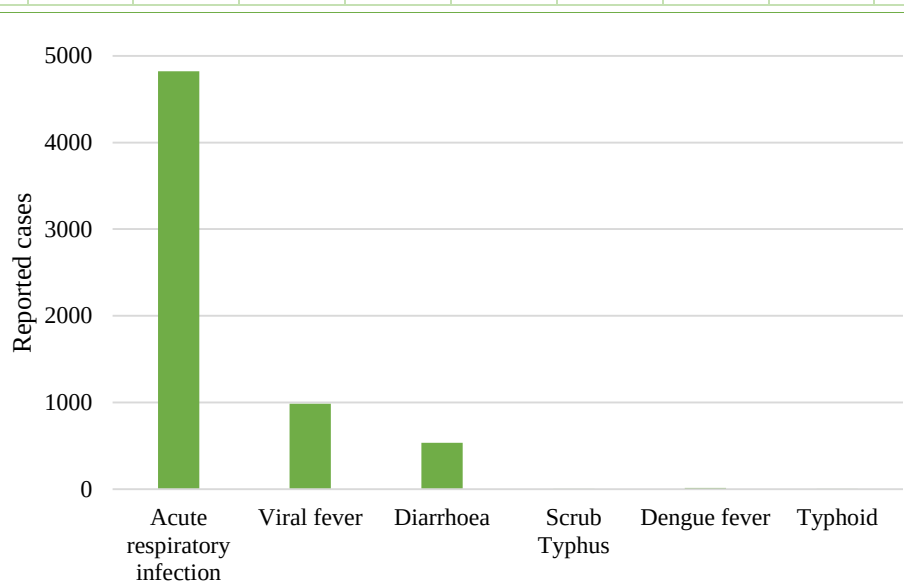


Figure 81: Common types of ailments on Fuvahmulah (Source: DNP, 2016)

6.11 ACCESS TO SOCIAL SERVICES AND CIVIC AMENITIES

Fuvahmulah is among the few islands outside Male' which has better infrastructures, facilities and services established. Numerous government projects have been implemented on the island in the past and even today development projects are taking place on the island. The isolated nature of the island together with relatively large population size inherently requires all services to be available not only for convenience but also to make it affordable and less dependent. Government sponsored projects and donor assisted projects have resulted heavy investments on the island. Most notable such project include the construction of the island's harbour on the southeast coast and the adjacent domestic airport. Successful completion of such development projects have resulted in improvements to quality of life enjoyed by the people. Almost all facilities that are generally required for a comfortable life are available on the island. Many teashops, restaurants, guesthouses, and convince stores, taxi services and sports facilities, are available on the island. Although the roads are not paved, they are maintained by MRDC unit in Fuvahmulah, regularly. Piped sewerage system and water supply service projects are now underway in Fuvahmulah.

6.11.1 Electricity

All houses in Fuvahmulah enjoys 24hrs of uninterrupted electricity service provided to the islands by state owned company; Fenaka Corporation Pvt. Ltd. Electricity is provided for 24 hours and according to the 85% of the respondents of the survey, the quality of the service provided by them is good. But the generator sets used to provide electricity are old and hence the service providers face difficulties in maintaining and managing the engines.

6.11.2 Communication

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

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

6.11.3 Transport

Until the development of the island's harbour on the north-east side, it was considered as one of the most difficult islands in the country for accessibility. The shallow and narrow lagoon associated with rough wave conditions that prevail around the island for much of the year created conditions that were extremely difficult for sea-going vessels often causing damage to vessels and even loss of many lives during their passage through the house reef. Ten different historical reef entrances

or channels have been created on the reef to get excess to the island (see Figure 82). The use of a particular entrance channel is believed to be dependent on the prevailing weather conditions at the time. According to the interviews conducted, creation of some of these channels heightened erosion and subsequently some of those were closed and even wave barriers placed. Most notable of these effects was visible at Rasgefannu where entrance, creation resulted severe erosion of the beach facing the channel. A small breakwater constructed opposite the channel seen at present was to prevent the heavy waves reaching the coast.

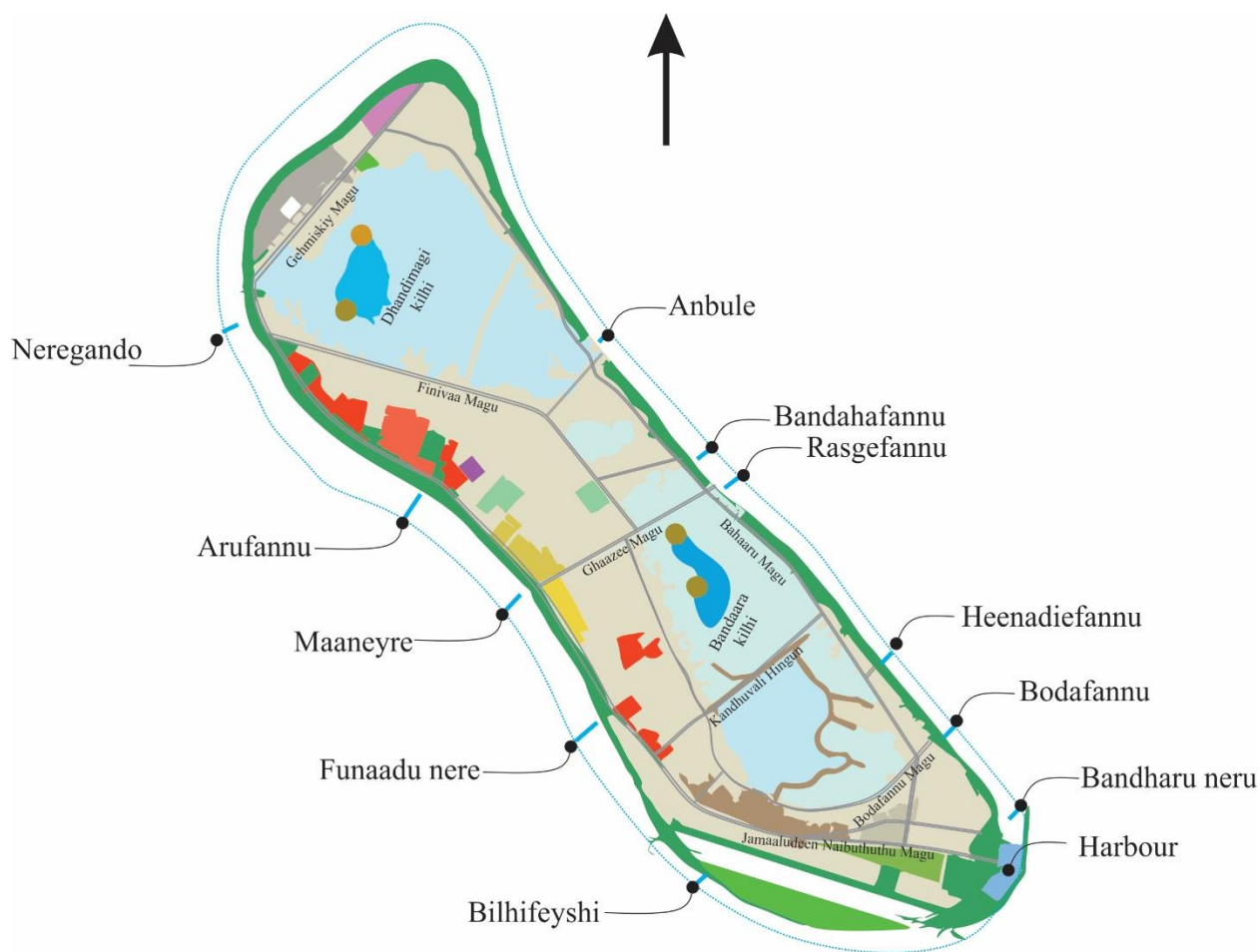


Figure 82: Reef entrances around Fuvahmulah reef

With the inception of the harbour operations, it was seen as the main gateway which “really” opened up the island to the rest of the country. There are regular ferry service that operates between Addu atoll and Fuvahmulah and passenger and cargo boat operations to and from the nation’s capital Male’ has become more continent and frequent as a result.

Most common modes of land transport used in the island is by bicycles and motor cycles. Use of four-wheeled vehicles such as cars, lorries and pick-ups are on the rise. The increase in use of

vehicles associated with poor conditions of the roads have resulted road accidents some of which were quite serious. At the time of this EIA study only *Mohamed Jamaaludeen Naibu Thuththu Magu* is the only road that was partly paved. According to the island council, currently there are 3256 vehicles registered on the island.

In 2012, Fuvahmulah airport was opened and currently there are two scheduled flights every day enhancing connectivity between Male' and Fuvahmulah.

6.11.4 Leisure and Sport

The main sports played in the island are football, cricket, volleyball, netball, badminton and a traditional game called *bashi*. There are 3 football grounds and 1 cricket stadium in the islands. Other leisure activities include swimming, surfing, snorkelling and fishing.

In Fuvahmulah, there is no safe swimming area. However, on calm days when the coastal areas are mild enough for swimming, swimming occurs at some spots near the beach (see Figure 77), also at the project area. Most youngsters take dips in the freshwater ponds. However, this swimming experience in a still water body cannot be compared to swimming in the sea.

6.11.5 Water and Sewerage

Fuvahmulah at the moment do not have a proper sewerage and piped network system in place although designs for both systems have been completed and work is about to begin to provide these services to the community. Currently the main source of drinking water is rainwater which is collected on roofs and stored in tanks. Rainwater is collected and stored in community water tanks within household compounds. Well water is contaminated in terms of smell, taste and colour as well as high salinity, and is not suitable for drinking purposes. Almost all households have toilets connected to septic tanks.

6.11.6 Waste Management

In spite of the relatively large population size, the island does not have a proper waste management system in place making it one of the most important issue faced to the island community. Similar to other inhabited islands the largest fraction of waste produced on the island is organic and due to the lack of a waste management centre on the island waste dumping and littering is common in the island (CDE, 2010). The government is however currently undertaking a project aimed at south region of the country to improve on the waste management infrastructures and capacity under which Fuvahmulah waste management system has been planned to be up graded.

6.12 NGOS

A number of non-governmental organisations and clubs have been registered to function in the island. These include youth clubs, sports clubs and organisations formed with the objective to protect the environment and development.

6.13 PARTICIPATION OF PEOPLE IN GOVERNMENT DEVELOPMENT SCHEMES

Public participation in developmental projects is important to make sure that government addresses the real needs of communities in the most appropriate way. Participation also helps to build an informed and responsible citizenry with a sense of ownership of government developments and projects.

Public participation and communication are very often treated as add-ons and dealt with only by consultants and outside agencies, instead of the responsible Government agency. However, consultation with public will help Government make more appropriate decisions based on the real needs of people and the more informed people are, the better they will understand what government is trying to do and what the budget and resource limitations are. For a communication and participation strategy to be effective, problems, concerns and suggestions raised by the target communities must be properly processed and addressed during the planning stages of developmental projects.

6.14 INCOME AND EXPENDITURE PATTERN

The most recent nationwide household income and expenditure survey (HIES) was conducted by Department of National Planning during 2010. The report of HIES was published in 2012. The report presents income and expenditure of households in Male' and the Atolls and assesses the economic wellbeing of the population. For the purpose of this report, the HIES data in HIES 2012 for Atolls is used to represent the Income and Expenditure data for Fuvahmulah. As per the report, the average monthly expenditure per household in the Fuvahmulah is 10,417 Rufiyaa. The daily expenditure per person in the Atolls is Rufiyaa 59. The average monthly income per earner is 4824 rufiyaa in the Atolls. On average there were two members earning in every household in Fuvahmulah (Figure 83).

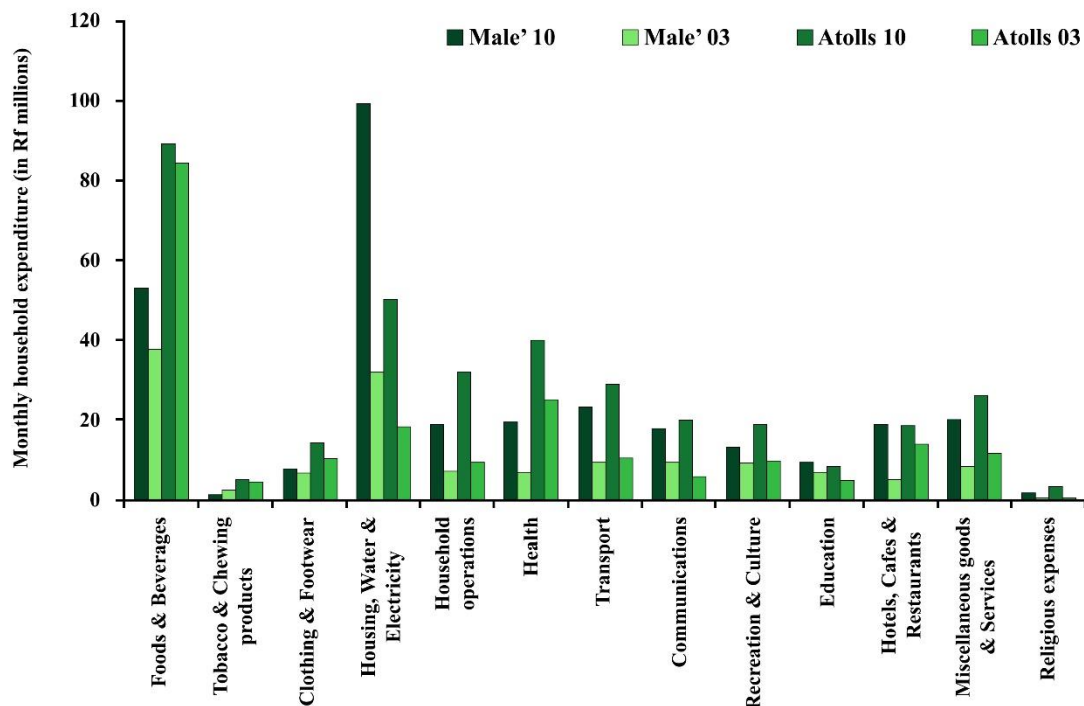


Figure 83: Household expenditure by expenditure groups for Male' and Atolls (National Bureau of Statistics, 2012):

The main household expenditure is spent on foods and beverages, followed by expenditure spent on housing, water and electricity and health.

6.14.1.1 Poverty and Vulnerability Groups

Fuvahmulah is considered as one of the well-off islands in Maldives. This is clearly reflected on the living styles, spending, and income of its population and on the infrastructure of the island. However, there are no recent data available which reflect this.

According to the Maldives Vulnerability and Poverty Assessment of 2004, in Fuvahmulah the percentage of population with less than one US dollar (15 Rufiyaa) per person per day is 10% which is less than head count ratio of the country (21%). Similarly the income poverty index for Fuvahmulah (0.04) is also lower than that of the country average (0.1). Meanwhile, the human vulnerability index for Fuvahmulah (0.21) is a little lower than the vulnerability index for the whole country (0.25). Therefore, poverty is considered to be less of a problem in Fuvahmulah compared to the whole country (UNDP, 2005) (Table 34).

Table 34: Information on income poverty for Maldives and Fuvahmulah. (Source: UNDP, 2005)

Locality	2004	2004	2004	2004	1997	2004
	Head count ratio, percentage of the population with less than Rf.15 per person per day	Average income of the population with less than Rf.15 per person per day (RF)	Income Shortfall of the population with less than Rf.15 per person per day (%)	Poverty gap index of the population with less than Rf.15 per person per day	Human vulnerability Index	Income Poverty Index
Maldives	21	10.6	29	0.06	0.25	0.1
Fuvahmulah	10	10.9	27	0.3	0.21	0.04

6.14.1.2 Assets and Durables Possessed

The community of Fuvahmulah are in possession of the following durable assets such as:

- Natural capital that include natural resource assets (island, land plots, beach, sand and soil, ground and rainwater, air and sea);
- Reproducible capital (mainly consumer durables from household electric appliances to transport and communication equipment to audio-visual equipment);
- Human capital (the productive potential of human beings such as the employed population in the community); and
- Social capital (norms and institutions that influence the interactions among community such as airport, sewerage system, harbour, hospital, schools, etc.)

These four major components of durable assets empower the community of Fuvahmulah to be self-sufficient even in times of hardship, as they possess the materials necessary for ensuring their livelihood regardless of the larger economic climate. Unlike other countries in South Asia, Maldives lacks the livestock on land, however, fishing and resources from the sea compensates for this.

Fuvahmulah is a farming island which grows mangoes and coconuts for nationwide sale. There is a need to operative a farming cooperative to markets these products. This would bring in a better income and would facilitate the inherent creativity of people for pursuing livelihoods for themselves and their families.

6.15 COMMUNITY COHESION

Dynamic political situation will have significant impacts on the project which might have a negative or positive effect on the community. Political unrests and economic recessions will directly affect the community and the project implementation. Regardless of political affiliations,

there appear to be no difference in opinion with regards to the importance of this Project to the island.

The major strength of the local community is their willingness and unity in having a common vision for the development of the island. Different groups come together in their respective levels to make event, like the opening of the airport into a success. The different ward councils through the help of local NGOs run programmes and refresher courses for youths and women groups on life skills, small business management skills and leadership building. The people interviewed noted the opportunities made available make them develop strong, positive relationships within neighbourhoods, in the workplace, in schools, etc. The community NGOs, Women's committees, clubs and youth groups are very active in arranging different community level activities especially on special occasions like Eid and public holidays. A major event such as national level athletics meet among the southern atolls is a good example of community participation in the Fuvahmulah. The island as a whole came together for this event, which was arranged very well. The inhabitants of the island speak a distinctive dialect of Dhivehi language, known as *Mulakubas*. This difference in spoken language can be seen in all southern atolls. Being a 100% Muslim nation Maldives is subject to various pressures from the rest of the world. Movements which could be considered as religious extremism are increasing day by day in the Maldives and the situation in Fuvahmulah is no different. The cultural values and religious values Maldivians held from generations are being questioned and the ideas of extremism is spreading at fast pace. There was overwhelming agreement that people in the island will help each other during a natural disaster event, regardless of any political, economic or social differences.

A number of non-governmental organisations and clubs have been registered to function in the island. These include youth clubs, sports clubs and organisations formed with the objective to protect the environment and development.

6.16 CHALLENGES AND CONSTRAINTS

A number of resource and other constraints faced to Fuvahmulah is inherently due to its unique geographical and geomorphological characteristics. Most critical of these is coastal erosion and associated flooding. Land is an extremely scarce resource owing to the large population size and the two wetland systems occupying one-third of the island. The island take naturally almost the entire space on the reef flat, leaving virtually no lagoon space for potential reclamation and adding new land to existing island. Coral sand obtained from approved areas is considered an important resource for the construction works in the Maldives.

However, similar to other inhabited islands in the Maldives mining of sand from the island's beach is prohibited in Fuvahmulah, although to some extent illegal mining of sand to some extent still occur (Nippon Koi, 2011). Due to severe erosion faced to the island and legal protection status given to *Thundi* beach literally leaves the people with no place to legally obtain sand to meet their needs. Due to the isolated nature of the island and lack of nearby lagoons and reefs adds to this challenge.

Although agriculture is one of the most important sector for the local economy growing need to give up land for development purposes are creating constraints to get land plots for agriculture. It was reported that recent airport development project took up 50% of the island's agricultural land and further 20% was sacrificed for a city hotel (Nippon Koi, 2011). Occurrence of crop diseases, pests on the island have resulted farmers having to use pesticides and insecticides without proper knowledge and awareness further aggravating the problem. Lack of bulk transport facilities and a reliable arrangement to supply agricultural produce have resulted in farmers having to sell their produce to "middlemen" at a rate much lower than their market value.

Rain and sea induced flooding is yet another environmental challenge faced to the community. People of the island have been expecting the effects of flooding for a long time without a long lasting solution. Higher island ridge compared to the rest of the island makes natural drainage into the sea ineffective needing an engineered solution to the problem. The existing artificial drainage system proved in effective and the people of the island are expecting a proper system in place to overcome this grievance.

Development of fishing sector on the island is constrained by the limited reef systems available to collect baitfish necessary for traditional pole and line fishing. According to local fishermen the island's house reef only a limited supply of baitfish for skipjack tuna is available. In addition there is also a declining interest among the young people to get engaged in fishing. The lack of an ice plant on the island and constraints harbour space are also challenges faced to fisheries sector (Nippon Koei, 2011).

7. STAKEHOLDER CONSULTATION IN THE PROJECT

A detailed stakeholder engagement in the process of formulation of the Project included three rounds of consultations. The first round of consultation was conducted in May 2015 as part of the feasibility study and the second round of consultation were conducted in July 2016, in both Male' and Fuvahmulah as part of the Environmental and Social Impact Assessment for the project. The final stakeholder consultation was carried out with the public and Atoll council of Fuvahmulah in October 2016 to present the findings and results of the EIA and present the final outcome of the alternatives analysis.

At the beginning of the process a detailed stakeholder analysis was carried out to identify the primary and secondary stakeholders of this Project (Table 35). The stakeholders identified were consulted to identify their issues and needs in relation to the Project.

The primary stakeholders identified from community and government groups, such as women's development committee, shopkeepers, school teachers/students, and non-government organizations (NGOs), atoll council and Government ministries were consulted individually, in homogenous sub-groups and mixed groups to understand the local needs and responses to the proposed project and also to ascertain the impact of the proposed Project on the communities, the area and the overall island as whole.

As part of the public consultation in Fuvahmulah, a mixed-method approach was used which consists of both quantitative and qualitative data collection techniques, depending on the requirements of the information.

The first set of consultations in July 2016 were held with stakeholders in Male such as Ministry of Environment and Energy, Environmental Protection Agency, Ministry of Housing and Infrastructure and with an environmental NGO called Save the Beach. In these various advantages and disadvantages of the different options of shore protection such as on-shore and off-shore alternatives were discussed.

Stakeholder discussions revealed that the most of the primary stakeholders identified would benefit directly from this project and most the secondary stakeholders would benefit indirectly from this project. A summary of the main interests of each stakeholder group is given in Table 35.

Table 35: Stakeholders and a summary of their interests

Stakeholder	Level of Interest	Key Stakeholder Interests
General Public		
Community (general)	P	The island is in need of a sustainable coastal protection system to prevent erosion and flooding for the social well-being of the community
Women/ Women Development Committees	P	Decreasing the community vulnerability to uncontrolled erosion and as there a lot of female headed households in islands, this would mean better quality of life even for women with decreased climate induced vulnerability
Fishermen	S	A better quality of life, would perhaps increase their health and diet and perhaps the demand for fresh fish would increase?
Retailers/ Small Businesses	S	To ensure reliable, adequate and timely supply of retail goods to the Contractor and workforce during the construction stages of the project
Students/Schools	S	Need for a sustainable coastal protection system to prevent erosion and flooding and ensuring the ability to study in a safer natural environment.
Hospital	S	During the construction stage, in case of injuries at worksite, patients would be treated at the hospital
Public Companies (Maldives Road Development Corporation)	P	The main paved roads in Fuvahmulah are maintained by MRDC and the heavy vehicles and the transport of supplies needed during construction would use these roads.
NGOs	P	There are some active environmental NGOs who work closely with Government and local government in environment related projects and disaster resilience
Police	S	During the construction stages, influx of additional people to the island (from the Contractor) may lead to social problems due to fights, etc
Local and Central Government		
Atoll and Island Councils	P	Elected atoll and local councils are responsible for working and lobbying with central government towards the needs of community such as accessing development resources, managing island affairs to maximize social and economic benefit, which is directly affected by coastal protection and reduced vulnerability. A safer natural environment positively impacts on the achievement of this role.
Ministry of Housing and Infrastructure	P	MHI is mandated with physical development planning policy and regulations, land-use planning in islands and improving accessibility infrastructure of inhabited islands.
Ministry of Environment and Energy	P	MEE is mandated with overall environmental policy and regulatory framework. All the developmental projects, including coastal development projects are initiated after conducting an Environmental Impact Assessment.
Ministry of Home Affairs/Local Government Authority	P	Local Government Authority is mandated with developing island management plans and overseeing the works of the elected atoll and island councils. Improved coastal protection would improve the implementation of island development plans
Ministry of Fisheries and Agriculture	S	Responsible for development of the necessary infrastructure for the growth of the fisheries and agriculture sector

The first meeting in Fuvahmulah were held with Atoll Council in Fuvahmulah. The second consultations were held for Climate Change Adaptation Project Management Unit in Fuvahmulah. Consultation meetings were also held with members of the community from youth groups to women's groups, NGOs, Women's Development Committee, School administration and teachers, Fenaka officials, Health Professionals, Police, entrepreneurs, business owners and members from Island Councils where shore protection project would occur. All efforts were taken to select most suitable, impartial and knowledgeable members from each group that were chosen for the consultation process. The consultative process focussed on mainly collecting information on the following areas;

- General introduction of the work carried out by the organisation or introduction/say about the island by the group;
- challenges faced by the group/institution from the on-going coastal erosion and flooding,
- discussions on the pros and cons of off-shore and on-shore alternative;
- gender and poverty issues – keeping focus on employment and other opportunities for females with the implementations and future developments of a coastal protection system and
- lastly, additional comments or feedback – and other additional feedback for the design and implementation phases from the community groups.

7.1.1 Findings of Stakeholder Consultations

In general, there was a consensus among all the participants of the consultations that the development of a coastal protection system along the area would bring in economic prospective, wellbeing and social development to the island.

It seems that a majority of the preferred an off-shore alternative. Their main reasoning was that an off-shore alternative would provide:

- Minimal damages to the vegetation belt around the island;
- Safe swimming areas could be created; and
- Access to beach and shore-line would not be blocked and natural beauty would be maintained.

However, the risk of affecting *Thundi* beach was not well understood at that time. Some stakeholders raised this concern and were afraid that this risk would be higher with an offshore option than with an onshore option.

The findings from the stakeholder consultation with various groups is summarised in Table 36 and the list of people consulted is given in **Annex 4**

Table 36: Summary of stakeholder discussions

	Meetings	Discussion Points
July 2016		
1	Meeting with Ministry of Environment and Energy Coastal Unit (2 men and 1 woman)	- MEE has preference to offshore alternative. Safe swimming areas can be created. And damage to trees can be minimized. Preferably original coastline is repaired with sand or gravel. When presented the results of the MCA, MEE followed the reasoning to select an onshore option, because the risk of affecting <i>Thundi</i> Beach is considered less for an onshore than for an offshore option. - With regard to construction methodology, MEE is concerned on using the current port (where the quay beams which will be repaired soon and dredging is foreseen) and a temporary loading site may need to be constructed. Utilizing the old Rasgefannu area (old landing spot) for unloading is proposed as an option. - Transport of rock over land will create quite some impacts.
2	Meeting with Ministry of Housing and Infrastructure (1 woman)	- Concerns are raised on disturbance of the sediment balance by constructing the coastal protection. - Proper sediment study is requested. - Availability of rock material is a concern - Experience with construction methods of breakwaters will be shared by MHI; - There are positive results of both offshore and onshore coastal protection solutions in Maldives. However, there is no specific recommendation from MHI as cases differ and is based on the specific case.
3	Meeting with Environmental Protection Agency (EPA) (2 men and 1 woman)	- EPA indicated that they received reports from people on the island indicating a net loss in beach sediments at <i>Thundi</i> beach; - EPA will carry out inspection during construction, to verify whether mitigation measures are implemented; - Dredging only allowed on very specific places (some 100m from vegetation line, 200m from reef: dredging and reclamation regulation). - Removal of any tress from vegetation belt will need a special approval from EPA
4	Meeting with Fuvahmulah Atoll Council (3 men)	- Skilled staff and labour for the construction of the works is available in the islands, there will be limited need for outside construction workers; - Views of on-shore option are: - Maintenance will be easier - Trees will be damaged, needs replanting; - Access to beach and shoreline blocked; - Risk of waste on revetment. - The preferred method is an off-shore alternative - The harbour can used for the works; - Other projects in the island are: - Rehabilitation of the port (beams on the quay and dredging?); - Sewerage and drainage; - Housing (under construction) - Paving the existing ring road; - The Atoll Council would like to see the construction works to start before the next local council elections due early next year.
5	Meeting with CCAP Project Management Unit (2 women)	- Concerns about impacts on <i>Thundi</i> beach from erosion - Concerns about impacts on vegetation belt in an on-shore alternative is used - There are two swimming areas currently. Accidents are limited; - There is no impact expected from the proposed project on the wetlands
6	Police – Main Land	- Influx of outside workers has never resulted in problems with the local population - Traffic risks are no problem, people are well aware of the risks

	Meetings	Discussion Points
	(2 men)	- There have been 2 drowning incidents in the last years. On Fuvahmulah this risk seems higher than on the other islands - Community cohesion is quite good.
7	Women's Committee (17 women)	- Onshore Pros – Deposition of sand? - Onshore Cons – Enhanced erosion? - Contamination of freshwater lens - Damage to trees and other coastal properties - Offshore Pros – Reduce wave speed - Reduce damage to trees and coastal properties - Offshore Cons – Reduce sand deposition - If not done around the whole island, one side of the island will erode
8	Meeting with health sector (8 men and 2 women)	In case of serious accidents during construction the hospitals (primary and secondary class) cannot treat the patient and he/she will need to be transported to another island, which may take 24 hours. The population does not grow significantly, so that the capacity of the hospital is still enough. When the population would grow, more capacity will be required. Views on design options: - Risk of affecting <i>Thundi</i> area; - Will there be water passing through the breakwater? - With the onshore option access to the beach and sea may be blocked; - Construction activities will result in air pollution, traffic safety risks. A traffic awareness training would help. Onshore - Pros - Reef will be protected, - fish can remain same – Onshore - Cons - Beach and sand will be damaged - Children can't use the beaches as the current will be very high Offshore - Pros - Beach will be protected - The natural beauty will remain the same - Children can use the beach Offshore -Pros - Reef will be damaged - Diving will be limited and Pebbles and sand will be limited
9	Meeting with Education Sector (7 men and 6 women)	- Preferred the off-shore method; - Technically skilled people are available from the island for the construction work, foreign labour will be more difficult. However unskilled labour force will be less available. - A course on traffic awareness would be good;
10	Meeting with three island councils near to project site (7 men)	The main concerns were: - Vegetation belt should not be damaged; - Reef should be protected; - On-shore option will hamper access to the beach; - On-shore option will create less impacts on <i>Thundi</i> area than offshore option; - Off-shore option will create more erosion. - Breakwater closer to the shore to minimize effect on reef, creating also an opportunity to reclaim land; - Repair the land that was lost; - There is enough technical staff and workers in the island to support the construction;

	Meetings	Discussion Points
		• With climate change will the on-shore option be high enough? Off-shore option can be made higher. • Openings in bw required to sustain circulation; • Can options be constructed from the sea side? • Swimming area is highly desired.
11	Meeting with farmers and fishermen (5 female and 6 male)	• Agriculture is growing while fishing is seasonal • Part of the farmers (women) say their production is hampered by saline water (spray, groundwater and/or flooding); • Demand for agricultural produce (Taro) is high. Land scarcity is more the problem; • People eat more as wealth has increased; • More tourism and restaurants also resulted in an increased in demand. • They fish about 200-300 tuna fish a day per boat. Every 2 weeks about 20 tons of fish is delivered to the boat of MEFCON (?) • This project will not have an effect on fishery.
12	Meeting with three NGOs (3 men)	• NGOs in field of Community Work, Sport, Red Crescent Branch; • Red Crescent works in disaster resilience; • There is no experience in working on the reef and with corals; • NGOs could support in traffic awareness course; View on 2 design options: Onshore - Pros - Give locals the assurance of reduced erosion Onshore - Cons - Loss of natural island beauty - Loss of beach - Loss of land due to erosion Offshore - Pros - Reclamation of lost land space Offshore -Pros - If put in place without leaving any reef space then sand deposition may stop completely - Practical Challenges and Risks in the Implementation - Sand deposition can stop - Waste dumping and waste deposition can increase
13	Meeting with MRDC (5 men)	• Roads are repaired by levelling and no additional sand is added and this is not available; • The sewerage project will require the opening of roads and repair afterwards. Trucks should not damage new new sewage pipes. • This could interfere with our project; Discharge of the sewage plants is all on the southern side; • MRDC resides under the Capital Market Development Authority and is a 100% state-owned company; • They have 47 staff in the island, possibly increasing to 64; • Road construction equipment is present in the island; • The port can have vessels of max 3,500 tons. They can moor just outside the actual port in the port access, where a temporary cay would be required; • The road near the beach can be used for transportation from the harbour to the site, which would need to be extended through the vegetation belt with a temporary road. This would require uprooting of some trees; • Vibration and related damage to houses is a serious concern; • Other projects: ○ Ring road: MVR30 million

	Meetings	Discussion Points
		○ Sewerage and water supply: MVR18-20 M million ○ Housing: 270 apartments: part is dedicated for people from outside the island
14	Meeting with tourism sector (2 men)	• Currently there are 4 guesthouses at present, 2 registered; • In total about 60 beds with an occupancy rate of about 30%; • Now 200 foreigners per year, Maldivians are coming more. maybe double in 3 years time, they stay on average for 1 week; • Hampering tourism: • Ticket price from Male’; • Only 3 years open; • Diving just starting, not yet registered; • Lack of marketing.
15	Meeting with community members (8 men and 1 woman)	In this meeting also communities view on the two options for the breakwater were asked: • Views on 2 design options: - They felt that any on-shore structure would pose difficulty to fish from the lagoon but were uncertain about what impact would be felt to the onshore currents and wave action and also they were concerned with the loss of natural island beauty • However, the community members thought that onshore alternative would increase the sand deposition if put in place a distant away from the beach (<i>heylihifah</i>) • Regarding an offshore alternative, they thought it would be easy for swimming and would increase the community cohesion and would be easy for future land reclamation projects • They felt that with an offshore alternative, there is an increased chance of damage to the beach side and more impacts on the wave and currents and thus impacting the islands flora and fauna. However, they preferred an offshore alternative even though it might be expensive.
October 2016		
16	Meeting with Atoll Council	• The Atoll council stressed the importance of shoreline protection and incorporating more steps in the design, as it could be used for recreational fishing as well. • They also highlighted that drainage should be part of the design. • They also emphasized that if loading and unloading will be done the harbor will be blocked and need alternative options. • The council was convinced and happy with the onshore protection as it gives maximum protection to the island and thundi beach.
17	Meeting with Community (32 people, including many women)	• The community participation was higher compared to previous community meetings. • After the presentations, people stressed the importance of expatiating the process and welcomed the technical expert’s findings, accepting the onshore protection. • At the end expressed that they look forward for the practical work sooner. These included people who previously expressed importance of off-shore protection. •



Figure 84: Stakeholder discussion with both government and non-government stakeholders

7.1.2 Project Awareness

In all stakeholder consultations the participants stated that they were aware of the proposed coastal protection project by the MEE.

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

All stakeholders expressed strong desire for the Project and community's readiness to accept the Project. Figure 84 shows selection of photographs taken during discussions with some stakeholders. Furthermore, the third consultation trip was arranged to brief the public about the outcome of the EIA, alternatives analysis, impacts, and inform the public regarding the work method, project risks and perceived commencement date of the project in line with the participatory approach utilised throughout the design phase of the project. During this final meeting, general consensus was reached on the major findings of the EIA report as well as technical details of the Project. (See Figure 85 for selected photos of final presentation and consultation meetings and Annex 4 for the list of participants)



Figure 85: Presentation to the stakeholders of outcome of the EIA and findings of the design phase of project

8. ALTERNATIVES

Ocean waves, currents, tides, storm surges, and relative sea-level rise contribute to the erosion of sandy shorelines affecting the community and coastal properties. Various different approaches have been adopted in the Maldives in combatting erosion consisting of hard structures, such as groynes, breakwaters, seawalls and revetments, and in some cases soft solutions such as beach nourishment and establishing vegetation belts and in some cases combination of these have also been adopted. More recently new technologies such as use of geo-tubes and geo-bags have been used as erosion mitigation measures. Each of these established erosion mitigation measures has proven effective when used under favourable conditions; yet, none is suitable for every location, and implementation under the wrong conditions may have severe negative impacts on a coastal community. In the following sections, the most appropriate of these methods of erosion control for the situation at Fuvahmulah have been evaluated.

Decisions regarding management of shoreline erosion at Fuvahmulah are made after a thorough evaluation of available erosion mitigation alternatives. The following chapter describes a variety of established coastal engineering methods for erosion mitigation, as well as several less traditional approaches. The ideas upon which these methods were developed are explained, and the suitability of their application at Fuvahmulah coast is discussed. Therefore, the choice of coastal protection was made by evaluating a range of commonly used coastal protection alternatives.

A variety of factors were considered when evaluating the various alternatives (e.g., cost, feasibility, performance, environmental impacts, constructability, technological competence and material availability.), with the overall objective focused on selecting the optimal solution. As such, the goal of the assessment is to evaluate reasonable, practicable, and feasible alternatives that will achieve the goals and objectives of the Project, while minimizing the short and long term adverse effects on the environment. The alternatives analysis procedure developed for Fuvahmulah coast, including a comprehensive list of the alternatives evaluated and the alternatives developed for more comprehensive evaluation, is presented in this chapter. The studied alternatives were geared towards determining a long-term solution for eroding coastline, improved storm damage protection for the people and the island's infrastructure. Ultimately eight specific alternatives, including both structural (e.g., revetment, seawall, etc.) and non-structural (e.g., retreat, beach nourishment, etc.) were determined by the expert team of consultants with the inputs from the island community and the Ministry of Environment and Energy.

These alternatives for evaluation were selected based on existing coastal protection practices in the Maldives. Having considered all factors the selected alternatives were thoroughly discussed amongst all members of the EIA team and the final decision was agreed by all members.

In the detailed alternatives analysis, a range of traditional coastal protection alternatives were considered to determine potential solutions that may be feasible at Fuvahmulah. These alternatives, in addition to the no-action alternative, were considered in the evaluation of potential solutions for Fuvahmulah north-eastern coast. Types of alternatives that were considered included:

1. No-development option;

2. Retreat/re-locate;
3. Beach nourishment;
4. Developing submerged reef;
5. Onshore revetment;
6. Offshore breakwater;
7. Seawall; and
8. Groynes.

First a selection of the most promising alternatives has been determined from the above list based on a qualitative multi-criteria analysis. After this two alternatives have been studied in more detail to come to the most effective and sustainable solution. These two alternatives have been compared in a quantitative multi-criteria assessment. Both alternatives have been assessed on their environmental and social impacts in chapter 9.

8.1 PASSIVE ALTERNATIVES

8.1.1 No Development Option

This alternative would consist of taking no action at eroding coastline of Fuvahmulah and making no changes to the existing environment. With no action to protect the north-eastern coastline of Fuvahmulah, all impacts related to the construction of the sea defence can be fully avoided, while its infrastructures, residential and commercial properties and agricultural lands will continue to have been threatened by erosion and intrusion of seawater. The psychological stress caused to the community due to deteriorating condition of the island's coastline will aggravate and their waiting time in search of a proper solution will be increased. Hence, this alternative is considered unacceptable by the EIA team as the island is facing serious risk due to serious erosion problem. If left unattended the existing shoreline on the north-eastern side would continue to be eroded, losing a sustainable beach and with no protective action the upland infrastructure would face increased risk for potential damage or loss. Therefore, the "no action" alternative was not recommended.

8.1.2 Retreat/Relocation

This alternative is similar to the no action alternative in that the island's coastline is allowed to continue to erode; however, the most seriously threatened houses and infrastructure either be removed or relocated further landward. This retreat option may be extremely difficult to achieve due to land shortages and is also believed to be complicated due to compensation and legal issues. Even if these challenges could be overcome, retreat/relocation will not be successful if it is not combined with coastal protection alternatives/techniques to avoid flooding during storm surges. Hence this alternative was not recommended for further evaluation.

8.2 DEVELOPMENT OPTIONS

8.2.1 Beach Nourishment

One of the primary causes of coastal erosion being a deficit of sediment within a particular portion of the coast, nourishing the beach with compatible sediment placement is a logical means for improving the shoreline where it is economically feasible. However, nourishing the beach does not translate into stopping erosion even though the beach width is increased, recreational area is improved, and potential damage to upland infrastructure is postponed by extending the shoreline toward the ocean. Hence, regular re-nourishment must be anticipated. Beach nourishment is typically the most non-intrusive technique for coastal enhancement and involves placing sand, from an offshore or upland source, on an eroding beach.

This alternative although is seemingly simple and non-intrusive in nature, in the case of Fuvahmulah, there is no offshore or upland area to source the sediment needed let alone finding the material of right grain size. This is further complicated by the fact since nourished sand is gradually displaced alongshore or transported offshore, regular arrangement need to be in place to supply right materials to replace sediment that have been lost to erosion. Discussions with the community revealed that the community is facing acute shortage of sand needed even for construction purposes. It is also illegal in the Maldives to mine sand from inhabited islands. The closest atoll to Fuvahmulah being Addu Atoll is also facing shortage of areas which can source sand. This alternative would become financially unsustainable if source material had to be supplied from another atoll or imported from overseas. In addition to these challenges a number of environmental concerns have been generally associated with beach nourishment of which most notable being temporarily decrease water quality when sediments are dredged and deposited, and impacting the island's house reef when removing or depositing the dredged material from the source area. Although sediment plume can be controlled to some extent by use of appropriate barriers, continuous beach nourishment and dredging for source material can have cumulative effects that are difficult to accurately predict. Lack of guaranteed source of finance and human resource will also be additional difficulties to go for beach nourishment alternative.

Although in several resort islands in the Maldives beach nourishment is carried out as their preferred way of maintaining the beach, the challenges described above beach nourishment alone is not considered a viable alternative for protecting north-eastern coastline of Fuvahmulah.

8.2.2 Perched Beach

As an alternative to beach nourishment, sand can be placed on the eroding coastal area with a submerged ridge to help retain the material for a longer time period. The nourishment volume is reduced by using a submerged sill to hold up or "perch" the beach above the natural bottom, significantly reducing the amount of sand required for beach construction and maintenance.

A perched beach cannot be considered solely a soft solution, since the ridge is typically composed of rocks or engineered structures. Figure 86 presents a schematic drawing of a perched beach.

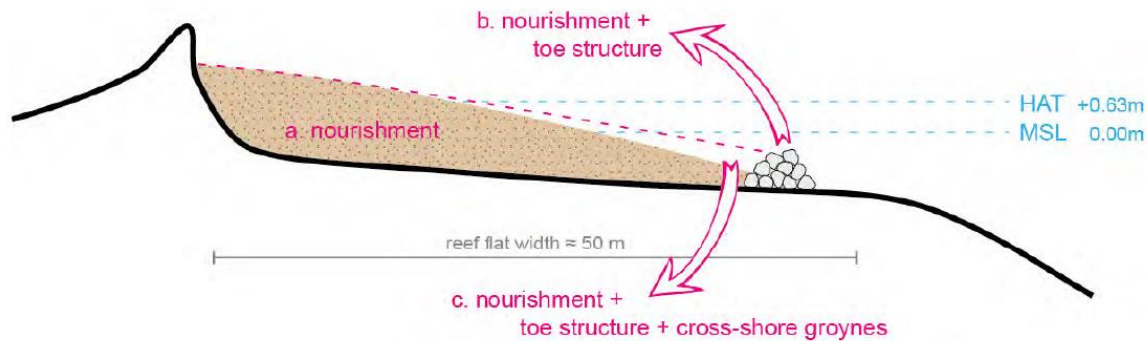


Figure 86: schematic drawing of a perched beach (Source: RHDHV. 2015)

The perched beach is not a common engineering solution implemented in the Maldives and there is no design or maintenance costs information available. In addition, similar to reclamation or beach nourishment, it would be extremely challenging to get material of proper texture to fill the area. The island has no source area for sediment and if had to be borrowed from elsewhere the borrow site would too be impacted due to dredging in addition to high transportation costs. The new coastal equilibrium expected as a result of additional materials a lot of uncertainty exists so as for how long the beach would last. Hence frequent maintenance can be expected as a result. This alternative too can have significant impact on the coral reef environment due to sediment settling on corals. Construction of the sill structure can also result in the loss of recreational value as swimming and water based activities would become unsafe in such a setting, due the large rocks offshore that are hidden from view. This alternative is not recommended further evaluation for Fuvahmulah due to unfamiliarity of this technique, lack of information and high uncertainty of suitability of this alternative in a strong wave environment such as found in Fuvahmulah.

8.2.3 Land Reclamation

Land reclamation as a way of combatting erosion is not uncommon in the Maldives. In a similar way a combination of a large coastal nourishment with a proper offshore breakwater in front of the Fuvahmulah coastline can solve the erosion problem as outlined in Figure 87.

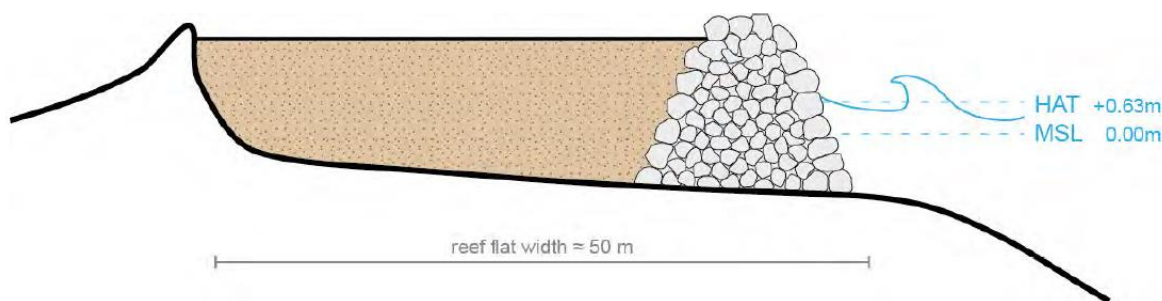


Figure 87: Conceptual diagram showing land reclamation (Source: RHDHV. 2015)

By constructing a rubble mound breakwater near the reef drop, a strip of approximately 50 meters reclaimed land can be created. The land created can be used for new developments such for housing and commercial activities. Disturbance to island's existing coastal vegetation can also be kept minimal by this alternative. However, obtaining required volume of sand will be challenge since there is no potential borrow area close by. Reclamation will also cause permanent and irreversible loss of significant lagoon space, damage and loss of corals, loss of potential swimming and recreational area, environmental impacts caused to the borrow area, transport risks of having to bring materials from long distances all make this alternative unsuitable environmentally and socially. Furthermore, due to the exposure of the coastal protection to heavy wave conditions, the structure is expected to be significantly larger than a protection closer to the shoreline. The high construction cost of coastal protection close to the reef edge along with high costs of transporting large volumes of materials from long distances also make this alternative financially not feasible. Hence this alternative is not considered for further evaluation.

8.2.4 Onshore Revetment

Revetments are sloping structures, constructed of concrete or rocks installed to serve the primary function of reducing wave energy and protecting the land behind them from the erosional forces of waves and currents (Figure 88).

The structure can consist of various types of materials:

- a) A rubble mound armour layer on top of a rock filling is a traditional and very reliable method to construct a revetment. A core filling is required to restore the steep erosion profile into a milder slope (appr. 1:3). The amount of core filling (or backfilling) can be varied for this solution.
- b) An armour layer consisting of placed concrete blocks on top of a rock filling. The filling is required to restore the steep erosion profile into a milder slope (approximately 1:3). Various types of concrete blocks can be applied.
- c) Geotubes are bags of geotextile, filled with sand. The geobags are placed in front of the ridge and protects the coastline from further erosion. Regular inspection is required to identify damage to the geotextile (due to UV radiation, people walking on the construction

or vandalism). When the geotextile is damaged, repairs are required in order to prevent sand washing out which reduces the stability of the revetment.

- d) Sheet piles drilled into the ridge prevent ongoing erosion of the ridge. The sheet piles are anchored to prevent instability. Ongoing erosion in front of the sheet piles is not stopped, which might ultimately result in a vertical wall separating the ridge from the reef flat. Besides, the sheet piles are expensive and the piling process causes significant damage to the delicate coral reef/ridge. Depending on the type of revetment, a geotextile or filter layer might be required to prevent erosion of underlying fine sand. The amount of filling material to restore the ridge profile can be varied in order to restore the original coastline to a desired extent.

Onshore revetment can effectively protect upland by proper designing. Poor design and use of improper material in the construction can result in magnified erosional forces of the waves as they reflect from the structure.

In addition, toe scour and flanking at the ends of the wall may threaten the structure itself as erosion continues. Additional forces threatening the structure may be induced if the structure is overtopped, as soil becomes saturated and soil pressure is increased behind the wall and reduced by scour in front of the wall.

Revetment can benefit the natural coastal environment and the adjoining land behind if the elevation of the structure is sufficiently high to prevent regular wave overtopping and deep enough to resist scour and toppling. Revetment needs to be engineered to provide wave energy dissipation, the structure can provide protection from rare severe erosive forces.

Revetments are commonly used in many islands in the Maldives as an effective barrier to check erosion. The technology is familiar to local contractors and can be built to meet engineering specifications. Also on the positive side, for the project site, since revetment will be placed closer to the coastal edge, damage to the coral reef can be minimised and use of construction material will be less compared to offshore breakwaters or reclamation. Due to many advantages use of revetment to protect north-eastern coastline of Fuvahmulah is considered reasonable and therefore further evaluation is considered.

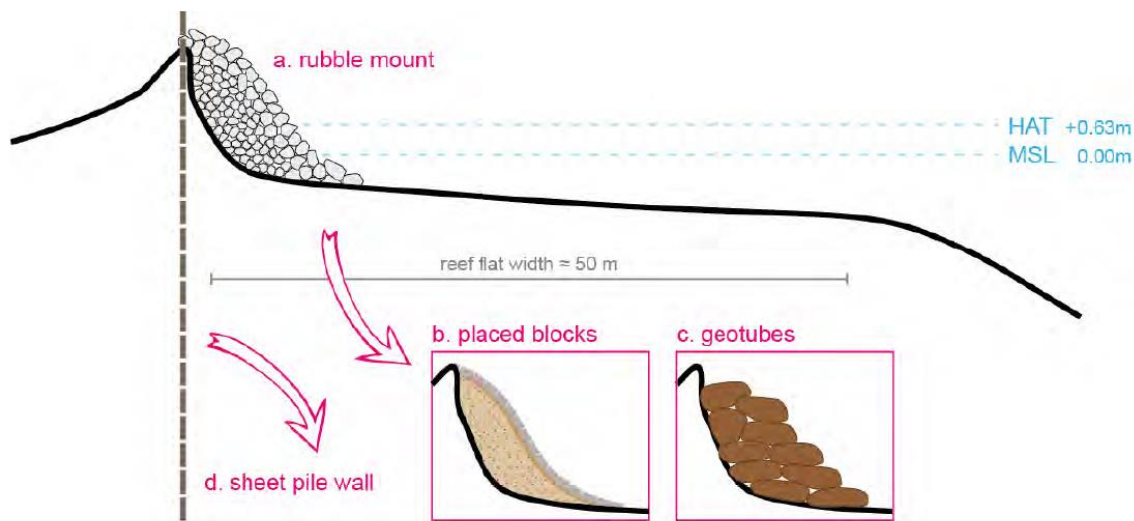


Figure 88: Conceptual representation of onshore revetment (Source: RHDHV. 2016)

Onshore revetments are constructed as an integral part of the coastal ridge. It could be constructed gently sloping towards the sea. The steep erosion profiles need to be profiled (with filling material) in order to create a milder slope (approximately 1:3). On top of this filling, a protective armour layer (rock boulder or interlocking concrete blocks armouring) will be constructed to prevent erosion of sub-layers or the ridge. The structure can be built at a depth of -0.5m from MSL with a rock grading of 1000 – 3000kg. The crest height is expected to be reaching a height of 3.5m from MSL. On top of the revetment, possible small constructive measures will be taken into consideration which prevents nuisance due to overtopping of the ridge during storms. Overtopping can be reduced by a small wall-type of structure on top of the revetment crest.

A number of environmental impacts that are associated with onshore revetment include, that it is visually unappealing and it would impair access to the beach. Onshore revetment would eliminate creating a calm sea space for people to enjoy. The beach and calm water are valuable resource for the island population and is actively used by the people. Other impacts include, onshore revetment can create an obscured habitat, potentially can reduce sediment supply to the beach and it can accelerate erosion of the coastal edge immediately down drift of the revetment.

Use of natural local rocks may be considered to reduce the visual impacts although suitable natural materials of adequate size and volume will be nearly impossible to obtain locally. Wave reflection may be reduced by use of lower angles and rougher surfaces during construction.

Nevertheless, all the identified impacts associated with the onshore revetment can be mitigated to an acceptable level by mitigation actions.

8.2.5 Offshore Breakwater

Offshore breakwater is typically detached from the coast and are placed in the moat region of the reef platform (see Figure 89). The structure can be constructed either by using rubble mound (rock boulder) or concrete elements.

Breakwaters are traditionally constructed with rubble mound, especially when the required rock size is relatively easily available near the project. When no rubble mound is available, or not available in the required grading, concrete armour units can be an effective alternative. By creating inter-locking blocks, the net volume of material can be reduced compared to the rubble mound structure. Different types of concrete elements exist, all with their own advantages and disadvantages, for example: Tetrapods, Accropodes or X-blocks. The construction costs of both materials mainly depend on the local availability or import prices of respectively rubble mound or concrete.

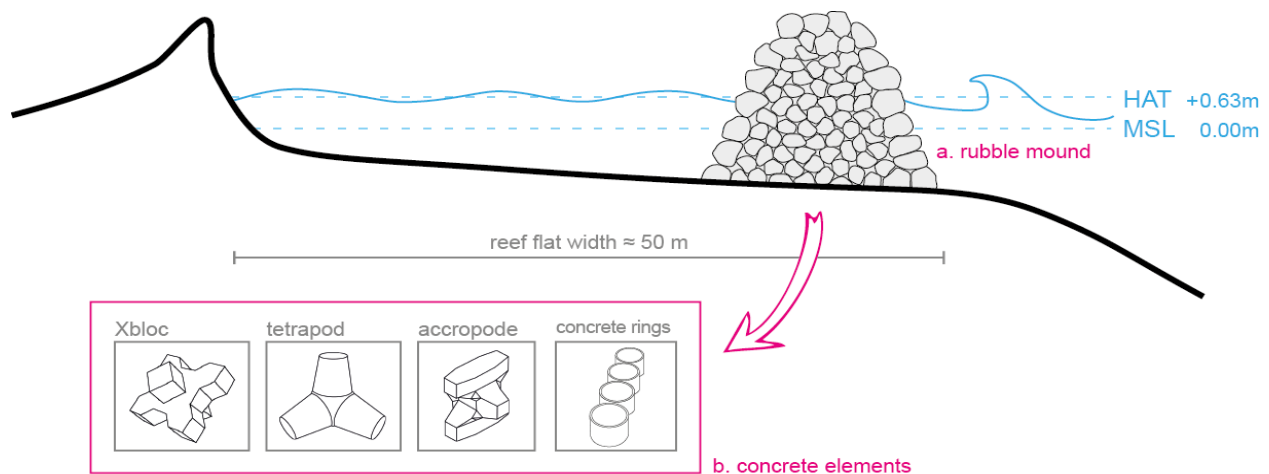


Figure 89: Diagrammatic representation of offshore breakwater (Source: RHDHV. 2016)

The advantages of the offshore breakwater is that it creates an area of calm water between the coast and the structure providing calm area for people to enjoy the sea for purposes such as swimming and leisure fishing. Offshore breakwater will also provide unhindered access to the beach and resulting low energy wave action can potentially nourish the sediment starved areas of the coastline. Although significant environmental, economic and recreational benefits are expected by the offshore structure, cost implications and potential negative environmental effects arising out of footprint location of the structure can restrict how far from the shore it can be placed in the lagoon. The large footprint on the reef flat has the potential to damage the ecosystem, the structure itself can be an eyesore and environmental damage can be expected for the source material location. Construction of breakwater in high energy wave zone adds risks to workers and idle time due to bad weather are also disadvantages associated with this alternative. By understanding the environmental drawbacks of offshore breakwaters and designing them to mitigate these concerns, they may be a viable option to control coastal erosion.

In order to make the offshore breakwater effective, maintaining appropriate distance from the coastline and height of the structure are important. With the increase in distance from the coastline

depth of the water increases which will directly affect the cost of constructing the structure. In Fuvahmulah, offshore breakwater can create a calm swimming area and the structure can be carefully positioned to create minimum disturbance to coral reef. Due to the anticipated benefits of offshore breakwater structures in controlling the erosion, this alternative was considered for further evaluation.

The Feasibility Study for the project concluded that the further the structure is placed from the coast the stronger the structure will have to be created to face stronger waves and hence more costly. Design considerations for the breakwater will have to consider the over-topping aspect and hence the crest level will need to be at par with the maximum allowed wave height behind the structure. The structure will need to be armoured with rock boulder or concrete (tetrapod) armour layer. During the feasibility study phase, required dimension for the structure was calculated for placing at -2m from the MSL as well as for -1m from the MSL at 2 different slope aspects of 1:2 and 1:1.5 for each location.

The feasibility study concluded that the breakwaters on the -2 m from MSL are not feasible within the available financial resource. Also from an environmental point of view it was already concluded that the breakwater should preferably be placed at some distance from the reef drop where most live coral was found. Also placing the heavy structure too close to the reef slope increases the risk of slope failure as was experienced in Male' north side. It is therefore recommended to move ahead with the alternative of placing the breakwater around the -1 m MSL contour line (approximately 30 m from the shoreline). The breakwater variant placed around the -2 m MSL contour line (approximately 50 m from the shoreline) is not considered feasible financially and environmentally.

8.2.6 Ecological Engineering

Ecological engineering makes use of the capability of appropriate ecosystem engineering species to strengthen the coastal defence system. Ecological engineering can use species that trap sediment and break waves. For example enhancement of coastal vegetation or developing a submerged offshore reefs could act as a variation of the coastal revetment or as a breakwater discussed above. Different types engineered structures can be used to reduce erosional forces on the beach and/or prevent the loss of sediment from the near-shore. The theory behind these structures is to reduce the height of incoming waves by reflecting and dissipating energy as the waves propagate over the submerged structure. For sediment trapping purposes, the vegetation acts as a physical barrier blocking sediments from moving offshore (Figure 90).

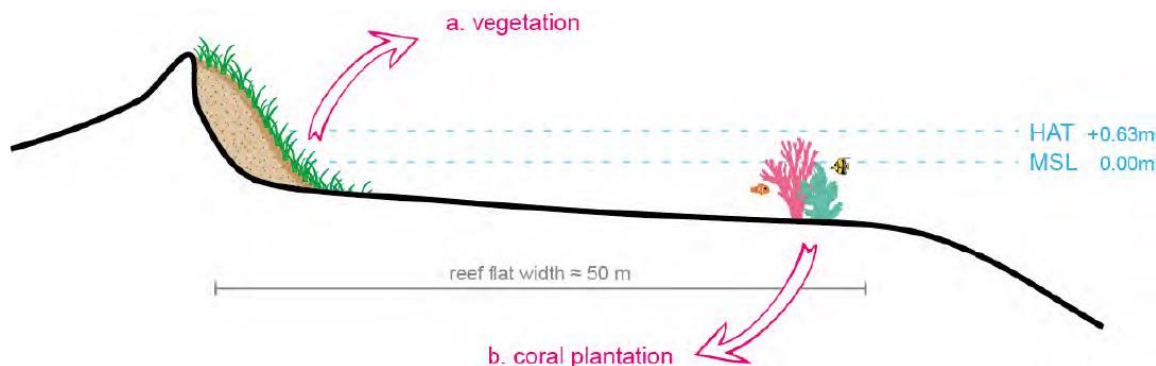


Figure 90: Concept of ecological engineering as an erosion control measure (Source: RHDHV. 2015)

There are a number of deficiencies in adopting this alternative as an effective measure. Firstly, lessons learnt from past coral planting programs in the Maldives show coral growth is an inherently a slow process requiring many years to achieve a good coral cover. This is further exacerbated by the fact that hardy coral species that can withstand high energy forces are even slower to grow. Even if the coral grow the method is not expected to be effective to achieve expected wave height reductions especially in storms because surge levels increase the water depth above the structure, allowing for higher than normal waves to break on the exposed beach.

Enhancing vegetation on the shore is another alternative. However, no suitable types of vegetation have been identified which are able to significantly strengthen the coastal ridge and prevent erosion in this saline and high-energy environment.

Although theoretically a robust coastal vegetation belt and an submerged artificial reef that can act as a breakwaters can provide an environmentally friendly protection for beaches by dissipating wave energy and trapping sand during normal wave conditions, and combined with the advantage of blending with the environment. These structures are associated with high degree of uncertainty and are not expected to be suitable for high energy conditions, and ineffectiveness considering the future sea-level rise due to climate change makes this alternative unsuitable for Fuvahmulah coast.

8.3 COMPARISON OF ALTERNATIVES

The previous section presented potential alternatives that can be considered to mitigate erosion at a coastal location. These measures are in use in the Maldives to various extent and most of the alternatives considered provide the ability to protect the shoreline and upland infrastructure. However, no alternative discussed above may suit to all environmental conditions and hence the choice of the alternative for the Project site shall be based on meeting specific conditions of the site. In the case of Fuvahmulah, the main focus of the project was to stop erosion on the north-eastern coastline. However, while providing coastal protection equally important is maintaining a healthy state of “Thundi” beach which is not only a unique environmental feature but also a critical recreational and economic asset for the people of Fuvahmulah.

Following the elimination of unsuitable alternatives, a comprehensive list of evaluation criteria was developed by the team of consultants to select the most appropriate alternative from the shortlisted ones.

8.3.1 Selection of most-favourable alternatives

Table 37 presents a summary of the five selected distinctive criteria which are used in the selection of the most favourable solutions among the eight solutions described in the previous section. These are the distinctive criteria to assess the feasibility of the conceptual solutions as defined in the previous section.

Table 37: Overview of the defined criteria

No	Criteria	Description
1	Effectiveness	The effectiveness of the solution to prevent damage on the island due to flooding as a consequence of ongoing erosion (breach of ridge).
2	Cost	The total costs of the project during its 50 years design lifetime, including construction costs, operation and maintenance.
3	Environmental impacts	The impact of the proposed solution on the environment and ecological resources.
4	Operation and maintenance	The embedding of operation and maintenance activities in order to fulfil the functional requirements of the structure during its design lifetime. If operation and maintenance is not correctly embedded, the structure might not be sufficiently sustainable in protecting against erosion.
5	Social impacts	The social impact of the proposed solution for the communities on Fuvahmulah. During construction phase and after implementation, during operation and maintenance.

Table 38 describes for each criterion the range of scores possible. The condition under which the criterion scores the lowest and the highest are described. Three scores are distinguished:

Negative score (-)

Neutral score (0)

Positive score (+)

The economic feasibility for each alternative was evaluated in the Feasibility Study and the resulting recommendations were used in deciding economic aspects in the evaluation.

Table 38: Description for various criterion the range of scores possible

No	Criteria	No-Go score	Negative score (-)	Positive score (+)
1	Effectiveness	The solution is not effective against erosion of the ridge.	The effectiveness of the proposed solution is slightly uncertain.	- Effective against erosion of the ridge. - Proven technology, limited uncertainties.
2	Costs	The solution with certainty does not fit within the Available implementation budget or O&M budget.	- Relatively high investment costs, but within the available budget. - Complex construction (large transport distance, difficult working conditions) resulting in high costs. - Relatively expensive maintenance required (high frequency or large amount of materials).	- Relatively low investment costs. - Limited maintenance effort and material required.
3	Environmental impacts	Unacceptable irreversible environmental impact, which cannot be mitigated.	Damage to corals or trees due to construction works or sedimentation), which can be mitigated.	- Enhancement of biodiversity. - Limited amount of material is used (resulting in limited transport and exhaust).
4	Operation and maintenance	Required operation and maintenance of proposed solutions is cost-wise not realistic.	- High frequent maintenance required. - Complex maintenance activities where high-end specialists of material is required.	- Low frequency of maintenance activities - Easy (well-known) type of maintenance activities.
5	Social impacts	Unacceptable irreversible social impact, which cannot be mitigated.	Danger for locals during construction (i.e. working from land is potentially more dangerous than working from water).	- Access to water for locals/tourists - Limited contact between to communities during construction phase.

Table 39 shows assessment of the eight alternatives against the selection criteria as concluded in the Feasibility Study (RHDHV, 2015). According to the scores four feasible options (solutions without a single No-Go score) have been identified. These feasible alternatives are as follows:

Alternative 1: Offshore breakwater. With a variation between:

- Rock boulder armour layer
- Concrete element armour layer

Alternative 2: Onshore revetment. With variation between:

- Rock boulder armour layer
- Concrete armour units

Table 39: Comparison of the shortlisted solutions (Source: RHDHV. 2015)

	Offshore Breakwater		Nourishment		Land Reclamation	Floating Breakwater	Onshore Revetment				Ecological Engineering
Criteria	1A	1B	2A	2B	3	4	5A	5B	5C	5D	6
	Rock boulders	Concrete elements	Sand	Sand & groynes			Rock boulders	Concrete places blocks	Geotubes	Sheet piles	
Effectiveness	+	+	No-go	No-Go	+	No-Go	+	+	0	0	No-Go
Costs	0	-	No-go	No-Go	No-go	-	+	+	+	-	0
Environmental impacts	-	-	No-go	-	-	0	0	0	0	No-Go	+
Operation & maintenance	+	0	No-go	No-Go	0	No-Go	+	+	No-Go	-	-
Social impacts	+	+	0	-	+	-	0	0	0	-	0

8.3.2 Comparison of two most favourable alternatives

In addition to the findings of the Feasibility Study additional data collection and numerical modelling were also considered in further evaluation of the two shortlisted alternatives.

Comparison of the alternatives is done by a quantitative Multi-Criteria Analysis (MCA).

The final evaluation considered the key aspects of the project as follows:

- A protection length: 2650 meters;
- The design lifetime: 50 years; and
- Designs based on a 1/100 per year extreme storm event, including 0.75 m Sea Level Rise (in line with Maldives Climate Risk Resilience guidelines and IPCC predictions¹⁰).

I. Off-shore Breakwater

IA. Low-crested offshore breakwater with rock armour top layer

¹⁰ Formulation of Guidelines for Climate Risk Resilient Coastal Protection in the Maldives - Report 8 – Final Guidance Manual (UNDP and MEE)

- Offshore breakwater at the -1.0m MSL depth contour
- Relatively low crest level (+2.5 - +3.5m MSL) to reduce wave transmission
- Calculations have shown that this crest level is *insufficient* to stop the ongoing erosion of the coastline
- Core and top layer of the structure consists of rock armour, to be sourced abroad

Figure 91 shows an example of an offshore rock armour breakwater constructed in the Maldives.



Figure 91: Example of offshore breakwater constructed at Maamigilli Island

IB. High-crested offshore breakwater with rock armour top layer

- Offshore breakwater at the -1.0m MSL depth contour
- Design comparable to IA, but with higher crest level (+4.5 - +5.0m MSL), to be more effective against erosion than the low-crested offshore breakwater
- Core and top layer of the structure consists of rock armour, to be sourced abroad

Figure 92 shows an example of concrete armour units used as sea defence in the Maldives.



Figure 92: Tetrapod concrete armour units offshore breakwater in Male'

IC. Low-crested offshore breakwater with concrete armour top layer

- Offshore breakwater at the -1.0m MSL depth contour
- Relatively low crest level (+2.5 - +3.5m MSL).
- Calculations have shown that this crest level is *insufficient* to stop the ongoing erosion of the coastline
- Top layer consists of concrete armour units (f.e. Tetrapods or X-blocks). The core of the structure consists of rock armour, to be sourced abroad

ID. High-crested offshore breakwater with concrete armour top layer

- Offshore breakwater at the -1.0m MSL depth contour
- Design comparable to 1C, but with higher crest level (+4.5 - +5.0m MSL), to be more effective against erosion
- Top layer consists of concrete armour units (f.e. Tetrapods or X-blocks). The core of the structure consists of rock armour, to be sourced abroad.

II. Onshore Revetment

Four sub-alternatives have been identified to assess the most appropriate option. These alternatives are briefly discussed in the following paragraphs.

IIA. Rock revetment (landward)

A typical landward rock revetment is shown in Figure 93.

- Onshore revetment. Crest level at +3.5m MSL to be climate-resilient (prevent significant overtopping during 50 years life time).
- Crest line of the structure is on same location as existing crest line. (figure 92, right). This will minimize material volume, but requires part of the footprint inland of the existing crest line and therewith removal of trees in vegetation belt.
- Core and top layer of the structure consists of rock armour, to be sourced abroad

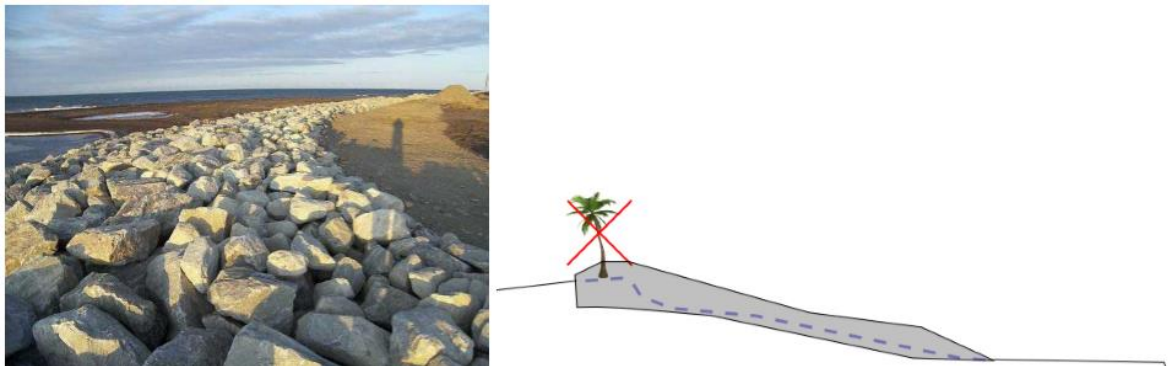


Figure 93: Example of rock revetment (left) and location of crest line in existing profile (right)
(Source: RHDHV, 2015)

IIB. Rock revetment (seaward)

- Onshore revetment, design comparable to IIA.
- Structure crest line is shifted seaward (figure 94), to reduce damage to vegetation belt. However material use and footprint on reef flat is larger compared to IIA.
- Core and top layer of the structure consists of rock armour, to be sourced abroad

Figure 94 shows example of seaward rock revetment used to protect coastline.



Figure 94: Rock revetment used to protect coastline at Gulhifalhu

Seaward rock revetment can result in shifting crest line seawards (see Figure 95).

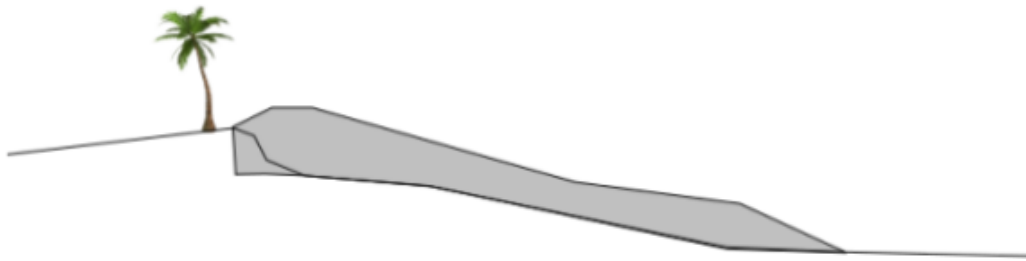


Figure 95: Crest line shifted seawards (Source: RHDHV, 2015)

IIC Concrete placed blocks revetment (landward)

- Onshore revetment, with concrete placed blocks (dimension ca. 30x30x60cm) as a top layer (see table 43).
- Very high crest level (+5m MSL) (more than man size) required to be climate-resilient (to prevent significant overtopping during 50 years life time).
- Crest line of the structure is on same location as existing crest line (comparable to IIA)

IID. Concrete placed blocks revetment (seaward)

- Onshore revetment, with concrete placed blocks (dimension ca. 30x30x60cm) as a top layer
- Very high crest level (+5m MSL) (more than man size) required to be climate-resilient (prevent significant overtopping during 50 years life time).
- Crest line of the structure is shifted seaward (comparable to IIB)

The two most favourable alternatives are compared on the following criteria:

1. Durability / effectiveness
2. Costs
3. Impact on vegetation belt
4. Impact on reef
5. Impact on *Thundi* area
6. Social impact

For the alternatives a score is given for every aspect. Scoring is between 1 and 5 in which a score of 1 is most negative, a score of 5 is most positive. Further break down of the scoring is shown in the Table 40.

Table 40: Alternatives scoring breakdown

Criteria	Lowest possible score (=1)	Highest possible score (=5)
1. Durability / effectiveness	Uncertain whether alternative stops erosion during full lifetime of structure. Large maintenance effort.	Proven technology, minimum maintenance, 100% sure to be effective against erosion
2. Costs	Construction costs >30 million	Construction costs between €10-15 million
3. Impact on vegetation belt	Permanent removal of large amount of trees	No (or limited) damage to trees
4. Impact on reef	Large footprint on reef flat and risk of affecting live corals	Small footprint on reef flat and limited risk of affecting live corals
5. Impact on <i>Thundi</i> area	Significant erosion of <i>Thundi</i> beach	No impact on longshore sediment transport and reduced risk of affecting <i>Thundi</i> beach
6. Social impact	A combination of high crest (preventing sea view); no swimming area; less opportunity for employment and intense on-land construction activities	A combination of high opportunity for employment; safe swimming area; low crest level and limited on-land construction activities

Weighing factors of the criteria indicate the relative importance of the factors to each other. Together the weighing factors of all criteria sum up to 1. The higher the factor the more important it is considered.

Results of the MCA are shown in the Table 41 and Table 42 for offshore and onshore alternatives respectively.

Table 41: Multi Criteria scoring for offshore breakwater alternatives (Source RHDHV, 2016)

Criteria	Weighting factor for each criterion	I. OFFSHORE BREAKWATER							
		IA Rock, low crested		IB Rock high crested		IC – Concrete elements, low		ID – Concrete elements, high	
		Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
Scoring 1-5 (1 is negative and 5 is positive)									
Durability/ Effectiveness	0.33	1.00	0.33	3.00	1.00	1.00	0.33	3.00	1.00
Cost	0.07	4.00	0.27	1.00	0.07	3.00	0.20	1.00	0.07
Impact on vegetation belt	0.13	5.00	0.67	5.00	0.67	5.00	0.67	5.00	0.67
Impact on reef	0.00	2.00	0.00	1.00	0.00	2.00	0.00	1.00	0.00
Impact on <i>Thundi</i> area	0.27	2.00	0.53	2.00	0.53	2.00	0.53	2.00	0.53
Social impact	0.20	4.00	0.80	3.00	0.60	5.00	1.00	4.00	0.80
Total weighted score			2.60		2.87		2.73		3.07

Table 42: Multi Criteria scoring for onshore breakwater alternatives (Source RHDHV, 2016)

Criteria	Weighting factor for each criterion	II. ONSHORE revetment							
		IIA – Rock, Landward		IIB – Rock, Seward		IIC – Concrete Blocks, Landward		IID – Concrete Blocks, Seward	
		Score	Weighted score	Score	Weighted score	Score	Weighted score	Score	Weighted score
Scoring 1-5 (1 is negative and 5 is positive)									
Durability/ Effectiveness	0.33	5.00	1.67	5.00	1.67	4.00	1.33	4.00	1.33
Constructability	0.07	4.00	0.27	4.00	0.27	1.00	0.07	1.00	0.07
Impact on vegetation belt	0.13	1.00	0.13	3.00	0.40	1.00	0.13	3.00	0.40
Impact on reef	0.00	5.00	0.00	4.00	0.00	5.00	0.00	4.00	0.00
Impact on <i>Thundi</i> area	0.27	4.00	1.07	4.00	1.07	4.00	1.07	4.00	1.07
Social impact	0.20	2.00	0.40	2.00	0.40	1.00	0.20	1.00	0.20
Total weighted score			3.53		3.80		2.80		3.07

The elaborate MCA shows in all scenarios that the alternative 2B (seawards rock revetment) is the highest ranked solution to protect Fuvahmulah island. This alternative scores medium/high on all criteria, except for the social one related to creation of the swimming area, construction activities

on the shore and potential job opportunities. Different sensitivity scenarios show the robustness of the results, as in all sensitivity scenarios (even the social one) alternative 2B remains the highest ranking solution.

Alternative 2B has the main advantage that rock revetment is based on proven technology and will definitely stop the erosion along the coast of Fuvahmulah, which is of utmost importance. In addition, this option has a low risk of a change in sediment transport along the coast that may affect *Thundi* Beach. The sea view will not be blocked, there will be limited (temporary) damage to a small part of the trees and the risk of damage to the coral reef is minimal. Furthermore, based on estimated construction cost, it is expected that this solution fits within the available budget (see RHDHV, 2016 for additional details).

Both alternatives have been included in the following chapter for the impact assessment and the formulation of mitigation and enhancement measures.

9. ENVIRONMENTAL IMPACTS AND MITIGATION

9.1 INTRODUCTION

This chapter describes the potential positive and negative environmental and social impacts of the coastal protection works at the northeast coast of Fuvahmulah Island. Mitigation and enhancement measures have been proposed for the related impacts. The study evaluated a number of potential alternatives as described in the Chapter on Alternatives. This chapter focuses on the impacts associated with two most promising alternatives that are considered: the offshore breakwater and onshore revetment.

9.2 OFFSHORE BREAKWATER

9.2.1 Construction Phase

The results of the impact analysis carried out for the offshore structure for the construction phase using the methodology described in Section 1.6.3.1 is given in Table 43.

Table 43: Impact matrix - Construction phase of offshore breakwater option

	Envisaged impact factors	C1 Rock boulder quarrying	C2 Energy generation for construction from fuel	C3 Transportation of rock boulders inland	C4 noise and vibration from civil works	C5 Placement of rock boulders at reef flat	C6 Sloping rock boulders (reef slope failure)	C7 Stockpiling rock boulders	C8 transportation of alien/invasive species from abroad	C9 Risk to vegetation	C10 Underwater works and barge movement	C11 Maintenance of offshore construction structures	C12 Construction waste generation	C13 Construction zone boundary establishment	C14 Irresponsible practice of workers and contractor	C15 Congestion in port area due to material transport etc	Total (Impact Area)	
Physical Components	Seawater		-1										-3		-1		-5	
			1										5		1		7	
	Ground water	-3	-1	-1									-3				-11	
		5	1	1									2				13	
	Air	-6	-8	-6									-2		-2		-24	
		5	8	3									3		1		20	
	Noise	-5	-2	-1								-8					-16	
		5	2	2								3					12	
Coastal Zone		-1										-2	-4	-6	-3	-2	-19	
		2							-1			1	5	3	1	2	15	
Biological Components	Flora		-2	-1	-1			-3	-7	-5			-2		-1		-22	
			2	1	1			3	1	3			3		1		15	
	Coral Reef		-2		-1	-10	-7				-5	-2	-5		-3		-35	
			2		1	8	1				10	2	5		2		31	
	Fauna		-1		-7					-5		-5	-1	-5		-4		-28
			1		2					1		6	1	5		1		17
Socio-Cultural Component	Accidents	-5		-2				-2	-1		-3	-3			-2		-18	
		5		2				1	1		3	3			1		16	
	Landscape	-7	1	2		-10	-7	-3					-4		-2		-30	
		5	2	3		10	1	2					4		1		28	
	Health	-3	-1	2	-1						-2	-2	-2	-4	-3		-22	
		5	1	3	1						3	2	4	6	1		28	
	Cultural heritage					-9											-9	
						10												10
Local economy	6	-2	3		-10				-1				-3			-2	-8	
	5	1	2		10				1				3			2	24	
Total (Construction Activity/Risk)		-23	-20	-4	-10	-39	-14	-8	-15	-5	-23	-10	-33	-10	-21	-4		
		35	23	17	5	38	2	6	5	3	25	9	39	9	10	4		

The following sub-sections discuss the predicted positive and negative impacts of developing an offshore breakwater structure at the eastern coast of Fuvahmulah as given Table 43.

9.2.1.1 Landscape impacts on source area

Suitable material required for the construction of the offshore structure is not locally available. Hence for all coastal protection works granite rock is imported from abroad to the Maldives. India is the main supplier and other source countries include, Indonesia, Malaysia and UAE. Mining for rock from mountains and hills will inevitably deface the area bringing irreversible changes to physical characteristics of the site. It will also create dust and noise in the process affecting people living in the vicinity. Mining also involves risks to labourers and infrastructures in the nearby areas. At the global level, the quantity of granular rock needed for the Project may not be significant and the magnitude of impact on landscape would also depend on whether material is sourced from a single quarry or multiple quarries. Considering the quantity needed in relation to the global trade in granular rocks, the impact is believed to be in the order of minor to moderate. Granular rock exporting countries have in place their internal rules and restrictions believed to be aimed at minimising impact of quarrying on the natural and human environment. Hence it is imperative to ensure that material brought for the Project is obtained from a certified query to encourage responsible mining. Certified suppliers are believed to obtain rocks from approved areas by the respective governments. Certified miners are also expected to respect rights of their workers ensuring their safety and wellbeing during the work. Compensations arrangements for loss and damage are also expected to be in place by the responsible miners. In the past there had been reports of locals from source region protesting against mining when illegal suppliers try to mine materials from sensitive locations. Therefore the following mitigation measures are recommended in procuring granular rock for the Project to minimise the impacts.

Measures

- Ensure that the material obtained is from a licenced query;
- ensure that the local rules, regulations are followed in obtaining rocks;
- obtain materials from the closest source available; and
- optimising the design to minimise the amount needed.

9.2.1.2 Impact on climate

Transportation of the materials from source country to Fuvahmulah and from the port to Project site would require fuel for the vessels and vehicles with resulting global warming gases into the atmosphere. As part of an EIA, a CO₂ footprint is calculated for the Coastal protection project at Gn. Fuvahmulah, Maldives. The main source for the calculation is the report coastal protection at Gn. Fuvahmulah. Deliverable 2e: Technical Design, d.d. 25 September 2016 (RHDHV, 2016). Sources for the CO₂ emission factors and other key calculation factors are mentioned in **Appendix 6**.

From table 5-4 of the technical design report can be calculated that a total volume of 129,268 m³ natural rock is needed for the project. This corresponds to 212,387 tonnes (density of 1.64 t/m³, 38% voids). This rock needs to be produced and transported to the site. For the production a CO₂ emission factor of 4.3 kg CO₂ / t natural rock is used.

This is a rather low factor, but the best one available from literature. The distance of the freight from India (an average distance of 1,350 km is used) will lead to major emissions. On several phases the natural rock needs to be transhipped as shown in Figure 96.

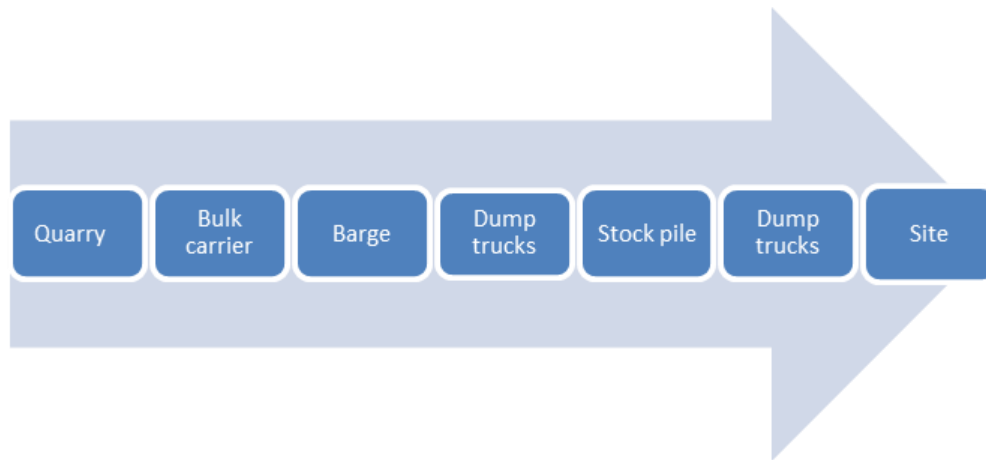


Figure 96: Transportation stages of the rock to Project site

For all transhipments a standard energy consumption factor is used of 1.3 kWh / t. This factor is calculated from a European study and assumes transhipments will take place with electric power. Here it is assumed use of only Diesel, however.

For on-site processing a distinction is made between excavation, cleaning of revetment footprint, placement of materials and profiling. These emissions are particularly hard to calculate due to many assumptions. The bucket of an excavator needs time to load and unload. This time is estimated to be 5 minutes but could be higher or lower as well. Furthermore, two experience numbers are used from an earlier study (Ketenanalyse dijkbekleding met waterbouwasfaltbeton Van Oord Nederland B.V. BD4591-101-100 d.d. 2 December 2014): a Diesel usage of 35 l/h for the excavator and 1.3 kg CO₂ / m for cleaning and profiling. The latter factor assumes 15 l/h Diesel usage, a velocity of 0.002182 h / m² and an average surface of 12.65 m².

Appendix 6 provides the details of the calculations for the onshore revetment of the total CO₂ emissions for the complete construction works. In total 9,650 ton CO₂ emissions will be generated by the production and transportation of the construction material and the placement of the materials as the revetment. For the offshore breakwater this amount will be about 50% more as the total amount of material needed will be more or less 50% more.

Measures

- Design to optimise the volume of materials required;
- procure materials from nearest source country to minimise transport distance;
- select material storage location as close to the work site as possible to minimise land transport distance;
- procure in bulk volume;
- avoid idle time for vehicles and plants to reduce emission;

- regular servicing and maintenance of vehicles and plants; and
- ensure vehicles used meets the local road-worthiness requirements.

9.2.1.3 Impact on roads

Project would require transport of large volumes of bulky materials from the small bulk carrier to the stockpiling area and from temporary storage to the work site. However, as described in section 2.8 transport overland has been minimised by using the breakwater itself for the transport of construction material from the stockpile area near the port to the site of placement of the material as a transportation route.

However, still the project will generate some transportation overland, which is additional to the current traffic. Land transport could create traffic, and may increase incidences of accidents, risks of spills on land can also be greater during the Project. Movement of vehicles can damage unsurfaced roads and cause compaction of soil and reducing the drainage capacity. Damage to the road surface can be more pronounced if the material movement period coincide with the rainy season (see Figure 97).

Considering these aspects, the work methodology has been carefully worked out to address most of these concerns. Hence in the case of offshore breakwater, the land transport movement have been planned to be restricted to a small area near the harbour (see Figure 9 (A)). Therefore, the impact of the Project's land transport on the roads, in the case of offshore option is believed to be minor. Nevertheless, the road areas where vehicle movements are expected to be concentrated, have not been paved and therefore the following mitigation measures have been proposed.



Figure 97: Damage caused to sand-surfaced road in an island by heavy vehicles

Measures

In order to reduce the impact on the roads and avoid road accidents and minimize the impacts of dust on the local population, main delivery route has been carefully devised in the work methodology (see **Section 2.8**). Hence, the material transport and stockpiling areas specified in the work methodology shall be strictly followed. However, some level of road transportation can still be expected hence the following mitigation measures have been recommended.

- Use the breakwater as a path of transporting the construction materials to the location of the placement of the materials (as described in chapter 2).
- Implement proper traffic safety measures;
- use modern clean transport means;
- transport during daylight hours;
- vehicles carrying building and waste materials must have their cargos covered when moving in public roads;
- the shortest delivery routes should be used and road shall be repaired before and after the construction works;
- To repair the roads before, during and after construction to limit the effects on the normal traffic.
- during loading and unloading public shall be kept out of bounds;
- inform community living along roads used by material transport route about construction plan and schedule as part of the work preparatory activities;
- vehicle drivers observe prescribed speed limits especially when traversing road sections along residential areas;
- apply dust suppressant techniques especially during dry periods; and
 - cover cargos of trucks transporting materials;
 - spray water on the road surface and on other fine construction materials;

9.2.1.4 Impact of noise and vibration

Noise and vibration needs to be considered and potential concerns of nearby populations taken into account for smooth implementation of the work schedule. Several types of heavy vehicles will be in operation at the Project site during the course of the Project. Noise will be generated by the engines of excavators, plants and other vehicles. The unloading and stockpiling of the construction material is another important source of noise and vibrations. The average peak noise of four typical vehicles expected to be used in the proposed Project's construction works; front-end loaders, excavator, dump trucks and pickup trucks within a radius of 15 m (50 feet) is given in in Table 44.

In the Maldives at present there is no legal noise control requirement standards nor sensitive hours of the day prescribed. Additionally, duration of the construction defined in terms of short, medium or long-term has not been defined. Therefore, for the purpose of this assessment, as described by Roberts (2009), short term construction activities are taken as those which would affect any one noise or vibration sensitive site for up to 14 days, medium term for more than 14 days and up to 20 weeks while long term activities exceed 20 weeks but less than 18 months. In the case of current Project, any one sensitive receptor is not expected to be affected for more than 20 weeks and hence construction work is considered medium term. The sensitive hours are taken as prayer times and

between 10pm and 6am except Fridays and on Fridays between 10am and 2pm in the context of the Maldives.

Table 44: Peak noise measurements of construction machineries - Source: (U.S. Department of Transportation/Federal Highway , 2016)

Vehicle type	L _{max} noise limit at 50 feet / (dBA) as per specifications	Actual Measured L _{max} at 50 feet (dBA)	Acoustic Usage Factor/ (%) ¹¹
Front-end loader	80	79	40
Excavator	83	81	40
Dump truck	85	76	40
Pickup truck	55	75	40

Applying standard noise limits that have been in effect for construction activities elsewhere as noise criteria are lacking in the Maldives, and assessing against actual measured noise level shown in Table 44), it appears that for medium term construction activities at a 50 feet distance, the noise level may exceed the prescribed standard noise limits for general construction during restricted hours as given in Table 45. It should however be noted that and during standard working hours noise limits exceeding 10 dB(A) greater than the values presented in Table 45 is allowed (Roberts, 2009).

Table 45: Standard noise limits for restricted hours Source: (Roberts, 2009)

Time period	General construction activities L _{Aeq,15min} dB(A)		
	Duration of Activity ¹²		
	Short term	Medium term	Long term
Daytime, restricted hours	65	60	55
Evening period 6:00pm – 10:00pm any day	60	55	50
Late night/early morning period, 10.00pm to 7.00am on any day.	45	45	45

¹¹ The 'Acoustic Usage Factor' represents the percentage of time that a particular item of equipment is assumed to be running at full power while working on site.

¹² Short term construction and maintenance activities are those which would affect any one noise or vibration sensitive site for up to 14 days, medium term for more than 14 days and up to 20 weeks while long term activities exceed 20 weeks but less than 18 months.

While construction activities have been planned to be carried out at the coastal areas and the construction vehicles will be largely operating on the breakwater itself, but will also use pre-determined restricted pathways as explained in work methodology, the increase in ambient noise level as a result of work related activities in comparison to recommended noise limits given in Table 45 on most of the sensitive receptors are not expected to be significant. The noise is expected to be dampened on the sensitive receptors as a result of the vegetation belt that separates the work location and sensitive receptors in most cases and prevailing westerly winds in the project environment.

Sensing construction noise and vibration depends on a number of factors such as the proximity to the noise and vibration source, the geology of the location, structural aspects of the receiving buildings as well as nature of people at the receiving end. For instance Computer modelling of the ground vibration transmitted by various items of construction equipment indicated that the ground vibration decreases progressively from hard competent rock ($n = 1.0$) to weak or soft soils ($n = 1.4$) (Roberts, 2009).

It has also been found that, a separation distance from heavy construction equipment to sensitive receptors for continuous vibration and various soil types can vary from 20m to 75m to achieve an acceptable annoyance criterion (strongly perceptible) of 2.5mm/s would be required (Roberts, 2009). Based on these findings, and considering the soil type, separation distance, and the nature of work, the impact of vibration as a result of operation of construction vehicles is considered minor. In the case of offshore breakwater, the impact of noise and vibration will be felt smaller compared to onshore structure mainly due to increased separation distance between the sensitive receptors and work site.

Even though the impacts of noise and vibration are expected to be minor to moderate, the proposed mitigation measures are aimed at further minimising the perceived impacts.

Measures

- Use the breakwater as a path of transporting the construction materials to the location of the placement of the materials (as described in chapter 2.
- Ensure vehicles used in the construction meets local road worthiness certification to ensure noise emission limits are maintained;
- ensure the vehicles and plants used in the works are regularly serviced and maintained to achieve manufacturer's absolute equipment noise emission limits;
- turn off vehicles and plants when not in use;
- maintaining maximum separation distance possible between the nearest buildings and the location of plants and vehicle operations by opting to described work methodology and in particular the proposed transportation route;
- informing the potentially affected population of the works schedule and record-keeping and addressing to any complaints received; and
- discontinue the works during the sensitive hours;

9.2.1.5 Impact on lagoon space

Lagoon space of Fuvahmulah is inherently thinly spread and placing footprint would mean permanently having to give up existing space from the lagoon for placing the footprint of the

breakwater. As per the design the footprint of the breakwater would be 22 m wide reaching a length of 2650 m. This would mean taking up of 58,300 m² of existing lagoon space (see Figure 98).

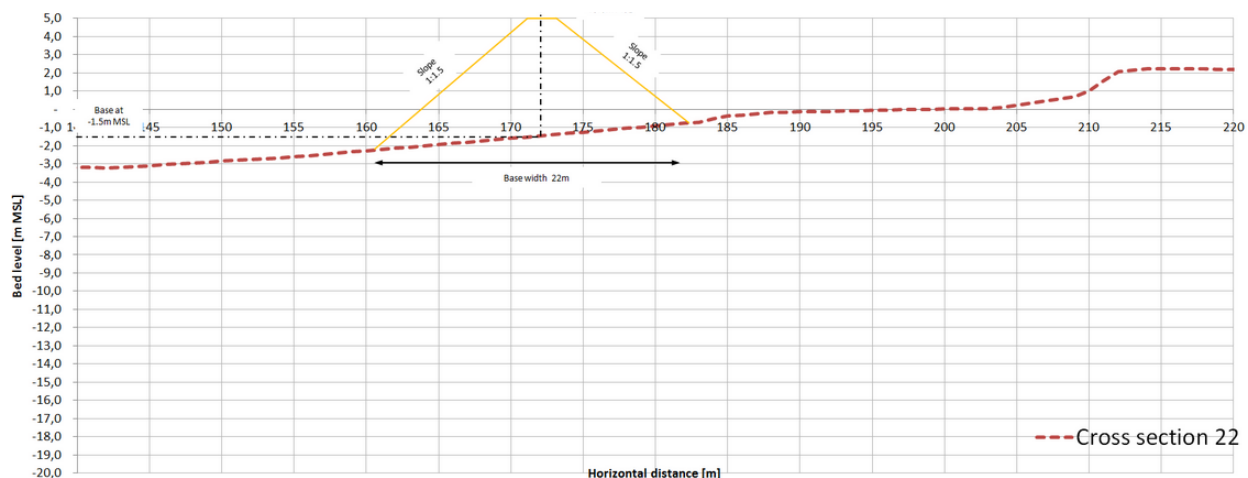


Figure 98: Footprint cross-section of the proposed breakwater (Source: RHDHV, 2016)

The existing lagoon space along the length of the proposed breakwater has been estimated to be 20ha (200,000m²) which means the footprint of the breakwater would take up approximately 30% of the existing lagoon area permanently. The footprint of the structure cannot be placed too close to the reef edge to avoid high coral cover and potential reef slope failures. This would mean that the actual loss of lagoon space from lower wave energy area would be perceived as much higher than the calculated value. Loss of lagoon space also mean loss of equivalent habitat space for reef and lagoon organisms. This non-reversible impact is considered to be significant due to considerable space lost from the lagoon.

Measures

- Design to optimise the base area of the structure; and
- loss of lagoon space can be reduced by opting the shore based revetment instead of the offshore structure.

9.2.1.6 Reef slope failure

Heavy structure placed near the edge of the reef may result in reef slope failure due to the heavy weight imposed upon it. Reef slope failure has not been too commonly reported in the Maldives except in the case of northeast house reef slope failure in multiple locations in Male' which attracted a lot of attention and scientific research. According to published literature reef system in Male' consisted of 2 to 3 m of weakly consolidated cap rock under which 4 – 6 m of weakly cemented rubble and coral sand was observed (Riyaz & Park, 2008) implying once the overlaying cap rock is damaged or broken the physical disintegration of the reef system would become unavoidable due to continuous wave and current actions. According to these findings, heavy structures placed too close the reef slope may increase the risk of reef structural failure due to stress and physical damage caused to area as a result of the placement of the structure.

Measures

- Placing the footprint of the structure at reasonable distance away from the reef edge;
- Selecting a technically competent party as a contractor to ensure good workmanship so that unnecessary physical damage is not caused to the reef; and
- The impact can be completely avoided by choosing the onshore revetment option.

9.2.1.7 Stockpiling of rock boulders

Stockpiling of rock boulders can damage vegetation, impact soil organisms and dust found on it may be blown away by the wind. Stockpiling operation can also be noisy when rocks grind against each other during stockpiling. This temporary impact is considered to be minor.

Measures

- The impact related to stockpiling on the vegetation and population have been avoided by selecting appropriate sites that are free from mature trees and away from residents for stockpiling (see Figure 9).

9.2.1.8 Introduction of pests and diseases

Small organisms such as insects and invertebrates that hitchhike on the rocks and plant seeds attached to the rocks may get introduced to the island and may become a source of introduction of pests and diseases to the island. Since agriculture plays such an important role in the local economy of Fuvahmulah, any such incident can cause a significant damage to the local farmers and economy. Although likelihood of an introduced organism establishing on the island and becoming a nuisance may be small, this impact cannot be completely overruled as incidences of introduced pests are becoming common in the Maldives.

Measures

- Physical inspection of the rocks for hitchhiking organisms both at the supply and receiving ends; and
- report to the Ministry of Fisheries and Agriculture of any incidences of an introduced organisms.

9.2.1.9 Impact on the vegetation

In the case of construction of offshore breakwater, most construction activity for the Project would be restricted to the marine environment and therefore the potential for impact upon the vegetation and is very limited expected. However, some vehicle movements may take place on-land and for safe movement of vehicles some areas with bush may have to be cleared to make way.

Measures

- Vehicles shall only be allowed to travel through routes predetermined which limits impacts to vegetation;
- during site preparation, paths for vehicle movement should be identified and explained to workers;

- do not cut down any mature trees and if there was no other choice, a tree may be uprooted carefully for relocation elsewhere on the island;
- low bushes needing removal to create access, they shall be uprooted and replanted;
- any issue involving removal of trees should be in line with the relevant laws and regulations and in coordination with the respective island council; and
- if a privately owned tree is to be removed compensation will have to be arranged in coordination with the respective Ward Council.

9.2.1.10 Damage to coral reef and lagoon ecology

The placement of footprint of the structure will have little impact on the live corals as the percentage of live coral cover in the area was found to be within the range 0 – 4.5% of the substrate cover. This percentage could be further decreased by manually relocating as much live corals from the proposed footprint location. On the other hand, accidental damage to the area beyond the footprint of the breakwater can be expected due to unintentional trampling by the workers and accidental fall of rocks in the process of their placement. The risks of oil spills, underwater noise generated, and physical disturbance caused during the placement of rocks, sedimentation, collision of barges and pontoons on the reef can also affect the coral reef and lagoon ecology.

Fish life in the area was found to be good. However, the impact on the mobile organisms are not considered fatal as they would escape from the area of disturbance and retreat into the areas where there is no disturbance. The total perimeter of the house reef being fairly large, and the region of disturbance at any given time during the construction work will be fairly small in comparison to the total reef perimeter, a relatively large undisturbed region of the reef would be available for mobile organisms. However, the immobile and benthic organisms found directly under the footprint of the breakwater will be the most affected. Overall, the impact of breakwater on the coral reef and lagoon ecology is considered to be moderately negative.

Measures

- Optimise the area of the footprint in the design;
- locate the breakwater at a reasonable distance from the reef edge with live corals
- remove and re-locate as much live corals to safe areas on the western side of the island during the site preparations;
- contractor is obliged to make an environmental action plan (EAP) in which actions and responsibilities are given to spills, waste, emissions;
- carryout the work in reasonable weather conditions;
- engage skilled labour with adequate experience to work in such moderately rough weather conditions;
- continuous monitoring of environmental impacts during and after construction of the revetment by an independent party; and
- the impact on coral reef and lagoon ecology can be avoided by opting for a near-shore coastal revetment.

9.2.1.11 Accidents and injuries

Working over-water, mobilisation of equipment and on and off vessels, lifting operations and transport of materials can be considered activities involving risks to workers and plants and

machineries. Reports of serious injuries stemming from such works are not common in the Maldives. However, given the unusual wave conditions that are found around Fuvahmulah these risks are considered moderate. In addition to Health, Safety and Security given in Section 2.10.7 of the report, the following mitigation measure will have to be implemented.

Measures

- Stockpile area work site shall be enclosed with clear safety signs;
- avoiding transport of materials during night time;
- ships arriving with materials shall not approach the island during night-time and properly coordinated with island authorities for safe navigation;
- monitor weather forecasts and pass the information to site supervisors;
- carryout the works during good weather conditions and the work shall not be continued in bad weather;
- personal protection equipments shall be available and used as appropriately during the work hours;
- life jackets shall be worn while working over-water and lifebuoys shall be kept within easy reach;
- first aid services shall be available at work site;
- surveillance from land should be conducted at all times when the work is in progress;
- safety measures and measures to reduce risks shall be included in the EAP by the contractor;
- safety signs shall be placed at work site;
- rescue post shall be established during the sea-based operations and shall be manned during work hours;
- assign safety mandate to an officer who be responsible for safety of personnel in the workplace; and
- develop emergency response plan and all workers shall be informed of the plan; and

9.2.1.12 Terrestrial and marine pollution

Construction works in the marine environment and litter and debris can find its way into the marine ecosystem. Careless servicing of vehicles and equipment, poor storage of oil and other hazardous goods can pollute the soil, water lense and marine environment. Operation of vehicles and equipment can emit gases that pollute air affecting people and ecosystem in the immediate vicinity.

Construction of the coastal protection will produce various types of wastes which has the potential to pollute marine and terrestrial environment. Fuvahmulah does not have a proper waste management system. Hence leaving project waste on the island would only add to the pollution problem of the island. In the absence of a proper waste management system on the island leaving behind

Although these impacts are reversible, in the long run, it is classified as moderately negative.

Measures

- Designate an area at the Project site for waste collection;
- arrangements should be made for the regular collection of litter and for its disposal only at the designated site;
- prohibit littering at the work site and place awareness signs for the workers;
- waste shall be transferred to Thilafushi on regular basis;
- all hazardous wastes shall be placed in an enclosed container and shall be transferred to Thilafushi;
- no refuelling shall be carried out at sea;
- vehicle maintenance and oil storage containers shall be carried out on a paved area;
- waste management plan shall be an integral part of the EAP of the Project.
- The site is to be cleaned of construction wastes and debris soon after completion of works to prevent wastes escape into the environment.
- Earthworks shall be carried out during low tides and in favourable weather as much as possible.
- Store fuel, oil, lubricants, and other petroleum products in secured areas, with concrete floor and waterproof roof;
- Ensure that vehicles and construction equipment are regularly maintained in good condition, promptly detect breakdowns for immediate repair and equipment operation license are renewed by contractor from competent authorities;
- When feasible, use manual construction methods with minimal equipment support;
- Do not wash vehicles and construction equipment on the beach or in an unpaved area to prevent soil and water contamination with oil, lubricants and other hazardous waste falling into ground or marine environment;
- Conduct regular vehicle and equipment maintenance as per the manufacturer's guidance, including changing engine oil, replacement of engine coolants, hydraulic fluids and inspection of moving parts.

9.2.1.13 Loss of beach access

During the construction of the offshore breakwater the majority of the beach can remain open and only on certain sections it will be closed for a short time. This impact is considered minor.

Measures

- The public should be informed about this change in inaccessibility to the beach before the construction mobilization work begins and should be encouraged to use alternative beach access areas such as *Thundi* beach and others; and
- open up areas as soon as the work is complete.

9.2.1.14 Impact of workers on the environment

Approximately 50 - 60 workers are expected in the workforce although this may not be huge number Project has to be planned and executed in a way their actions do not cause negative effects on the environment. These include, intentional or unintentional disturbance to nests, nesting sites,

catching, keeping or killing of animals, damage to corals. Haphazard disposal of waste can pollute marine and terrestrial environment.

- Prohibit littering in the work environment;
- place waste bins at convenient locations;
- designated areas for collecting waste shall be established at work site;
- toilet arrangement for workers shall be made from a nearby house;
- keep the workforce to minimum necessary;
- waste oil, used batteries shall be separate and placed in enclosed containers;
- vehicle service area to be paved and leaking of oil into the ground shall be avoided;
- regular servicing of the vehicles for leaks etc;
- all construction workers and persons on site must be given specific instructions not to catch or harm birds and animals allow them to retreat into undisturbed areas; and
- basic information on the protected sites and species found on the island shall be given during orientation.

9.2.1.15 Congestion in port and storage of materials in port area

The Project methodology has been carefully devised to avoid having to use the inner harbour of the island for unloading the bulk materials such as rock. The impact of minor increase in the number of vessels entering the inner harbour carrying workers and associated supplies is not expected to be significant. Additionally, the materials stored in the port area will cause some degree of visual impact. Additional vessels taking up space at the harbour may impact the local vessels and local vessels owners would not perhaps have the full supremacy they may have had in the harbour, once the construction work of the project commences.

- Temporary storage areas shall be enclosed; and
- use the harbour for the shortest duration possible; and
- place signs and provide information to the locals on the project activities;
- provide alternative temporary arrangements for the locals, where necessary, in coordination with the council.

9.2.1.16 Impact on utilities

No direct adverse impact on utilities is envisaged. Disruption to electricity, banking or telecommunication or any other services are not envisaged due to expected small increase in demand for services the utilities in the island such as the powerhouse have been designed to cater for temporary increase in demand. Increase in demand for services could be a positive impact as it would also enhance the revenue generated. As the workers would be accommodated in rental housing, it would come with toilet facilities (existing septic tanks) as the sewerage network development project is yet to commence. There are no public water services provided and it would be the contractors' responsibility to provide purchased mineral water for drinking. For domestic water uses the workers would be using groundwater and this would not cause additional stress on the water lens, as it would be only a few dozens of workers during the construction stage. The waste generated from workers would be taken to the waste management facility operated by

MRDC. However, the construction work generated waste would be mitigated as proposed in the environmental impact mitigation chapter.

The health services in the island are quite well developed. However, in case of severe injuries, patients have to be transported to other islands.

Measures

- Waste generated by workers and work shall be managed as per Section 2.10.6 on Waste Management; and
- emergency transport arrangements shall be in place for workers needing emergency transport out of the island.

9.2.1.17 Socio-cultural impact of workers

When a new group of foreign workers arrive on the island conflicts can arise with the resident population in the instances where local culture is overlooked or not respected.

Measures

- Hire locals for the workforce as much as possible;
- orient foreign workers on how to communicate with locals and personal hygiene and sanitation and prevention of sexually transmitted diseases and other infectious diseases;
- ensure illegal workers are not recruited for the project if foreign workers need to be hired; and
- establish rules for the behaviour of foreign workers and establish management unit tasked to monitor and discipline individuals who violates rules.

9.2.1.18 Impact on local economy

Although the project is worth €15 – 20million, significant proportion of the Project resources is expected to be expended abroad for procuring the required materials. Granite rock and needed for the revetment works are not locally available and therefore will have to be imported. Since the selection of the contractor will go through international competitive bidding, there is also the possibility of a foreign contractor getting selected for executing the works.

In that case direct financial benefits of the Project will be felt to a foreign party as opposed to a local company. Since there are no island level contractors who can undertake a project of this nature, the chances of a contractor from Fuvahmulah getting selected as the Project contractor is almost nil. Nevertheless, since 50 – 60 workers are expected to be required for the Project there can be limited temporary job opportunities for the locals. Also there would be direct and indirect socio-economic impacts such as increased sales. Supply chain opportunities to construction works for fuel, food and beverage, accommodation and any other materials which has to be bought locally would bring in a positive impact on the local economy. Hence direct economic benefits of the Project on the local economy is considered to be minor positive during the construction phase.

Enhancing benefits

- Encourage Maldivian contractors to bid for the Project;

- hire locals for the workforce as much as possible; and
- food, accommodation for the workers to be arranged using existing facilities.

9.2.1.19 Risk of poor labour conditions

Since there is quite some unemployment among the people, and especially the youth, living in the Island, there may be quite some eagerness to find temporary employment in the construction of the power plant project. It is also possible that the Contractor will recruit unskilled labour from outside the Maldives. Often workers from Bangladesh are hired as they are relatively cheap. There is a risk that the Contractor may get tempted to recruit labour force against insufficient labour and working conditions to save costs. As this Project will be managed under international conditions and monitoring, the risk is considered minor.

Measures

To prevent the exploitation of the workforce, the Contractor should comply with the provisions in the Labour Act of the Maldives and the international ILO conventions. The following items apply specifically for this Project:

- Develop transparent human resources policies and procedures for recruitment process, working conditions, terms of employment wages, worker-employer relations, non-discrimination policy, monitoring, roles and responsibilities;
- Provide reasonable, and if applicable negotiated, working terms and conditions.
- No use of child labour (workers under age 18) or forced labour is allowed;
- Provisions to ensure compliance with labour standards by supply chain and subcontracts, including training if required;
- Provide proper work place facilities for water/sanitation/rest rooms; and
- No hiring of short-term labour to be made at the site gate;

If indeed the Contractor implements their human resources procedures in line with the Maldivian Labour Act and ILO Conventions and his held by these through their construction contract, the risk of exploitation of the labour force can be kept to a negligible level.

9.2.2 Operation Phase

The results of the impact analysis carried out for the offshore structure for the operational phase using the methodology described in Section 1.6.3.1 is given in Table 46

Table 46: Impact matrix - Operational phase of offshore breakwater option

	Envisaged impact factors		O1 Flooding	O2 Risk of shifting erosion northwest	O3/O4 Creation of swimming/fishing area	O5/O6/O8 Protection of agricultural land, coastal properties groundwater lens	O7 Visual impact of breakwater	O9/O10 Demographic and community	O11 Protection of significant landmarks	Total (Impact Area)
Physical Components	Seawater			-1	-4					-5
				1	3					4
	Ground water	7		-1		5				16
			9		1		6			
	Air	1			-1	2				6
			1			3	3			
	Noise				-1					-1
						2				
Coastal Zone	9		-6	6	6			6	19	
		9		9	8	7			3	36
Biological Components	Flora	5		-3	4	3	-3		4	13
			3		2	1	3	3		4
	Coral Reef	2		-1	-1				4	4
			-2		2	1				2
	Fauna	5		-1	5	5			4	18
			4		1	2	6			3
Socio-Cultural Component	Accidents	8			9	6	-2	9	-3	27
			6			6	3	1	8	3
	Landscape	9		-6	6	6				15
			7		2	3	4			
	Health	7		-1	6	9	-9	9	10	31
			6		1	2	7	8	8	8
	Cultural heritage	8				2			10	20
			4				2			9
	Local economy	8		-1	3	-10	-9	7	10	8
			5		1	2	10	8	8	6
Total (operational Phase Activity/Risk)		69	-21	32	34	-23	25	45		
		52	20	33	51	20	24	38		

Predicted impacts given in Table 46 and proposed mitigation measures associated with the operational phase of the offshore structure are discussed in the subsequent sub-sections.

9.2.2.1 Erosion control, reduced risk of flooding & damage to properties

Erosion prevention and control is the main objective of the project; hence most significant positive impact of offshore structure is expected to be the reduced risk of erosion brought about by the Project. In addition, reduced risk of the island to flooding as a result of protection provided to the natural ridge by the new offshore structure is also considered to be a significant positive impact. There is a strong sense of belief among the community members that the coastal protection works will reduce damage to properties, reduce the risk of loss of life, reduce damage to assets, and reduce the ultimate risk of having to abandon the island. These are considered significant positive impacts of the Project.

Measures

- Develop, manage, implement and monitor an integrated development plan for Fuvahmulah in consultation with the population enhancing the socio-economic development of the Island

9.2.2.2 Risk of moving erosion problem to *Thundi* area

Construction of the offshore breakwater will reduce the approaching wave height and therefore reduces the impact of the waves on the coastline compared to the actual situation. The breakwater will significantly change the nearshore hydrodynamic such as waves, water levels and currents. Consequently, also the longshore currents which drive the longshore sediment transport will change.

It is expected that the direction of the longshore sediment transport will not change, because the breakwater is aligned parallel to the coastline and not very far from the coastline. The transport capacity will change due to changed hydrodynamics, however due to the limited amounts of sediment present on the reef flat this impact will be limited. Behind the breakwater a sheltered area is created, where some accretion of sand can be expected. In front of the breakwater, no accretion is expected.

The impact of the structure to adjacent coastal areas, such as *Thundi* beach in the north, shall be considered. *Thundi* beach is located approximately 700m north of the end of the envisaged breakwater. *Thundi* area is a protected beach and a vital asset of the island for the locals and visitors. The local population may have a concern that the new coastal protection works will affect the extent and development of *Thundi* beach. As *Thundi* is of cultural importance to the people, this concern may have considerable effect on the well-being of the people. Hence any negative effect on *Thundi* as a result of the offshore structure will be considered negative.

Due to the changed hydrodynamics near the breakwater, changes in currents and wave patterns can be expected especially in the vicinity of the northern tip of the breakwater. The unprotected coast directly north of this tip is most vulnerable to be affected by the breakwater construction. However, this risk is considered low due to limited sediment availability and sediment transport capacity in the system.

Because *Thundi* beach is even some 700 meter away from the breakwater, the risk for erosion impact in this area is even lower. Nevertheless, such dynamic coastal systems remain very complex and unpredictable. Although no immediate significant negative impacts are expected as a result of the offshore structure, due to the uncertainties of what might happen to *Thundi* beach it is recommended to put in place a regular monitoring program for *Thundi* area.

The expected coastal processes are illustrated in the two figures below for both the offshore and the onshore option, derived from Van Rijn, 2013.

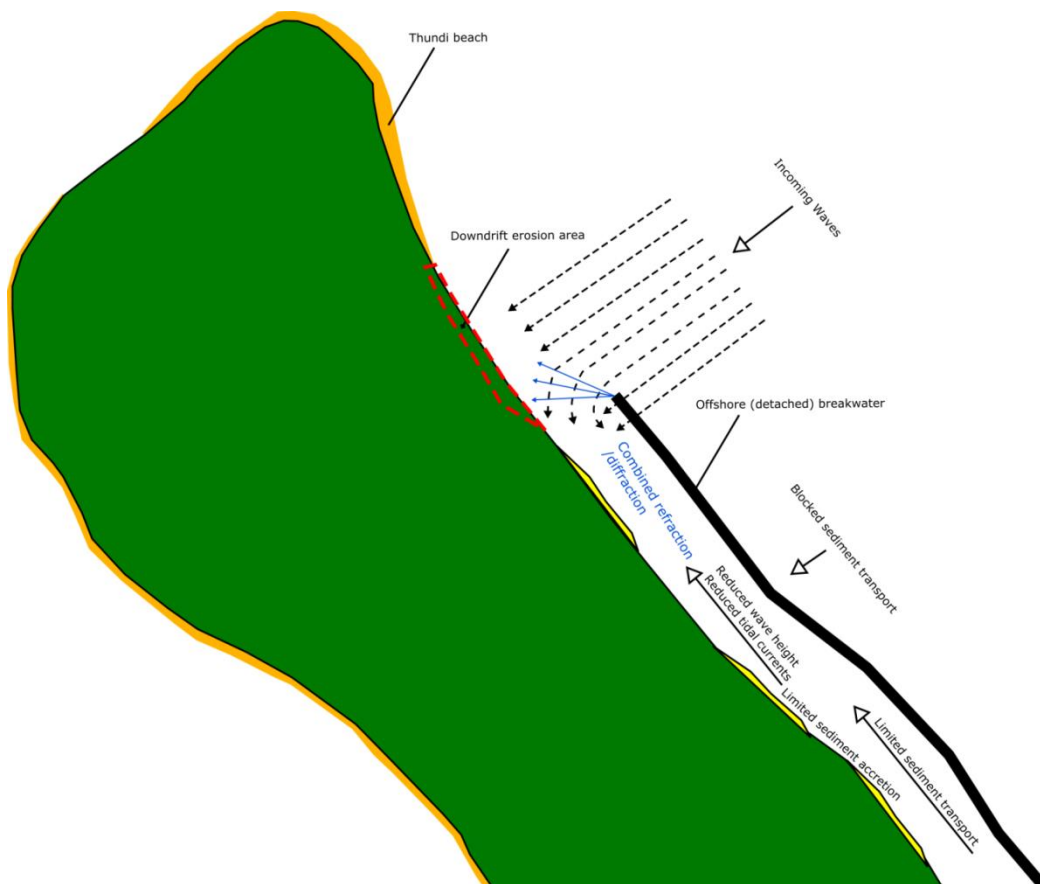


Figure 99: Expected erosion pattern at northern end of offshore breakwater (derived from Van Rijn, 2013)

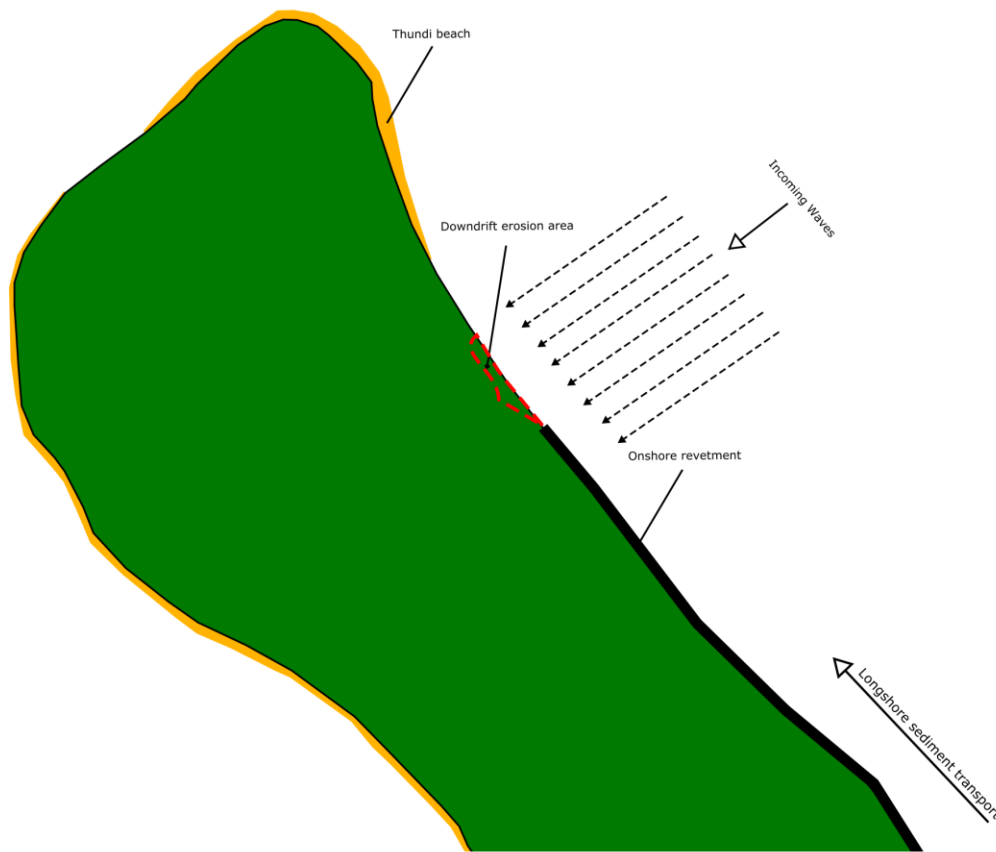


Figure 100: Expected erosion pattern at northern end of onshore revetment (derived from Van Rijn, 2013)

Measures

- Bi-annual monitoring for 10 years of beach profiles to understand cycles of erosion and accretion relating to the changes in coastal processes and producing the first environmental audit of the changes after the first 5 years of monitoring; and
- involving the local population in the monitoring, to create better understanding and enhancing transparency.

9.2.2.3 Safe swimming and recreational fishing area

Anbule, Bandahafannu and Rasgefannu are locations people use for enjoying the sea. However, none of these sites are considered usable throughout the year mostly due to the unprotected nature of the sites. Generally strong waves and rip currents created in the lagoon on the east coast makes it dangerous for swimmers to use it during much of the year. The situation can be greatly reversed by construction of the offshore breakwater by creating calmer conditions in the lagoon between the coastline and the structure. The breakwater will create safe space for people of all ages to enjoy the lagoon without having to be concerned of dangerous rip currents. This impact is considered to be moderately positive. However, the calmer conditions created in the lee of the breakwater can create conditions that favour settlement of sediments gradually making the area shallower.

Enhancement

- Install safety measures (floating lines with balls in opening breakwater) and information panels at the swimming area. Put signals in case of rough weather; and
- Monitor lagoon bathymetry for 10 years to determine changes to the bathymetry.

9.2.2.4 Risk of deteriorating lagoon water quality

Breakwater constructed without breaks in between may create stagnation lowering water quality in the lee of the structure. This impact is considered to be moderately negative.

Measures

- Leave breakwater detached from beach at the beginning and ending and create some openings in the breakwater. Bi-annually monitor changes to coastline for 10 years.
- Water quality shall be measured bi-annually for 10 years for the following parameters.
 - Nitrates
 - Phosphates
 - pH
 - BoD
 - CoD
 - Salinity
- Water quality baseline shall be established before the construction works begins..

9.2.2.5 Protection to agricultural land

Offshore structure will reduce the wave energy approaching the island's protective coastal ridge and thereby ongoing erosion of the coastline is expected to be controlled. As has been described in this report, continuous erosion would mean greater intrusion of saltwater into the groundwater lens. Further, incidences of breaching of the ridge coupled with overtopping of waves causing flooding will be controlled by the breakwater. These will benefit the agricultural lands due to controlled storm wave flooding of the island. In the past numerous such incidences have severely affected the crop production causing significant damage to the crops and the local economy. This impact is considered minor to moderately positive.

Measures

- Monitor groundwater quality bi annually for 10 years;
- baseline to be established just before the construction works begin; and
- establish a proper system at the council office for keeping records of abnormal weather events.
- Enhance socio-economic development of the Island by preparing, implementing and monitoring an integrated development plan for the Island.

9.2.2.6 Impact on groundwater lens

Groundwater salinization can occur due to flooding of the island by over-topping waves during storm surges. In addition, continuing erosion of the island enhances salinization of the groundwater due to direct seepage of saltwater into aquifer. The groundwater lens of an island is formed in

proportion to the island size and the aquifer exists in a dynamic equilibrium with the seawater (Falkland, Custodio, Arenas, & Simler, 1991). When the erosion becomes an on-going process, no equilibrium is expected and the seawater intrusion continues or the freshwater lens is gradually lost. Although this may be a gradual process, in the case of Fuvahmulah, the topography of the island is such that, once the higher island ridge is broken due to erosion the risk of saltwater intrusion getting enhanced exists. Since the proposed breakwater will control the erosion at the most vulnerable coastline of the island, the risk of saltwater seepage is expected to be greatly reduced and wave over-topping incidents are also expected to be greatly reduced. However, since breakwater is not expected to be as effective as the revetment alternative in controlling the erosion, the effect of breakwater on groundwater salinization is expected to be minor to moderate.

Mitigation

- Groundwater monitoring program shall be carried out for up to 10 years from the locations shown in Figure 12 and 5-yearly audits shall be produced

9.2.2.7 Visual impacts

When viewed from beach, the wall protruding out of the sea would reduce the natural vista and amenity therefore may lower the quality of the coast from enjoyment viewpoint. The naturalness and openness qualities are lowered due to the seawall. Hence, from landscape perspective hard defence structures will result in a negative visual impact which is moderate, although visual impacts can be subjective and the perception could differ from person to person. For instance, many resort islands are known to have such breakwaters facing the beaches frequented by visiting tourists.

Measures

- Keep crest height of breakwater as low as possible while creating sufficient protection against erosion; and
- rehabilitating coastal vegetation to mask the view from inland.

9.2.2.8 Increased social well-being

With developmental of coastal protection works, the infrastructure around the island and especially close to coastal buffer zone would be protected and this would increase the social well-being of the community. This may induce further socio-economic development in the Island resulting in more job opportunities. Local tourism and potential for opening of other income generating business in the land areas close to the coastal protection zone will enhance the local economy. Any investments in the lands close to the coastal protection area would have the confidence of having reduced erosion related impacts.

The biggest positive social impact from the project would be provision of reduced vulnerability from severe coastal erosion and therewith creating security for the future.

Without any intervention to reduce erosion and flooding, the islands population feels threatened in their existence (part of the land might be claimed back by the sea) and therewith investments for the future are not promoted.

Enhancement measures

- To enhance the socio-economic development of Fuvahmulah, an integrated development plan should be prepared in close consultation with the population of the Island and with the different economic sectors (e.g. agriculture and tourism). This plan should preferably be prepared as an initiative of the Atoll Council. Finances should be sought to implement the plan and it should be carefully monitored.

9.2.2.9 Community cohesion strengthened

The anticipation for this development would increase the community cohesion and would help to achieve their vision for the development of the island. This project would provide a safe and healthy environment to live and work in and provide a sustainable stable basis for further socio-economic development.

Enhancement measures

Same as given in **Section 9.2.2.8**

9.2.2.10 Impacts on demographic developments (migration)

With the protection of the Island against erosion the population will have more confidence in the future and this may have an effect that less people will reside outside of Fuvahmulah and more people may move back to Fuvahmulah. Also people from other islands may move to Fuvahmulah. It is hard to predict how significant the change in migration patterns may be.

Measures

N/A

9.2.2.11 Impacts on cultural sites and heritage

It is part of Maldivian culture to live and enjoy the coast and the sea. The protection against erosion will enhance the positive experience of passing time at the coast.

Further there are cultural and heritage sites in the coastal areas where major erosion take place in Fuvahmulah and where the project will be implemented. A century old mosque sitting close to the shoreline will be preserved as a result of the Project. Also some graveyards and pre-Islamic archaeological sites will be protected.

Enhancement measures

Same as given in **Section 9.2.2.8**

Impacts characteristics and proposed mitigation or enhancement measures associated with the proposed off-shore protection is summarised in Table 47. The impact mitigation actions will form an integral part of the EMP for the Project.

Table 47: Environmental and social impacts and mitigation or enhancement measures off-shore protection

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
C1	Quarrying of rock boulders and quarry run changes landscape of the source area.,	People and ecosystem around the query site of the source country	negative	Moderate	• Ensure that the material obtained is from a licenced query. • Ensure that the local rules, regulations are followed in obtaining rocks. • Obtain materials from the closest source available. • Optimising the design to minimise the amount needed	In construction costs
C2	Energy generation and consumption for the project activities generate GHGs and other pollutants into the atmosphere impacting climate change and the ecosystem,	Global environment in general and people and ecosystem found close to project activities	negative	Moderate	○ Design to optimise the volume of materials required; ○ procure materials from nearest source country to minimise transport distance; ○ select material storage location as close to the work site as possible to minimise land transport distance; ○ procure in bulk volume; ○ Avoid idle time for vehicles and plants to reduce emission; ○ Regular servicing and maintenance of vehicles and plants; and ○ Ensure vehicles used meets the local road-worthiness requirements	
C3	Transportation of rock boulders in Fuvahmulah can damage the roads, generate dusts and pollutants and increases risks of accidents and injuries	People and ecosystem along the transportation route	negative	Minor	• Implement proper traffic safety measures; • use modern clean transport means; • transport during daylight hours; • vehicles carrying building and waste materials must have their cargos covered when moving in public roads; • the shortest delivery routes should be used and road shall be repaired before and after the construction works; • during loading and unloading public shall be kept out of bounds; • inform community living along roads used by material transport route about construction plan and schedule as part of the work preparatory activities; • vehicle drivers observe prescribed speed limits especially when traversing road sections along residential areas; • apply dust suppressant techniques especially during dry periods. ○ spray water on the road surface and on other fine construction materials	In construction costs
C4	Impact of noise and vibration			Minor	• Ensure vehicles used in the construction meets local road worthiness certification to ensure noise emission limits are maintained; • ensure the vehicles and plants used in the works are regularly serviced and maintained to achieve manufacturer's absolute equipment noise emission limits;	

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
					• turn off vehicles and plants when not in use; • maintaining maximum separation distance possible between the nearest buildings and the location of plants and vehicle operations by opting to described work methodology and in particular the proposed transportation route; • informing the potentially affected population of the works schedule and record-keeping and addressing to any complaints received; and • discontinue the works during the sensitive hours;	
C5	Loss of lagoon space (approx. 58,300m ²)	Lagoon ecosystem at the footprint of the detached breakwater	negative	Major	• Design to optimise the base area of the structure. • Can be reduced by opting the shore based revetment.	N/A
C6	Potential for reef slope failure	Reef fractures can occur due to the weight of the structure if placed too close to the reef slope	negative	Minor	• Placing the footprint of the structure at reasonable distance away from the reef edge. • Selecting a technically competent party as a contractor to ensure good workmanship so that unnecessary physical damage is not caused to the reef. • The impact can be completely avoided by choosing coastal revetment option.	
C7	Stockpiling of rock boulders	Ecosystem around the stockpiling site	Negative	Minor	• Allocate area for stocking near the coast that is free from vegetation. • Ovoid night time movement of rocks in vehicles and stockpiling to avoid unintentional damage to vegetation.	In construction costs
C8	Introduction of pests and diseases	Island ecosystem	Negative	Minor	• Physical inspection of the rocks for hitchhiking organisms both at the supply and receiving ends. • Report to the Ministry of Fisheries and Agriculture of any incidences of an introduced organisms.	
C9	Impact on the vegetation	Coastal vegetation and private owners	Negative	Minor	• Vehicles shall only be allowed to travel through routes predetermined which limits impacts to vegetation; • during site preparation, paths for vehicle movement should be identified and explained to workers; • do not cut down any mature trees and if there was no other choice, a tree may be uprooted carefully for relocation elsewhere on the island; • low bushes needing removal to create access, they shall be uprooted and replanted;	

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
					- any issue involving removal of trees should be in line with the relevant laws and regulations and in coordination with the respective island council; and - if a privately owned tree is to be removed compensation will have to be arranged in coordination with the respective Island Council	
C10	Damage to coral reef and lagoon ecosystem around footprint due to construction works, risks of spill, underwater noise and collision of barges and pontoons on the reef	Coral reef and lagoon ecosystem around footprint of the detached breakwater	negative	Moderate	- Contractor is obliged to make an environmental action plan (EAP) in which actions and responsibilities are given to spills, waste, emissions; - carryout the work in reasonable weather conditions; - engage skilled labour with adequate experience to work in such moderately rough weather conditions; - continuous monitoring of environmental impacts during construction period and after by an independent party; and - the impact on coral reef and lagoon ecology can be avoided by opting for a near-shore coastal revetment.	To be included in the construction costs.
C11	Likelihood of accidents and injuries During the construction and maintenance of offshore structures much of the work will be done over water in relatively strong wave conditions. Risks to workers can be moderately high as a result.	Workers and general public of Fuvahmulah	negative	Minor	- Stockpile area work site shall be enclosed with clear safety signs; - avoiding transport of materials during night time; - ships arriving with materials shall not approach the island during night-time and properly coordinated with island authorities for safe navigation; - monitor weather forecasts and pass the information to site supervisors; - carryout the works during good weather conditions and the work shall not be continued in bad weather; - personal protection equipments shall be available and used as appropriately during the work hours; - life jackets shall be worn while working over-water and lifebuoys shall be kept within easy reach; - first aid services shall be available at work site; - surveillance from land should be conducted at all times when the work is in progress; - safety measures and measures to reduce risks shall be included in the EAP by the contractor; - safety signs shall be placed at work site; - rescue post shall be established during the sea-based operations and shall be manned during work hours;	To be included in the construction costs

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
					- assign safety mandate to an officer who be responsible for safety of personnel in the workplace; and - develop emergency response plan and all workers shall be informed of the plan. - r.	
C12	Terrestrial and marine pollution from construction related wastes Construction project of this nature will produce various types of wastes which has the potential to pollute marine and terrestrial environment.	People of Fuvahmulah	Negative	Moderate	- Designate an area at the Project site for waste collection. - Arrangements should be made for the regular collection of litter and for its disposal only at the designated site. - Prohibit littering at the work site and place awareness signs for the workers. - Waste shall be transferred to Thilafushi on regular basis. - All hazardous wastes shall be placed in an enclosed container and shall be transferred to Thilafushi. - No refuelling shall be carried out at sea. - Vehicle maintenance and oil storage containers shall be carried out on a paved area. - Waste management plan shall be an integral part of the Environmental Management System of the Project.	Included in the construction cost
C13	Loss of access to beach and sea. During the construction works, the work site has to be sealed off from public for safety and security reasons. The entire coastline will become fully accessible to the general public only when the construction period is over.	People of Fuvahmulah and visitors	Negative	Minor	The public should be informed about this change in inaccessibility to the beach before the construction mobilization work begins and should be encouraged to use alternative beach access areas such as <i>Thundi</i> beach and others.	Included in the construction costs
C14	Impact of workers on the environment. Irresponsible activities of the workers can affect the ecosystem and pollute the environment	People and ecosystem of Fuvahmulah	Negative	Minor	- Prohibit littering in the work environment - Place waste bins at convenient locations - Designated areas shall be established at work site - Toilet arrangement shall be made from a nearby house - Keep the workforce to minimum necessary - all construction workers and persons on site must be given specific instructions not to catch or harm birds and animals allow them to retreat into undisturbed areas; - Basic information on the protected sites and species found on the island shall be given during orientation	Included in the construction costs

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
C15	Congestion in port area due to increased activities relating to supply of materials and workers and the requirement for storage space	Fishermen, boat owners, travellers	Negative		- Avoid using inner harbour for unloading of bulk materials; - temporary storage area near the harbour shall be limited just enough to meet the requirement; - use the inner harbour for the shortest duration possible; - limit number of vessels and number of trips to bare minimum required, - place signs and provide information to the locals on the project activities; - provide alternative temporary arrangements for the locals, where necessary, in coordination with the council	Included in the construction costs
C16	Influx of workers and increase in demand for resource for project related activities can strain the utility services of the island	People and visitors to Fuvahmulah	Negative		- Waste generated by workers and work shall be managed as per Section 2.10.6 on Waste Management; and - Emergency transport arrangements shall be in place for workers needing emergency transport out of the island; - Onsite generator for meeting electrical energy needs of the Project	Included in the construction costs
C17	Socio-cultural impact of workers		Negative	Minor	- Hire locals for the workforce as much as possible; - Orient foreign workers on how to communicate with locals and personal hygiene and sanitation and prevention of sexually transmitted diseases and other infectious diseases; - Ensure illegal workers are not recruited for the project if foreign workers need to be hired - Establish rules for the behaviour of foreign workers and establish management unit tasked to monitor and discipline individuals who violates rules.	Included in the construction costs
C14	Impact on local economy		Positive	moderate	- Hire locals for the workforce as much as possible. - Food, accommodation for the workers to be arranged using available facilities. - Purchasing locally available materials from Fuvahmulah or nearby Addu City.	N/A
O1	Reduced risk of flooding	Communities and visitors to Fuvahmulah	Positive	Major	Develop, manage implementation and monitor development plan for Fuvahmulah in consultation with the population.	50,000
O2	Risk of moving erosion problem to northwest with the risk of affecting <i>Thundi</i> area	Beach and <i>Thundi</i> area NW from the project site	Negative	Moderate	- Bi-annual monitoring for 10 years of beach profiles. - involving the local population in the monitoring, to create better understanding and enhancing transparency - Devise solutions to rectify if <i>Thundi</i> is negatively being affected.	200,000
O3	Safe swimming and recreational fishing area	Island community and visitors	Positive	Moderate	Install safety measures (floating lines with balls in opening breakwater) and information panels at the swimming area. Put signals in case of rough weather	2500

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
O4	Risk of deteriorating water quality of the lagoon between breakwater and beach	Lagoon space between breakwater and beach	Negative	Moderate	• Leave breakwater detached from beach at the beginning and ending and create some openings in the breakwater. Bi-annually monitor changes to coastline for 10years. • Water quality shall be measured bi-annually for 10 years. ○ Nitrates ○ Phosphates ○ pH ○ BoD ○ CoD ○ TDS • Water quality baseline shall be established before the construction works begin.	2000
O5	Protection to agricultural land Enhance agriculture production and marketing so that the sector can create more employment and more sale of agriculture produce in the country	Farmers and buyers	Positive	Minor to Moderate	• Monitor groundwater quality bi annually for 10 years; • baseline to be established just before the construction works begin; and • establish a proper system at the council office for keeping records of abnormal weather events.	20,000
O6	Impact on the groundwater lens is expected to be positive due to reduced incidences of wave overtopping and controlled erosion leading to controlled seepage of saltwater into aquifer	Farmers and general population of Fuvahmulah	Positive	Minor to moderate	• N/A	
O7	Visual impact of breakwater viewed from the beach	Locals and visitors	Negative	Moderate	• Keep crest height of breakwater as low as possible while creating sufficient protection against erosion; and • rehabilitating coastal vegetation to mask the view from inland	Included in design component
O8	Increased social well-being. With developmental of coastal protection works, the infrastructure around the island and especially close to coastal buffer zone would be protected and this would increase the social	People of Fuvahmulah and visitors	Positive	Moderate	• N/A	N/A

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
	well-being of the community					
O9	Community cohesion strengthened. The anticipation for this development would increase the community cohesion and would help to achieve their vision for the development of the island	People of Fuvahmulah and visitors	Positive	Moderate	• N/A	N/A
O10	Impacts on demographic developments. With the protection of the Island against erosion the population will have more confidence in the future and this may have an effect that less people will reside outside of Fuvahmulah and more people may move back to Fuvahmulah	People of Fuvahmulah and visitors	Positive	Moderate	• N/A	N/A
O11	Impacts on cultural sites and heritage. Several important sites of cultural and historical importance are found close to the eastern coastline. With the protection of coastline, these important heritages will be protected as well	People of Fuvahmulah and visitors	Positive	Major	• N/A	N/A
	Impacts from O&M same as from construction				• Monitoring of maintenance works, like for construction works over lifetime of the structure	In O&M costs

9.3 ON-SHORE REVETMENT

The following sub-sections discuss the predicted environmental and social impacts and proposed mitigation or enhancement measures; as appropriate, associated with the construction and operation of on-shore revetment option.

9.3.1 Construction Phase Impacts

The results of the impact analysis carried out for the onshore structure for the construction phase using the methodology described in Section 1.6.3.1 is given in Table 48

Predicted impacts and proposed mitigation measures associated with the construction phase of the onshore structure are discussed in the subsequent sub-sections

Table 48: Impact matrix – construction phase of onshore revetment option

	Envisaged impact factors	C1 Rock boulder quarrying	C2 Energy generation for construction from fuel	C3 Revetment construction	C4 Construction works conducted close to the shore and vegetation line	C5 Heavy vehicles driven on roads	C6 noise and vibration from civil works	C7 Stockpiling rock boulders	C8 transportation of alien/invasive species from abroad	C9 Risk to vegetation vehicles and equipment	C10 Construction zone boundary establishment	C11 Heavy vehicles driven close to land marks	C12/C13/C16 Irresponsible practice of workers and	C13 Construction zone boundary establishment	C14 Construction waste generation/pollution	C15/C18 Influx of workers to the island	C17 Congestion in port area due to material transport etc	Total (Impact Area)	
Physical Components	Seawater		-1										-1		-3	-1		-6	
			1										1		5	1		8	
	Ground water	-3	-1	-1											-3	-1		-12	
		5	1	1											2	2		15	
	Air	-6	-8	-6		-8							-2		-2	-2		-34	
		5	5	3		6							1		3	1		24	
	Noise	-5		-1			-7									-1		-14	
		5		2			7									1		15	
	Coastal Zone		-5	-10	-7				-1			-6	-2	-3	-6	-4		-2	-46
			3	10	5				1			3	1	1	3	5		2	34
Biological Components	Flora		-3	-2	-7		-1	-3	-7	-5			-1		-2			-31	
			2	1	5		1	3	1	3			1		3			20	
	Coral Reef		-3		-3		-1					-2	-3		-5			-17	
			2		1		1					2	2		5			13	
	Fauna		-3		-7		-7		-5			-1	-4		-5			-32	
			1		2		4		1			1	1		5			15	
Socio-Cultural Component	Accidents	-5		-4	-1			-2	-1			-3	-2			-1		-19	
		5		2	1			1	1			3	1			2		16	
	Landscape	-7	1	-10				-3					-2		-4			-25	
		5	2	10				2					1		4			24	
	Health	-3	-3	-9	-3	-7	-6				-4	-2	-3	-4	-2	-1		-53	
		5	4	7	2	6	4				6	2	1	6	4	1		50	
	Cultural heritage					-4												-4	
						3												3	
	Local economy	6	-9	3		-7			-1							-3	6	-2	-7
5		4	2		6				1						3	7	2	30	
Total (Construction Activity/Risk)		-23	-35	-40	-28	-26	-22	-8	-15	-5	-10	-10	-21	-10	-33	-1	-4		
		35	25	38	16	21	17	6	5	3	9	9	10	9	39	15	4		

9.3.1.1 Landscape impacts on source area

Impact characteristics and mitigation measures are similar as described in **Section 9.2.1.1**. However, the amount of material required for the onshore revetment is about 50% less than for the breakwater and therewith these impacts will be lower.

9.3.1.2 Impact on climate

Impact characteristics and mitigation measures are exactly the same as described in **Section 9.2.1.2**. However, the amount of material required for the onshore revetment is about 50% less than for the breakwater and therewith these impacts will be lower.

9.3.1.3 Impact on the coastal boundary

Even though there exists no beach per se on the coastal margin of the Project boundary, the current steep coastal edge and the very thin beach stretch which is visible during the low-tide will disappear at the location of the revetment. Furthermore, the existing 'natural' coastline will be permanently altered as a result of the placement of the footprint of the revetment. According to the revetment design, footprint will take up an area of 71,550m² from land-sea interphase (see Figure 101). Hence the Project would inevitably result in the loss of 71,550m² of coastal space, including some lagoon space from land-sea interface which is considered to be irreversible and significant.

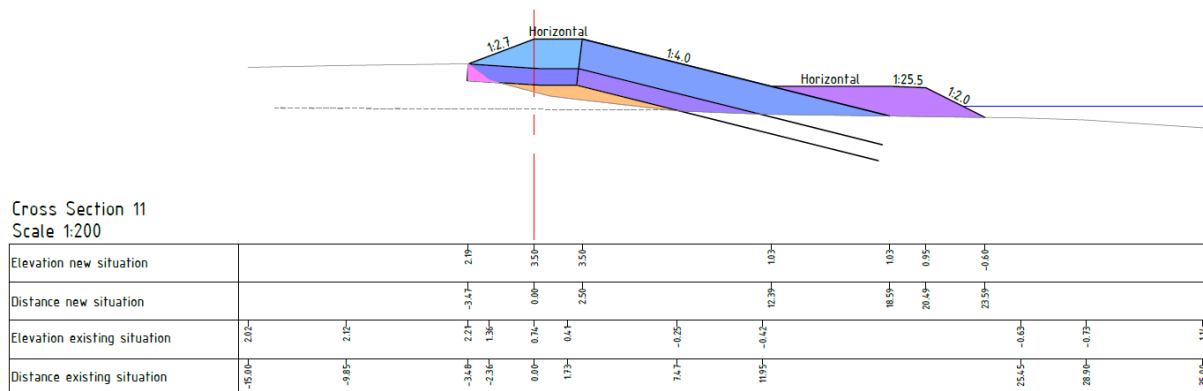


Figure 101: Cross-section of coastal revetment proposed for Fuvahmulah

Measures

- Design to optimise the base area of the structure
- Loss of beach-sea interface can be reduced by opting for the breakwater alternative. However, in that case more lagoon space will be occupied.

9.3.1.4 Damages to coastal ridge

Coastal ridge along the north-eastern coastline has been severely affected due to actions of heavy waves and associated erosion and uprooting of trees. Heavy vehicle movement and works in these areas has the potential to further damage the beach, island ridge, beach rock, and may cause compaction of the beach. Intertidal faunal habitat may also be affected as a result of vehicle

movement. Mobile organisms however may retreat into areas of less disturbance and they may get re-established when the disturbance cease to exist. As described in Chapter 2 the revetment itself will be used to transport the construction material to the site, where it will be placed. Therefore the damage to the coastal ridge can be minimised. This impact is considered moderately negative.

- Use revetment for transportation of construction materials
- Planks or plywood can be used as a driving surface to reduce damage;
- limit the vehicle movement to the routes given in Figure 9;
- minimise vehicle movement on the unprotected beach surface; and
- avoid unnecessary vehicle movement on the coastal areas.

9.3.1.5 Impacts on roads

As described in **Section 9.2.1.3**, the impact of vehicles on roads and increased risks of accidents is expected in the case of on-shore revetments as well. These impacts are expected to be greater compared to offshore breakwater as the work will be more on land. As in the case of the breakwater, the structure itself (in this case the revetment) will be used to transport the construction material to the location, where it will be placed. Herewith the majority of the transportation on existing roads can be avoided. Still there will be some transport overland.

If movement of vehicles carrying materials and workers would happen on *Bahaaru Magu*, the main road along the east coast of the island, which is not paved, the impacts can be moderately severe (see Figure 97). The movement of heavy vehicle on unsurfaced roads can compact the soil reducing the soil absorption capacity and thereby causing local level flooding during rainy season. Considering these aspects, the work methodology has been carefully worked out to avoid having to use *Bahaaru Magu* as the main road for transportation (see Figure 9 (B)). With the proposed work methodology, the impact of the Project's land transport on the roads, in the case of on-shore option is believed to be moderate to minor. Nevertheless, the road areas where vehicle movements are expected to be concentrated, have not been paved and therefore mitigation measures have been proposed.

Measures

- Mitigation measures prescribe in **Section 9.2.1.3** shall be implemented.

9.3.1.6 Noise and vibration

As explained in **Section 9.2.1.4** the impact of noise and vibration in the case of on-shore revetment construction will be higher compared to offshore breakwater due to smaller separation distance between sensitive receptors and work site and therefore the impact of noise on sensitive receptors is considered to be moderate for revetment option. In addition to mitigation measures given in **Section 9.2.1.4**, the following additional measures are recommended.

Measures

- Use the revetment as a path of transporting the construction materials to the location of the placement of the materials (as described in chapter 2).

- Mosque at Rasgefannu can be temporarily closed during the works, since there are other mosques not too far from Rasgefannu that can be used as alternative. This measure is important from public safety point of view as well.
- Historical and archaeological sites within the impact zone shall be fenced off before the work begins.

9.3.1.7 Stockpiling of rock boulders

Impacts and mitigation described in **Section 9.2.1.7** shall be applied.

9.3.1.8 Introduction of pests and diseases

Impacts and mitigation described in **Section 9.2.1.8** shall be applied.

9.3.1.9 Impacts on coastal vegetation

Since on-shore revetment works will be mostly carried out on land, damages to the coastal vegetation can occur as a result of profiling, vehicle movement and irresponsible actions of workers. Potential for damage to coastal vegetation is considered higher in the case of on-shore revetment works over offshore structure. Since coastal zone vegetation is legally protected unauthorised damage to coastal vegetation is considered a serious issue. However since careful planning, awareness among workers and applying proposed work methodology can greatly avoid damages to the coastal vegetation belt and hence the impact significance is considered to be moderate.

Measures

- Mitigation measures prescribe in **Section 9.2.1.3** and **9.2.1.9** shall be implemented.

9.3.1.10 Loss of beach access

From day one of the implementation of the project, from equipment mobilization to end of construction activities, the public access to the beach and other recreational areas from the project development area would be limited. Mobilization of heavy vehicles, clearance of any required vegetation and the construction stages itself would require the area be blocked for public use and with the development of the on-shore coastal protection structure, the free swimming access from the beach would be lost. However, there are other areas, where access to the beach and swimming is practiced now and can still be used in this period. The impact is reversible and the work can be planned in a way that the entire coastal boundary need not be closed off at the same time during the construction phase. The impact is thus considered to be minor.

Measures

Access to the shoreline will need to be closed, when construction works are ongoing on that section of the project site. As described earlier the works will start at the southern end of the revetment near the port and works will proceed towards the north by placing the bottom layer. Vehicles will be driving over the bottom layer of the new revetment towards new sections of the revetments. This means that the closure of the access to the shoreline will start in the south and will need to be extended towards the north until the complete stretch will be closed. It is proposed that this closure will happen in about 5 segments of about 500 meter. When the works on the bottom layer have

been completed till the northern end, the works will move back to the south with applying the top layer. When the works are finished at a certain segment the access to the shoreline will be restored. Here the same 5 segments can be applied. Gradually access will be granted over a larger stretch until the works have reached the port again and the complete stretch is open again. In this way the loss of access to the beach can be optimised within the limits of works efficiency and safety risks to the population. This means that only for a relatively short period (about 1-2 month) the complete stretch of the beach will be closed.

9.3.1.11 Impact on areas of social and cultural importance

Risk of damage or displacement of location of cultural and social importance can occur during the construction phase if proper planning has not been undertaken prior to the start of the Project. Island's harbour can become very busy during unloading and loading if it was decided to be used as such. During the works, site shall be sealed and access controlled for safety reasons. Work related areas shall be demarcated in such a way to avoid locations of social gathering as far as possible. However, beach and lagoon at the northeast coast shall be restricted to public during the course of the work. Since the project is expected to last for 9 months *Thundi* beach which is the most popular spot for socialising and picnicking by the visitors and locals alike will not have any access controls as a result of the Project.

Measures

- Avoid locations of social and cultural importance in deciding for stockpiling and site office through discussion with the Atoll and Island Council.

9.3.1.12 Impact of workers on the environment

Impacts and mitigation described in **Section 9.2.1.14** shall be applied.

9.3.1.13 Socio-Cultural Impact of Workers

Impacts and mitigation described in **Section 9.2.1.17** shall be applied.

9.3.1.14 Terrestrial, Marine and Pollution

Impacts and mitigation described in **Section 9.2.1.12** shall be applied.

9.3.1.15 Impact on the Local Economy

Impacts and mitigation described in **Section 9.2.1.18** shall be applied.

9.3.1.16 Accidents and injuries

Impacts and mitigation is described in **Section 9.2.1.11**.

9.3.1.17 Congestion in port and storage of materials in port area

Impacts and mitigation are described in **Section 9.2.1.15**

9.3.1.18 Impact on utilities

Impacts and mitigation are described in **Section 9.2.1.15 9.2.1.16**.

9.3.1.19 Risk of poor labour conditions

Impacts and mitigation are described in **Section 9.2.1.19**

9.3.2 Operational Phase Impacts

The results of the impact analysis carried out for the onshore structure for the operational phase using the methodology described in **Section 1.6.3.1** is given in Table 49.

Predicted impacts and proposed mitigation measures associated with the operational phase of the onshore structure are discussed in the subsequent sub-sections.

Table 49: Impact matrix – Operational phase of onshore revetment option

	Envisaged impact factors								
		O1 Flooding	O2/O3 Protection of agricultural land, coastal properties groundwater lens	O4 Risk of shifting erosion northwest	O5 Visual impact of breakwater	O6/O11 Access to beach and safe swimming areas	O7/O8/O9 Demographic and community	O10 Protection of significant cultural landmarks	Total (Impact Area)
Physical Components	Seawater			-1					-1
				1					1
	Ground water	7	5	-1					16
		9	6	1					20
	Air	1	2						7
		1	3						6
	Noise								0
									0
Coastal Zone	9	6	-6		-9		6	4	
	9	7	9		7		3	35	
Biological Components	Flora	5	3	-3	-3	-1		4	8
		3	3	2	3	1		4	17
	Coral Reef	2		-1				4	5
		-2		2				2	2
	Fauna	5	5	-1				4	13
		4	6	1				3	14
Socio-Cultural Component	Accidents	8	6		-2	-7	9	-3	11
		6	3		1	4	8	3	25
	Landscape	9	6	-6		-8			1
		7	4	2		6			19
	Health	7	9	-1	-9	-7	9	10	18
		6	7	1	8	5	8	8	43
	Cultural heritage	8	2			2		10	22
		4	2			2		9	17
Local economy	8	-10	-1	-9	-10	7	10	-5	
	5	10	1	8	10	8	6	48	
Total (operational Phase Activity/Risk)		69	34	-21	-23	-40	25	45	
		52	51	20	20	35	24	38	

9.3.2.1 Erosion control and reduced risk of flooding

Erosion control being the most important objective of the project, this positive effect will be the most significant impact of the project. A robust on-shore coastal revetment is believed to be even more effective than offshore structure in controlling the erosion problem in the case of Fuvahmulah. Additionally, reduction of the risk that the island is flooding as a result of breach in the ridge due to coastal erosion, reducing the risk of loss of life, damage to assets, economic development and ultimately abandon the island. Due to the positive results anticipated the effect is considered to be significantly positive.

Measures

Same as given in **Section 9.2.2.1**

9.3.2.2 Impact on the groundwater lens

Groundwater salinization can occur due to flooding of the island by over-topping waves during storm surges. In addition, continuing erosion of the island enhances salinization of the groundwater due to direct seepage of saltwater into aquifer. The groundwater lens of an island is formed in proportion to the island size and the aquifer exists in a dynamic equilibrium with the seawater (Falkland, Custodio, Arenas, & Simler, 1991). When the erosion becomes an on-going process, no equilibrium is expected and the seawater intrusion continues or the freshwater lens is gradually lost. Although this may be a gradual process, in the case of Fuvahmulah, the topography of the island is such that, once the higher island ridge is broken due to erosion the risk of saltwater intrusion getting enhanced exists. Since the proposed revetment will check erosion at the most vulnerable coastline of the island, the risk of saltwater seepage is greatly reduced. Further, the combined effect of the revetment in preventing wave overtopping and saltwater seepage into groundwater lens is considered to have a moderate positive impact on the groundwater lens.

Measures

- Groundwater monitoring program shall be carried out for up to 10 years from the locations shown in Figure 12 and 5-yearly audits shall be produced.

9.3.2.3 Impact on the agricultural land

With a more robust coastal protection as provided by the on-shore revetment, the over-topping of the waves will be better controlled and the effect of saltwater intrusion as a result of on-going erosion will be checked. Due to these positive impacts, agricultural lands will be better protected. This irreversible positive impact is considered to be significantly positive.

Measures

Same as given in **Section 9.2.2.5**

9.3.2.4 Risk of moving erosion problem to Thundi area

Construction of the onshore revetment will have a limited impact on the waves approaching the coast. Mainly the location where waves are breaking will shift slightly seawards. Water levels and currents in this area are expected to be limited impacted. Due to the changed wave breaking location, also the longshore currents which drive the longshore sediment transport will probably shift seaward.

The longshore transport gradients are hardly impacted by such onshore structures, where the structure is aligned to the existing coastline and is not extending very far onto the reef. This means that the erosive capacity remains the same compared to the actual situation, but the location of potential erosion is shifted towards the end of the structure. No noticeable change in accretion/erosion in front of the structure is expected.

The impact of the structure to adjacent coastal areas, such as *Thundi* beach in the north, shall be considered. *Thundi* beach is located approximately 700m north of the end of the envisaged revetment. *Thundi* area is a protected beach and a vital asset of the island for the locals and visitors. The local population may have a concern that the new coastal protection works will affect the extent and development of *Thundi* beach. As *Thundi* is of cultural importance to the people, this concern may have considerable effect on the well-being of the people. Hence any negative effect on *Thundi* as a result of the revetment structure will be considered negative.

Because the revetment is extending onto the reef flat, changes in wave patterns can be expected especially in the vicinity of the northern tip of the revetment. The unprotected coast directly north of this tip is most vulnerable to be affected by the revetment. This impact is minimized by creating a mild transition between the revetment and the unprotected coast. Compared to the offshore breakwater alternative, the effect of refracting and diffracting waves is smaller because the revetment is extending less far onto the reef.

Because *Thundi* beach is even some 800 meter away from the revetment, the risk for erosion impact in this area is even lower. Nevertheless, such dynamic coastal systems remain very complex and unpredictable. Although no immediate significant negative impacts are expected as a result of the revetment structure, due to the uncertainties of what might happen to *Thundi* beach it is recommended to put in place a regular monitoring program for *Thundi* area.

The coastal processes are illustrated in the figure in section 9.2.2.2.

Measures

Same as prescribed in **Section 9.2.2.2**

9.3.2.5 Visual impacts

Aesthetic quality of the coastal environment is expected to be lowered as a result of the revetment. The structure may also lower the land value for adjacent coastal areas for potential development due to reduced naturalness of the site.

Measures

- Keep protection works as much as possible seawards and not visible from current ridge area to keep visual impacts low.
- Coastal vegetation belt regeneration in those areas where vegetation is lost to erosion and scarce.

9.3.2.6 Impact on Beach Accessibility

Access to beach and sea will be hampered as a result of the revetment. Without proper access arrangement a long stretch of coastline will become almost completely inaccessible to sustainable

use of coastal and environment by the locals will be hampered as a result. The significance of this impact is considered to be major.

Measures

- Design features to include stairs conveniently located to ease the access to beach and sea (see Figure 90). In this way this major impact can be reduced to a minor impact.



Figure 102: Example of concrete steps in a rock armour revetment (isle of Ameland in the Netherlands), Source: RHDHV, 2016

9.3.2.7 Impact on social well-being

Impact characteristics and enhancement measures are same as explained in **Section 9.2.2.9**

9.3.2.8 Impact on community cohesion

Impact characteristics and enhancement measures are same as explained in **Section 9.2.2.99.2.2.9**

9.3.2.9 Impact on demographic development

Impact characteristics and enhancement measures are same as explained in **Section 9.2.2.99.3.2.9**

9.3.2.10 Impact on cultural sites and heritage

Impact characteristics and enhancement measures are same as explained in **Section 9.2.2.11**

9.3.2.11 Impact on access to safe swimming area

As opposed to breakwater, the revetment option will not create a year-round safe swimming area for people to enjoy which is perceived as a moderately negative impact of the revetment alternative.

Measures

- Enhance the possibility for safe swimming on the reef, by reinforcing the existing small tetrapod breakwater;

- Install safety measures (floating lines with balls in opening breakwater) and information panels at the swimming area. Put signals in case of rough weather; and
- Monitor lagoon bathymetry for 10 years to determine changes to the bathymetry.
- Construct steps in the revetment so that access to the safe swimming area will improve.

Table 50 summarises the impacts and the mitigation measures described above. A distinction is made between the construction (C) and operation and maintenance (O) phase. A cost indication of the measures is given in the last column.

Table 50: Environmental and social impacts and mitigation or enhancement measures of on-shore protection

No	Potential Risk/Impact	Receptor	Nature	Significance	Measures	Cost indication of measure
	Description	Description	Positive Negative		Description	USD
C1	Quarrying of rock boulders and quarry run changes landscape of the source area,.	People and ecosystem around the query site of the source country	negative	moderate	- Ensure that the material obtained is from a licenced query. - Ensure that the local rules, regulations are followed in obtaining rocks. - Obtain materials from the closest source available. - Optimising the design to minimise the amount needed	In construction costs
C2	Energy generation and consumption for the project activities generate GHGs and other pollutants into the atmosphere impacting climate change and the ecosystem,	Global environment in general and people and ecosystem found close to project activities	negative	Moderate	- Design to optimise the volume of materials required; - procure materials from nearest source country to minimise transport distance; - select material storage location as close to the work site as possible to minimise land transport distance; - procure in bulk volume; - Avoid idle time for vehicles and plants to reduce emission; - Regular servicing and maintenance of vehicles and plants; and - Ensure vehicles used meets the local road-worthiness requirements	In construction costs
C3	Permanent loss of beach – sea interface on the east coast as a result of placement of revetment footprint	People of Fuvahmulah and visitors	Negative	Major	- Design to optimise the base area of the structure - Loss of beach-sea interface can be avoided by opting for the breakwater alternative. - Integrate steps in design to be able to reach the water	
C4	Works in the coastal zone risks damage to beach, island ridge beachrock, cause compaction and affect the beach fauna		Negative	moderate	- Planks or plywood can be used as a driving surface to reduce damage. - Minimise vehicle movement on the beach. - Explore the possibility of using heavy vehicles from land side without having to drive on the beach. - Avoid unnecessary vehicle movement on the coastal areas.	

C5	Transport and works on land creates traffic, accidents, noise, dust, risks of spills on land, movement of vehicles can damage sand-surfaced roads	People living along the transport route	Negative	moderate	• Implement proper traffic safety measures. • Use modern clean transport means. • Transport during daylight hours. • Prevent overloading of vehicles. • Vehicles carrying building and waste materials must have their cargos covered when moving in public roads. • The shortest delivery routes should be used and road repaired before starting construction works. • During loading and unloading public shall be kept out of bounds. • Contactor to provide PPE for workers at all times. • Transport route to be repaired at the end of the work. • Procure in bulk volumes. • Inform community living along roads used by material transport route about construction plan and schedule as part of the work preparatory activities. • Vehicle drivers observe prescribed speed limits especially when traversing road sections along residential areas. • Apply dust suppressant techniques especially during dry periods; and ○ Cover cargos of trucks transporting materials; ○ Spray water on the road surface and on other fine construction materials; • Consider Rasgefannu area for loading and unloading to minimise land transport and congestion at harbour.	Included in the construction costs.
C6	Impact of noise and vibration	Sensitive receptors nearby the Project site	Negative	Moderate	• Ensure vehicles used in the construction meets local road worthiness certification to ensure noise emission limits are maintained; • ensure the vehicles and plants used in the works are regularly serviced and maintained to achieve manufacturer's absolute equipment noise emission limits; • turn off vehicles and plants when not in use; • maintaining maximum separation distance possible between the nearest buildings and the location of plants and vehicle operations by opting to described work methodology and in particular the proposed transportation route; • informing the potentially affected population of the works schedule and record-keeping and addressing to any complaints received; and	Included in the construction costs

					discontinue the works during the sensitive hours;	
C7	Stockpiling of rock boulders	Ecosystem around the stockpiling site	Negative	Minor	- Allocate area for stocking near the coast that is free from vegetation. - Ovoid night time movement of rocks in vehicles and stockpiling to avoid unintentional damage to vegetation.	Included in the construction costs
C8	Introduction of pests and diseases	Island ecosystem	Negative	Minor	- Physical inspection of the rocks for hitchhiking organisms both at the supply and receiving ends. - Report to the Ministry of Fisheries and Agriculture of any incidences of an introduced organisms.	Included in the construction costs
C9	Works in the coastal zone risks damage to coastal vegetation	Coastal zone vegetation	Negative	Minor	- Fence off vegetation to protect against damage from construction activities - Vehicles shall only be allowed to travel through routes predetermined which limits impacts to vegetation - Any tree needing absolute removal, it shall follow exiting rules. - No trees shall be cut down. - Low bushes needing removal to create access, they shall be uprooted and replanted.	
C10	Loss of access to beach and sea. During the construction works, the work site has to be sealed off from public for safety and security reasons. The entire coastline will become fully accessible to the general public only when the construction period is over.	People of Fuvahmulah and visitors	Negative	Minor	The public should be informed about this change in inaccessibility to the beach before the construction mobilization work begins and should be encouraged to use alternative beach access areas such as <i>Thundi</i> beach and others.	Included in the construction costs
C11	Impacts on areas of social and cultural importance	People of Fuvahmulah	Negative	Minor	- Avoid locations of social and cultural importance in deciding for stockpiling and use the site proposed in the report for such purposes; - Avoid congestion of harbour and other such important places through careful planning and coordination.	

					Demarcate areas of cultural and historical importance to avoid accidental damage.	
C12	Impact of workers on the environment	People of Fuvahmulah, visitors and ecosystem	Negative	Minor	- Prohibit littering in the work environment - Place waste bins at convenient locations - Designated areas shall be established at work site - Toilet arrangement shall be made from a nearby house - Keep the workforce to minimum necessary - all construction workers and persons on site must be given specific instructions not to catch or harm birds and animals allow them to retreat into undisturbed areas; - Basic information on the protected sites and species found on the island shall be given during orientation	Included in the construction costs
C13	Socio-cultural impact of workers	People of Fuvahmulah and visitors	Negative	Minor	- Hire locals for the workforce as much as possible; - Orient foreign workers on how to communicate with locals and personal hygiene and sanitation and prevention of sexually transmitted diseases and other infectious diseases; - Ensure illegal workers are not recruited for the project if foreign workers need to be hired. - Establish rules for the behaviour of foreign workers and establish management unit tasked to monitor and discipline individuals who violates rules.	Included in the construction costs
C14	Terrestrial and marine pollution from construction related wastes Construction project of this nature will produce various types of wastes which has the potential to pollute marine and terrestrial environment.	People of Fuvahmulah, terrestrial and marine environment	Negative	Moderate	- The site is to be cleaned of construction wastes and debris soon after completion of works to prevent wastes escape into the environment. - Earthworks shall be carried out during low tides and in favourable weather. - Store fuel, oil, lubricants, and other petroleum products in secured areas, with concrete floor and waterproof roof; - Ensure that vehicles and construction equipment are regularly maintained in good condition, promptly detect breakdowns for immediate repair and equipment operation license are renewed by contractor from competent authorities; - When feasible, use manual construction methods with minimal equipment support; - Do not wash vehicles and construction equipment on the beach or in an unpaved area to prevent soil and water contamination	Included in the construction costs

					with oil, lubricants and other hazardous waste falling into ground or marine environment; • Conduct regular vehicle and equipment maintenance as per the manufacturer's guidance, including changing engine oil, replacement of engine coolants, hydraulic fluids and inspection of moving parts. • Designate an area at the Project site for waste collection. • Arrangements should be made for the regular collection of litter and for its disposal only at the designated site. • Prohibit littering at the work site and place awareness signs for the workers. • Waste shall be transferred to Thilafushi on regular basis. • All hazardous wastes shall be placed in an enclosed container and shall be transferred to Thilafushi. • Waste management plan shall be an integral part of the Environmental Management System of the Project.	
C15	Workers impact on local economy	People of Fuvahmulah	Positive	Minor	• Higher locals for the workforce as much as possible. • Food, accommodation for the workers to be arranged using available facilities	In construction and supervision costs included
C16	Likelihood of accidents and injuries During the construction and maintenance, movement of heavy rocks, and vehicles can cause injuries to workers and the member of the general public.	Workers and general public of Fuvahmulah	negative	Minor	• Stockpile area work site shall be enclosed with clear safety signs; • avoiding transport of materials during night time; • ships arriving with materials shall not approach the island during night-time and properly coordinated with island authorities for safe navigation; • monitor weather forecasts and pass the information to site supervisors; • carryout the works during good weather conditions and the work shall not be continued in bad weather; • personal protection equipments shall be available and used as appropriately during the work hours; • life jackets shall be worn while working over-water and lifebuoys shall be kept within easy reach; • first aid services shall be available at work site;	In construction and supervision costs included

					- surveillance from land should be conducted at all times when the work is in progress; - safety measures and measures to reduce risks shall be included in the EAP by the contractor; - safety signs shall be placed at work site; - assign safety mandate to an officer who be responsible for safety of personnel in the workplace; and - develop emergency response plan and all workers shall be informed of the plan.	
C17	Congestion in port area due to increased activities relating to supply of materials and workers and the requirement for storage space	Fishermen, boat owners, travellers	Negative	Minor	- Avoid using inner harbour for unloading of bulk materials; - temporary storage area near the harbour shall be limited just enough to meet the requirement; - use the inner harbour for the shortest duration possible; - limit number of vessels and number of trips to bare minimum required, - place signs and provide information to the locals on the project activities; - provide alternative temporary arrangements for the locals, where necessary, in coordination with the council	Included in the construction costs
C18	Influx of workers and increase in demand for resource for project related activities has the potential to strain the utility services of the island	People and visitors to Fuvahmulah	Negative	Minor	- Waste generated by workers and work shall be managed as per Section 2.10.6 on Waste Management; and - Emergency transport arrangements shall be in place for workers needing emergency transport out of the island; - Onsite generator for meeting electrical energy needs of the Project	Included in the construction costs
O1	Reduction of the risk that the island is flooding as a result of breach in the ridge due to coastal erosion, reducing the risk of loss of life, damage to assets, economic development and ultimately abandon the island.	Communities and visitors to Fuvahmulah	Positive	Major	Develop, manage implementation and monitor development plan for Fuvahmulah in consultation with the population.	50,000

O2	Groundwater lens improved as a result of reduced incidences of seawater flooding	Communities and visitors to Fuvahmulah	Positive	Moderate	Carryout a groundwater quality monitoring bi-annually for 10 years from groundwater wells of buildings near coastline.	20,000
O3	Agriculture sector on the island is well protected against flooding from sea. Protection to agricultural land enhance agriculture production and marketing so that the sector can create more employment and more sale of agriculture produce in the country	Farmers and buyers	Positive	Moderate	- Monitor groundwater quality bi annually for 10 years; - baseline to be established just before the construction works begin; and - establish a proper system at the council office for keeping records of abnormal weather events.	20,000
O4	Risk of moving erosion problem to northwest with the risk of affecting <i>Thundi</i> area	Beach and <i>Thundi</i> area NW from the project site	Negative	Moderate	- Bi-annual monitoring for 10 years of beach profiles. - Take necessary measures, if required following the results of the monitoring	200,000
O5	Visual impact of breakwater viewed from the beach	Locals and visitors	Negative	Moderate	- Keep protection works as much as possible seawards and not visible from current ridge area to keep visual impacts low. - Coastal vegetation belt regeneration in those areas where vegetation is lost to erosion and scarce.	In design 50,000
O6	Access to beach and sea will be hampered as a result of the revetment	Inhabitants and visitors of Fuvahmulah	Negative	Major	Design features to include stairs to ease the access to beach and sea.	Included in the design costs

O7	Impact on social well-being	Inhabitants of Fuvahmulah	Positive	Moderate	N/A	
O8	Impact on community cohesion	Inhabitants and visitors of Fuvahmulah	Positive	Moderate	N/A	
O9	Impact on demographic development	Inhabitants of Fuvahmulah	Positive	Moderate	N/A	
O10	Impacts on cultural sites and heritage. Several important sites of cultural and historical importance are found close to the eastern coastline. With the protection of coastline, these important heritages will be protected as well,	Inhabitants and visitors of Fuvahmulah	Positive	Major	N/A	
O11	Impacts on access to safe swimming area	Inhabitants and visitors of Fuvahmulah	Negative	Moderate to Major	- Enhance the possibility for safe swimming on the reef, by reinforcing the existing small tetrapod breakwater; - Install safety measures (floating lines with balls in opening breakwater) and information panels at the swimming area. Put signals in case of rough weather; and - Monitor lagoon bathymetry for 10 years to determine changes to the bathymetry. - Access steps will be prepared in the revetment	
O7	Impacts from O&M same as from construction				Monitoring of maintenance works, like for construction works over lifetime of the structure	In O&M costs

9.4 DECOMMISSIONING

With the decommissioning of the coastal protection the benefits of erosion prevention from these structures will disappear and therewith have a serious negative impact on the land and the people living in the area, when no replacement would be constructed. This counts for both options.

Decommissioning would also mean a loss of resources, which were used to build the structures maybe lost. The construction materials may enter the environment and affect the water quality and eco-system. By the time decommissioning is a real consideration a new EIA should be made to identify and assess impacts of those works and to formulate mitigation and enhancement measures.

9.5 CUMULATIVE IMPACTS

The proposed rock revetment alternative has the potential to negatively affect the existing drainage system of the island (Figure 103). At one location within the project area, a drainage outfall crosses the (proposed) revetment. This outfall pipe discharges the rainwater from the island into the sea during low tide. During high tides (or dry periods), the outfall pipe is closed with a valve.



Figure 103: Existing drainage channel (left) and location of outfall towards sea intersecting proposed revetment (Source: RHDHV, 2016)

Although the construction of the coastal protection may not lead to dis-functioning of the outfall pipe or drainage system, the outfall pipe shall be lengthened as part of the Project. The following requirements shall be integrated in the detailed design:

- Drainage system shall remain it's functionality during and after the construction works;
- outfall pipe shall be lengthened to the toe of the coastal protection (see below Figure 104);
- elevation of the outfall pipe (exit point) shall be equal to actual elevation (no deterioration or improvement compared to actual functionality).

- The concrete slab on top of outfall shall be sufficient wide to facilitate passage by cars and maintenance equipment. From this slab, the outfall can be cleaned by a crane. A slab width of 5 meters is proposed.

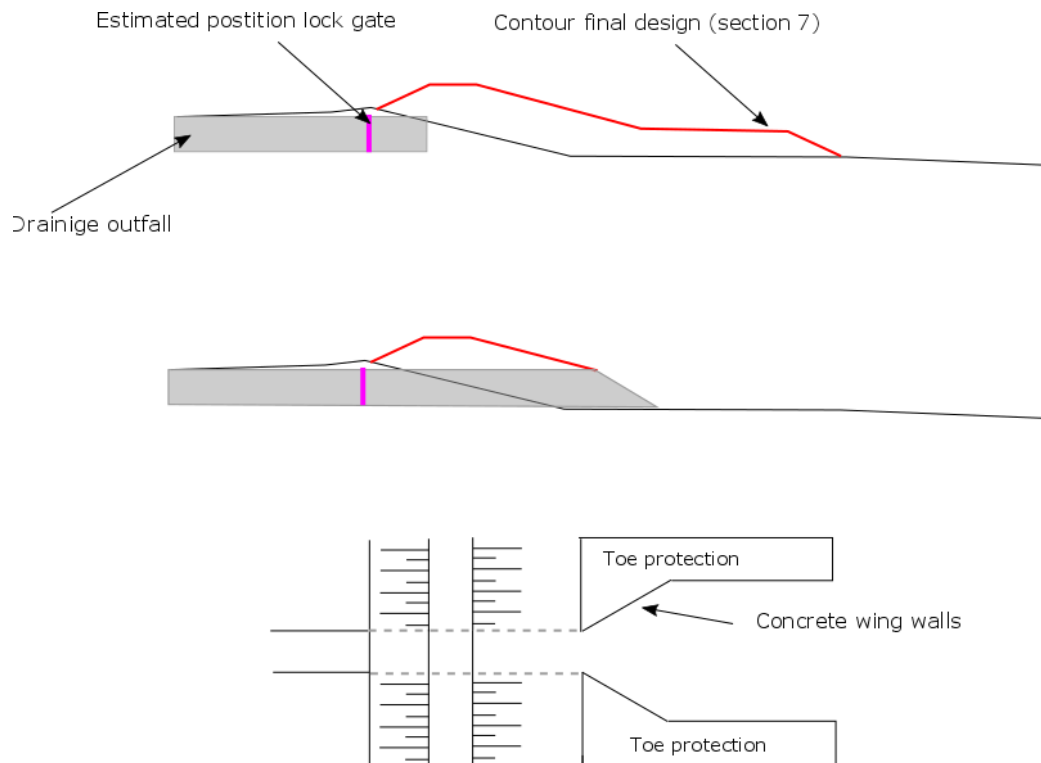


Figure 104: Design for integration of existing drainage channel (Source: RHDHV, 2016)

Foreseen projects in the near future (or already ongoing) are:

- Ring road pavement, which is located at the other side of the island.
- Sewerage and water supply project has just started. The sewage treatment plants is foreseen at the other side of the island than the coastal protection works. Sewerage works will be ongoing in the roads of the island.
- Housing: 270 apartments: part is dedicated for people from outside the islands, which is planned for more long-term.

Cumulative impacts with these projects can be expected when these works would be implemented simultaneously. Then there may be more movement of boats in the port and vehicles in the port area and on the roads, which may result in congestion, increased noise, vibration and dust impacts and damage to the roads. This means that these projects should be planned carefully in coordination to limit the risks of cumulative impacts.

10. ENVIRONMENTAL MANAGEMENT AND MONITORING

10.1 AIMS AND OBJECTIVES

This Chapter presents in detail the management and monitoring program put in place under the proposed Project to evaluate the actual impacts and the effectiveness of the proposed mitigation measures. This Plan focusses on the onshore revetment as the preferred option. The main objectives are summarized below:

- a) Monitor and manage significant negative impact of the project;
- b) enhance positive impacts;
- c) produce a framework for anticipated impacts, including practicable and achievable performance requirements and systems for monitoring, reporting and implementing corrective actions during dredging, reclamation and operational phase;
- d) collect information that can be used for documentation and verification of environmental impacts;
- e) collect information that can be used for evaluating the effectiveness of implemented mitigation measures so it can provide information for better decision making and future improvement of environmental quality for similar projects;
- f) ensure that the impacts are eliminated in a timely manner; and
- g) provide evidence of compliance assurance to laws and regulations and requirements of enforcement agencies.

In order to demonstrate the effectiveness of the proposed mitigation measures and to ensure unforeseen impacts arising out of project activities are controlled in a timely manner a robust environmental monitoring program is essential. Additionally, the monitoring program is also important to bring desired changes to the proposed mitigation measures as and when necessary and to enhance benefits of the Project. The detailed impact monitoring plan for the proposed for the Project is given in Table 46. Indicative cost of the monitoring and environmental management is also given in the same Table. Proponent will ensure that the monitoring program is carried out in a timely manner. A commitment letter confirming compliance on mitigation measures and monitoring is given in **Annex 2**.

10.2 RESOURCE REQUIREMENT FOR MONITORING & MANAGEMENT

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

The key players in the proposed monitoring program will be the Ministry of Environment and Energy as the project Proponent, the local authorities, the Contractor and the environmental consultant for the Project.

The primary function of implementing the mitigation and monitoring plan will lie with the Project Management Unit (PMU) within the MEE.

However, since the project implementation is expected not to last more than a year at most, it is imperative that MEE to have in place an arrangement to continue long-term monitoring beyond the life of the Project. It is believed that Coastal Department of the Ministry will take over the responsibility when the PMU cease to exist. It can be expected that the capacities of the staff in the Ministry is sufficient to manage the environmental and social measures and monitoring of the Project impacts. It is advised that the Contractor will be requested to have a permanent staff member on-site, who has the role of environmental/social officer. He/she will monitor the works from environmental and social point of view, prepare monitoring reports, train workers, inform the public, is contact person for the communities and can take action in case of emergencies.

The Contractor should prepare an Environmental Action Plan, which states all measures for mitigation and enhancement and monitoring as described here in the EIA with their responsible organisation and person, planning, methodology, timing and other relevant aspects. The Contractor should have this EAP approved by the MEE. The MEE will monitor the implementation of the EAP.

An independent environmental consultant shall be hired and contacted to undertake the monitoring program prescribed in this report. Following each monitoring visit the consultant will prepare a report with clear recommendations and corrective measure if necessary. The report will be reviewed by the MEE and required actions by the Contractor will be notified by MEE.

All communications regarding the monitoring will be copied to the Atoll Council (City Council in future) for their information. It is advised to implement the monitoring activities together with members of the population of Fuvahmulah. In this way the involvement of the communities in the works is encouraged, transparency is enhanced and capacity and awareness about environmental issues is raised.

10.3 MONITORING SCHEDULE

Monitoring frequency for various components given Table 46 shall be followed by all Parties. However initially during the early stages of the project monthly site visits is expected. Table 51 gives indicative timeline for the monitoring visits.

Table 51: Monitoring visit schedule

visit	Indicative timeline	Reporting
Visit 1	During site preparation	Submit summary report 1 to MEE within 2 weeks after the trip
Visit 2	One month after work begins	Submit summary report 2 to MEE within 2 weeks after the trip
Visit 3	Halfway into the project	Submit summary report 3 to MEE within 2 weeks after the trip
Visit 4	Project is near completion	Submit summary report 4 to MEE within 2 weeks after the trip
Visit 5	One month after completing the project	Submit first post-project monitoring report to MEE within 2 weeks after the trip
Follow up monitoring to continue	Bi-annually after completing the project for 10 years	Submit report to MEE within 2 weeks after each trip.

As indicated in Table 51, during the course of the Project implementation summary reports following each trips is expected to be submitted by the Project's environmental consultant. The first detailed monitoring report will be prepared after a month of completing the Project which will describe in detail the results of the environmental measures provided in the Project and will comment on their appropriateness, costs, adequacy, and administration as well as any problems that arose or changes that were made during the implementation of the project and the start-up of new operations. This audit will provide a basis for assessing at least the shorter-term efficacy of the environmental measures and thereby provide lessons to be learned for future projects with similar impacts. The consultant will prepare and submit the reports to MEE and MEE in turn will submit it to EPA.

The rest of the monitoring will continue on bi-annual basis for a period of 10 years. Long-term monitoring has been proposed due to the complex nature of coastal process that govern sediment dynamics around the island and also in order to observe certain effects mentioned in the mitigation measures require longer term data collection.

Since the Project duration is not expected to last 10-year period, it is suggested that the Proponent to work out a way to sustain the monitoring program as committed in the commitment letter attached to this report.

It is also expected for the long-term monitoring; financial resources will be coming through the Proponent's annual budget.

10.4 MONITORING AND MANAGEMENT REPORT FORMAT

Reporting will be carried out by the environmental consultant assigned for the purpose by the proponent.

The report will include among other information;

- Details of what was being monitored;
- methodology of data collection and data analysis;
- major findings; and
- effectiveness of the mitigation measures in place; and
- recommendations and conclusions.

A detailed environmental monitoring and management report is required to be compiled and submitted to the EPA at the end of the project and final report for this project will be submitted within a month after completing the Project as stated in Table 52.

In addition to this, regular site monitoring would be carried out by the contractor and site supervisors during the construction period. They are required maintain logs of events as explained in this report. Enforcement officers from EPA may also visit the site for inspection from time to time.

Table 52: Impact management and monitoring plan for the preferred alternative (on-shore revetment)

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
Impact on landscape of source country for granite rock is minimised	C1	Obtain licence copy of the supplier	Pre-construction	N/A	Communication	Within 3 weeks of signing the contract	Contractor	Licence copy from the supplier
Impacts on climate are minimised	C2	Vehicles servicing area established Road-worthiness certificates displayed on land vehicles. Closest source country selected. Shortest land transportation routes established. Vehicle idle time minimised.	Pre-construction/ construction	Included in the construction costs	Set-out surveys, island maps	One week after the construction works begin	Contractor	Copies of relevant documents and photographs
Minimum space from the beach-sea interface is given up to the footprint of revetment and beachrock and beach fauna is least impacted	C3	Boundary of the revetment footprint established as per the design criteria	Pre-construction	Included in the construction cost	Set-out survey Filed measurements	Within one week after mobilisation	Contractor Environmental consultant	Temporary boundary marks established and confirmed by the environmental consultant
Damages to the existing island ridge is minimised as a result of the construction activities	C4	Set out survey Identify routes for vehicle operations Explore possibility of using wooden planks for vehicle movement. Record damages to coastal zone	Pre-construction and construction phase	Cost included in the contract	Visual observation and use of survey maps	Monitor damages to the coast throughout the Project monitoring visits	Contractor Environmental Consultant	Report submitted to the Proponent Copy of the report submitted to Atoll Council
Roads are not degraded as a result of the project activities	C5	Identify routes for vehicle operations Placing road signs along the paths Identify road repair needs before the work Repair those sections of the road within the impact zone before and after the revetment construction works	Pre-construction and post-construction	Cost included in the contract	Discussions with island authorities, use of island maps, road repair equipments etc.	Before the construction works begin and after the construction work is complete	Contractor Environmental Consultant	Pictures, records, report prepared and submitted.

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
Impact of noise is kept minimal	C6	Measure Establish noise monitoring stations. along the impact boundary Have in place complaints record keeping arrangement.	Pre-construction and during-construction	Approx. USD20,000	Using standard noise measuring equipments	Baseline to be established before the construction begins and random sampling during construction period (at least one sampling carried out once a month during the construction period).	Contractor Environmental Consultant	Monitoring data and reports produced.
Ensuring coastal vegetation is protected during the construction phase.	C8	Set out survey Tree survey Identifying trees needing removal Identifying tree relocation plan Making compensation arrangements in the event a particular tree cannot be relocated. Boundary allocations for unloading area and stockpiling area. Marking routes of vehicle transport.	Pre-construction	Cost included in the contract	Use of land survey equipments and pegs	2 weeks from the date of signing the contract	Contractor Project Manager Environmental Consultant	Photos, maps, Report submitted to the Proponent Copy of the report submitted to Atoll Council
Damage to coral reef and lagoon ecosystem around footprint due to construction works, risks of spill, underwater noise and collision of barges and pontoons on the reef	C9 C10	! Monitoring of the marine environment	Construction - Operation	USD 20,000	Marine survey as baseline survey	Quarterly during construction and then 1, 3 and 10 years after completion of the works	Environmental Consultant with involvement of local Diving School	Reports
Ensuring locations of cultural and social importance are not affected by the Project	C11	Identifying and fencing off culturally important areas in consultation with the island authorities. Identifying temporary closure periods of mosques and other culturally important locations,	Pre-construction	Included in the main contract	Discussion/interviews maps	3 weeks from the date of signing the contract	Contractor Atoll Council Island Council	Locations identified and marked on the island map.

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
		Have in place arrangements to inform public of the temporary arrangements.						Meeting minutes
Impact of the workers on the environment is avoided/minimised	C12	House rules prepared and informed to workers Awareness signs placed in work environment Waste bins placed at work site Toilet arrangements made for the workers	Pre-construction and construction phase	Included in the main contract	Check list	Arrangements to be made before ground-breaking of the Project	Contractor Environmental Consultant	Documentary evidence and visual observations
Ensure social and cultural impacts of workers are avoided/minimised	C13	Establishing house rules for workers Workers recruitment criteria to eliminate illegal workers Arrange to hire as many locals for relevant works through local level advertising	Pre-construction	Included in the main contract	Checklist Public notices			Documentary evidence and visual observations
Terrestrial and marine pollution avoided/minimised.	C14	Arrangements for fuel and hazardous materials. Vehicle repair maintained area paved. Solid waste collection and transfer arrangements made. Undertake reef studies at least twice a year for 10 years particularly at depths > 10m. Baseline to be established just before the construction works begin. Minimum 2 monitoring shall be conducted during construction phase.	Construction period	Included in the construction cost	Visual observations		Contractor	Worksite kept clean Oil storage area developed Vehicle washing area free from leaking into ground Waste transfer to Thilafushi records maintained
Ensure the house reef on the north-eastern side was not affected by the Project.			Construction and operations period	30,000	Visual observations, LIT at 4 stations selected for EIA		Environmental consultant	Monitoring report produced
Ensure that marine water quality is not affected as a result of the revetment construction works			During construction phase. Turbidity, BO D ₅ ,	5000	On-site monitoring using standard water quality equipment.	Monthly throughout the construction phase	Environmental consultant	Monitoring report produced

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
			conductivity, pH shall be monitored monthly during the construction phase. Baseline to be established before the construction works begin					
Benefits to local economy is enhanced	C15	Contracts with local parties on housing, meal arrangements Advertising to hire local workers	Pre-construction phase	Included in the main contract		To be completed before the Project implementation begins	Contractor	Contracts and public advertisement Actual numbers of foreign and local staff
Ensuring work related accidents and injuries are avoided	C16	Workers safety plan and emergency response plan must be developed by the contractor and implemented. Records of personnel injuries shall be recorded and records maintained. First aid kit shall be available at work site. Personal protection equipments shall be used during work hours. Work shall be discontinued during extreme bad weathers. Weather forecast information to be displayed at work site.	Pre-construction	Included in the construction cost	Visual observations	Mostly to be completed before the works begin	Contractor	Workers safety plan prepared Record keeping arrangements for injuries First aid kit at the site PPE available at site. Relevant photos and copies of records.
Congestion in island's harbour/port is minimised.	C17	Discuss with island authorities offloading arrangements proposed in the work methodology Demarcate the location for offloading Have in place a coordination mechanism with incoming bulk carriers on proper navigation and anchoring.	Pre-construction	Included in the construction cost	Discussion, meetings, and field work	Pre-construction and construction period	Contractor Atoll council Island council	Meeting records' Field signs

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
Reduction of the risk that the island is flooding as a result of breach in the ridge due to coastal erosion, reducing the risk of loss of life, damage to assets, economic development and ultimately abandon the island.	O1	Proper record keeping arrangements at atoll council of unusual weather related events, flooding, loss and damages to properties erosion etc Bi-annual beach erosion program to be conducted for 10 years with reference to benchmarks established under this EIA study	Operational phase	50,000	Land survey methods and equipments Record keeping at Atoll and Island Council	Bi-annual beach monitoring (one during NE monsoon, one during SW monsoon)	Atoll Council Proponent Environmental consultant	Bi-annual report
Groundwater lens improved as a result of reduced incidences of seawater flooding	O2	Carryout bi-annual groundwater testing from groundwater wells for 10 years. Baseline to be established before the construction begins. pH TDS COD BOD5	Operational phase	10,000	Sampling	Bi-annual	Atoll Council Proponent Environmental consultant	Laboratory reports Monitoring reports
	O1							
	O2							
Agriculture sector on the island is well protected against flooding from sea	O3	Surveys of agricultural land Water quality testing Baseline to be established before the construction works	Operational phase		Interviews with farmers	Bi-annual	Atoll Council Proponent Environmental consultant	Monitoring report Council records
Reducing the risk of moving erosion problem to northwest with the risk of affecting <i>Thundi</i> area	O4	Beach profiles with reference to established monitoring stations	Operational phase	50,000	Beach surveys Aerial photos	Bi- annual One during NE monsoon, one during SW monsoon	Atoll Council Proponent Environmental consultant	Survey reports Monitoring reports
Visual impact of revetment viewed from the inland	O5	Coastal vegetation re-generation program conducted. Small nursery to be established to grow common coastal plants in association with Atoll Council	Operational phase	50,000	Consultative process to develop a development plan for the island	Nursery to be set up soon after the ground-breaking of coastal revetment works.	Atoll Council Proponent Environmental consultant	Monitoring report

Objective	Impact code	Activity	Phase	Cost	Method	Time frame	Responsible person	Verifiable indicator
						Planting to be conducted as soon as revetment work is completed. Monitoring of survival of plants to be monitored bi-annually		
Improving access to coast and sea	O6	Steps to include in the design of revetment	Construction phase	Included in the design and construction contract	Interviews with locals Visual observations	One off exercise after completing the revetment	Atoll Council Proponent Environmental consultant	Steps developed Interviews with locals Monitoring report
Enhancing social and physiological well-being	O7	No of new business and houses, especially near the east coast No of direct and indirect jobs created in the community Change in fish catch Change in agricultural output (baseline to be established before the project starts)	Implementation phase	40,000	Council data Visual observations Interviews	Year 1, 5 and 10 following completion of the Project	Atoll Council Proponent Environmental consultant	
Enhancing community cohesion	O8	Enhanced confidence of the people of security following the project	Implementation phase	10,000	Interviews, questionnaires	Year 1, 5 and 10 following completion of the Project	Atoll Council Proponent Environmental consultant	
Enhancing demographic development	O9	Change in migration	Implementation phase	1000	Data from island authorities Statistical year book	Year 1, 5 and 10 following completion of the Project	Atoll Council Proponent Environmental consultant	
Providing a safe swimming	O10		Implementation phase		Interviews Direct observations		Atoll Council Proponent Environmental consultant	

11. CONCLUSIONS AND RECOMMENDATIONS

This EIA study was carried out by a multi-disciplinary team of experts, who considered the requirements set forth in the TOR for the study. The team took into account available information, views of the stakeholders, primary information collected from the project site and knowledge and experiences of the consultant in deciding the most preferred alternative to address the coastal erosion at Fuvahmulah.

Information and data for the EIA was collected by making two field visits to the island conducted in May 2015 and July 2016 during which baseline data was collected and stakeholder discussions of the project conducted. In addition, all available relevant literature and comparable studies were reviewed.

In order to identify the most appropriate alternative to protect the coastline, a long list of eight potential coastal protection measures was compiled. This long list was assessed against a number of criteria to select the most favourable ones. Two feasible and effective options that are believed to be the most appropriate to the existing conditions of Fuvahmulah have been selected– an offshore breakwater and an onshore revetment. These two alternatives were further investigated in quantitative multi-criteria analysis (MCA) and in the Impact Assessment.

While an offshore breakwater will reduce the erosive force of the approaching waves, therewith creating calmer conditions on the lee of the structure, the onshore revetment will protect against erosion at the shoreline itself. The effectiveness to protect against erosion is considered higher for the onshore revetment than for the offshore breakwater. The offshore breakwater has more uncertainties in the design, making it less certain that erosion will be prevented completely. In addition, the risk that *Thundi* Beach may be affected by additional erosion due to the coastal protection structure is considered higher for the breakwater option than for the onshore revetment. Based on these main considerations the onshore revetment was selected as the most preferred option.

The onshore revetment has been designed taking into account wave characteristics and predicted sea-level rise for the Maldives. The structure will be placed seawards to limit the effect on the vegetation belt after profiling the broken ridge with a quarry run. Underneath the rock armour a geotextile layer may be placed to prevent undercutting. The crest level of the structure will be +3.5m from MSL and will have a design life of 50 years. The structure will have a length of 2,650 meters and a width of 27 meters, starting at the port towards the north. A total volume of 131,979m³ of granular rock will be required.

A bulk carrier would transport the materials to the island (most probably from India) while smaller bulk carriers, trucks and equipment that are commonly used for such works will be utilised for the processing and the placement of the rocks. Rocks will be unloaded and stockpiled in the outer harbour and transported to the site of placement by trucks running over the revetment itself, therewith minimising transport over the island itself. The construction is expected to take approximately 12 months.

Quality assurance during designing and constructions will ensure minimum maintenance during the design life of the structure.

All environmental and socio-cultural (positive and negative) impacts expected from the Project have been identified for both the onshore revetment and the offshore breakwater. Cost effective, robust measures have been identified to mitigate against adverse impacts and to enhance the positive impacts. Highlighted below are the likely impacts and related measures for the preferred alternative – the seaward onshore rock armour revetment.

The main positive impact of the project is the minimisation of the risk that the island will be flooded as a result of breach in the ridge due to coastal erosion. This limits the risk of loss of life, damage to natural and economic assets, feelings of insecurity of the population and limitations to socio-economic development and in the ultimate scenario an abandonment of the island. Protecting island's integrity will enhance the sustainable development of the island in economic, social and environmental terms. To coordinate and enhance integrated development of the island an integrated development plan should be prepared, implemented and monitored in close cooperation with the population and local stakeholders. .

Construction of 2650 m long and 27 m wide revetment would mean irreversible altering of a footprint of 71,550m² of existing coastal environment, which is inevitable. The long term erosion of the island's coastline has already effectively converted the footprint area into an area of low habitat value consisting mostly of rubble, beach rock and limited beach. Since the objective of the revetment is to provide protection and security to the people and the terrestrial habitat, the benefits of coastal protection far outweigh the negative impact of permanent conversion of the existing coastline.

Quarrying of rock boulders changes the landscape, creates noise, dust and safety risks at the location of the quarry. Hence, obtaining rocks from a certified supplier is required and the design has been optimised to limit the material requirements.

Transport (both land and sea) of materials from the source country to the project site and the energy utilised by the machineries and trucks would generate emission of Green House Gases (GHGs) and other polluting gases. A total of 9,650 ton CO₂ emissions will be generated by the production and transportation of the construction material and the placement of the materials as the revetment. Consequently, supplying materials from the closest available source, efficient use of vehicles, equipment and bulk supply and proper maintenance of vehicles and equipment are required to limit the CO₂ emissions.

In addition to climate change impacts, the movement of vehicles when used on the island itself can damage unsurfaced roads, create risks of accidents, noise, vibrations, dust and risks of spills of fuel or waste on land. However, a construction method has been proposed to use the revetment itself as a transportation route to get the construction material from the port to the site of placement. Construction of the first layer of the revetment will start at the port and while working towards the north a path will be laid for the vehicles to use. The second layer of the revetment will be laid starting in the north, working backwards towards the port still driving over the revetment. In this way transportation overland can be kept to a minimum and will mainly consider staff, small supplies and supervision. Access paths for vehicles will be located in areas of low habitat value, away from sensitive receptors and public to minimise transport related impacts.

An advantage of the offshore breakwater would have been the creation of a large safe swimming area at the lee side of the structure, which is not the case with the onshore revetment. This has been compensated by including steps in the design so that the water will be easily accessible and by

reinforcing the current small tetrapod breakwaters with rocks and installing a safety line to enhance the current swimming areas. Works in the coastal zone create risks of damaging coastal vegetation and sites of historical and cultural importance. Therefore, fencing and/or delineation of these areas prior to construction along with carefully selected routes for vehicle movement have been proposed. In addition, mature trees will not be removed unless all options have been explored. In the unlikely event of a tree removal existing regulations will be followed and implemented.

Next to the vegetation, there is also a risk of damaging the geological features such as the island ridge and beach rock. It can also cause soil compaction and can affect the beach fauna. Setting up access routes and using protective boarding for vehicles and low ground pressure machinery to drive on have been proposed to mitigate these effects.

Generation of construction waste, waste oil and other hazardous wastes, fuel spills have a potential to pollute the environment, as well on land as in the sea. Hazardous and non-hazardous waste generated by the Project shall not be allowed to be discarded on the island since Fuvahmulah lacks a waste management system. It is proposed to designate an area for waste collection for subsequent disposal at Thilafushi landfill site. Hazardous or potentially polluting materials such as fuel, oil, batteries, chemicals etc. will have to be stored on an impervious base (concrete pavement) away from water and properly banded and kept locked when unattended. In addition, storage of fuel, equipment and construction materials have also been proposed to be properly stockpiled so as to minimise the risk of soil or sediment contamination or water pollution and to avoid material wastage.

Vessel and barge movements shall be coordinated by the authorities to limit the risks of grounding or collisions, which can potentially cause spills or other hazardous substances.

An emergency plan that shall be submitted by the contractor will further ensure that procedures to prevent or mitigate impacts due to accidents or spillages are in place and operate effectively during the Project implementation.

The risk of moving the erosion problem to north with the risk of affecting *Thundi* area is an uncertain element in the current assessment. This is mainly due to lack of long-term data on longshore currents and sediment transport regime around the coast. However the expert opinion is that the risk of *Thundi* beach erosion is low and is considerable lower in the case of the onshore revetment compared to the offshore breakwater structure. Due to the uncertainties involved it is required to implement a detailed monitoring program to evaluate changes of *Thundi* area following the construction of the structure.

The visual impact of the revetment viewed from the beach may not be appealing to some people and may be considered an eyesore. In designing the structure measures that can minimise the visual impacts have been considered.

The rock armour revetment can also cause difficulties to access the beach and the sea for the people. Hence for convenience of the people steps have been incorporated into the design.

The magnitude and importance of all impacts has been evaluated and their significance assessed in the EIA report with necessary mitigation measures so that the residual impacts are well within accepted limits. With the mitigation measures in place, no activity planned under the project is expected to result in residual impacts that are of concern to the environment or to the people.

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

The Project does conform to the development policies, priorities and aspirations of people of Fuvahmulah. Additionally, the EIA team also found that the Project can be completed in full compliance with the relevant laws and regulations of the Maldives.

The following recommendations have been formulated:

- It is strongly recommended that the proposed mitigation measures in the report along with the monitoring plan be implemented to the fullest by the project proponent. In this regard, it is highly recommended that a designated focal point within the MEE to act as a focal point ensuring that the EMP is fully implemented during the construction and operational phase of the Project to ensure the project benefits are reaped while minimising the negative effects on the environment. In this regard, adequate budget and resources shall be allocated from the Project funds for environmental monitoring and auditing. An independent third party shall be appointed for the monitoring works.
- Since the proposed monitoring program is expected to last a decade to make it meaningful, provision of necessary financial resources is crucial. Hence it is recommended that the proponent secures the required amount of budget for the year in the annual budget requests to the Ministry of Finance and Treasury. It is advised to involve the local communities in the monitoring activities to enhance their understanding of the project, promote transparency and raise environmental knowledge and awareness.
- A detailed tree survey shall be carried out prior to the construction works and tree replantation program shall be devolved and agreed with the community and officials before any vegetation clearing takes place. Records of all trees removed and replanted shall be properly kept by the contractor.
- Prior to construction, all the island councils (wards) within the project corridor should be notified of construction schedule and completion time to instil ownership feeling in them.
- A clear coordination and information flow mechanism need to be established during the preparatory phase in which island council and atoll council of Fuvahmulah shall be given clear roles to enhance their sense of ownership of the Project and to observe and propose rectifications during the works in a timely manner.
- A holistic and integrated approach should be adopted and the coastal protection works should be an integral part of the overall development plan of the particular area. It means that in addition to coastal protection works, other development like improvements to public swimming areas and beach access facilities should be developed. In this regard formulation of a development plan for Fuvahmulah has been recommended as part of the mitigation measures that will take into account coastal vegetation re-habitation and conceptual architectural plan for the coastal areas to enhance natural vista of the coastline.

- It is strongly recommended not to set up a separate workers' camp as commonly practiced in similar projects in the Maldives. Whereas use of established services and facilities shall be encouraged to ensure benefits to the community. In order to link poverty alleviation with the Project it is necessary that at the construction stage the work relating to petty contracts and unskilled labour should be given to the local population especially the weaker and vulnerable groups so that it makes a dent of the poverty problem and social and economic status of local populace. Contracts for petty works like supply of food, water etc. should be given to the local population.
- Local labour residing on the island should be encouraged to work in the construction work and expatriate workers who are illegally staying on the island shall not benefit from the project.

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ANNEX 1: TERMS OF REFERENCE



203-EIARES/438/2016/116

Terms of Reference for Environmental and Social Impact Assessment for Coastal Protection Works in Fuvahmulah, Gnaviyani Atoll

The following is the Terms of Reference (ToR) following the scoping meeting held on 20/06/2016 for undertaking the EIA for the proposed Coastal Protection Project in Gn. Fuvahmulah. The proponent of this project is Ministry of Environment and Energy.

While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction and rationale** – Describe the purpose of the project. Objectives of the development activities should be specific and if possible quantified. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked to other activities that are carried out or that is being carried out within the project boundary. Identify the donors and the institutional arrangements relevant to this project.
2. **Study area** – Submit a minimum A3 size scaled plan and architectural drawings, cross sectional drawings with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, sensitive species nursery and feeding grounds).
3. **Scope of work** – The report should be categorised into the following components:

Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the coastal protection works, using maps at appropriate scales where necessary. The following should be provided including all inputs and outputs related to the proposed activities and shall be justified.

- Coastal defense construction and justification;
- Design parameters and project inputs and outputs;
- Justification for the selection of the location;
- Method and equipment to be used and impact control measures while construction;
- Duration of the construction activity and decommissioning;
- Location of the coastal defense structure, including justification for the selection of this location;
- Construction method, equipments and technologies;
- Temporary site setup labour arrangements;
- Emergency plan during construction activities;

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Ecology:

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles).
- Coastal and coral reef environment at the project location;
- Benthic and fish community in the areas directly affected as a result of the proposed development.
- Marine transect/quadrant stations every 500 m along the length of the breakwater and data from three 20 m transects laid in each station.

Existing Terrestrial/Shoreline Environment

- Beach profiles at 500m intervals in the immediate vicinity of the location proposed for coastal protection (northern side) beach profiles of the southern side of Fuvamulah (profiles of southern side need not be as frequent as the northern side).
- Beach profiles of the "thundi area" at 100m intervals.
- Shoreline and vegetation line to cover the whole island.
- Comparison of shoreline with historical available data.
- Details of the vegetation to be removed (including number, type and size) for any project related activities.

Natural Hazard and Vulnerability

- Vulnerability of the area to flooding and storm surges.

Socio-economic environment

- Demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Economic activities of the population;
- Economic situation and income situation;
- Land use planning, natural resources use and zoning of activities at sea;
- Accessibility and transport to other islands;
- Services quality and accessibility such water supply, wastewater disposal, solid waste disposal, energy supply and social services such as health, education etc.
- Community needs and wants.

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations, 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 report should clearly identify the different articles and clauses that applies to the proposed project and should state how the project meets these requirements. International standards of the IFC shall be incorporated to comply with the requirements of the potential donors.

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

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology; Changes to the "Thundi" area needs to be given special consideration and impacts identified through possible models.

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- Loss of marine bottom habitat, both in borrow area as well as due to enlargement of the island, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity;
- Sediment dispersal in water column (turbidity during the construction activities movement of marine based equipment's), possibly resulting in changing in visibility, smothering of coral reefs and benthic communities and affecting fish and reef organisms;
- Impact of noise, vibration and disturbance on sensitive areas such as mosque etc. at project area.
- Changes to currents and wave conditions due to installation of the breakwater;
- Impacts on ground and marine water quality resulting from project activities;
- Impacts on landscape/seascape integrity/scenery; and
- Any cumulative impacts.

Impacts on the socio-economic environment

- Impacts of the project and construction and decommissioning works on the public, businesses and way of life, giving particular attention to sensitive population;
- Impacts on demographic developments (migration);
- Impact on coastal fishing and tourism related activities and navigation;
- Impacts on agricultural development;
- Impacts on island employment, income and economy diversification;
- Level of protection against hazards like sea-level rise storm surges etc;
- Impacts of workers on the local population;
- Impacts on cultural sites and heritage;
- Impacts of increased demands on natural resources and services especially water supply, land availability, waste management, energy supply, harbour capacity;
- Monitoring of socio-economic impacts.

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 – Alternatives including the “no action option” should be presented. Determine the best practical environmental option. 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 coastal protection measures, locations, alternative designs, materials and methods. The report should highlight how the best options were determined. All alternatives must be compared according to accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

- Explore options to replenish existing northern side coast, if considered details regarding sourcing material/amount/ preferred areas etc shall be provided.

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 pollution control and future changes in coastal processes and prevention of flooding.

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Mitigation measures to avoid or compensate habitat destruction caused by the project activities will have to be considered. Measures for both construction and decommissioning phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of financial 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. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction and after project completion. A realistic schedule of implementation of the monitoring program shall be provided. The baseline study described in Task 2 of Section 2 of this document is required for data comparison. Details 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. Some important aspects to monitor include the following:

- Changes to groundwater quality in near coastal areas and marine environment;
- Impacts of sedimentation as a result of the disturbance during the construction activities;
- Assessment of nearby sensitive ecosystems and marine resources;
- Health of the corals relocated (if undertaken);
- Erosion and accretion along the coastal areas;
- Effectiveness of the coastal defence structure;
- Social and cultural issues;
- Effectiveness of the mitigation measures.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – Identify appropriate mechanisms for providing information on the project to all stakeholders. Consultation shall be undertaken with Fuvahmulah council, Ministry of Housing and Infrastructure, NGO's, relevant communities and the general public of Fuvahmulah. The EIA report should include evidence of consultation including a list of people/groups consulted, their contact details and summary of the major outcomes. The report shall also include the methodology of the consultation with justification, date, time and place of consultation. The report should also include evidence that EIA has been submitted to Fuvahmulah council prior to submission to EPA.

Presentation- The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012 and the relevant amendments.

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.

30th June 2016



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ANNEX 2: COMMITMENT LETTER (PROPONENT)


Ministry of Environment and Energy
Male', Republic of Maldives.

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Date: 26th October 2016 No: 438-ECAS/203/2016/98

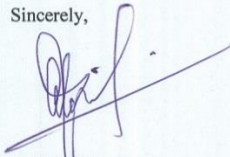
Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Malé

Dear Sir,

SUB: EIA for the Proposed Coastal Protection at Gn. Fuvamulah

As the proponent of the project, we confirm our commitment to finance and implement all construction/operation phase mitigation measures and the environmental monitoring program as specified in the EIA report.

Sincerely,


Abdulla Ziyad,
Minister of State



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ANNEX 3: LETTER FROM ATOLL COUNCIL



Secretariat of the Fuvahmulaku Atoll Council
Fuvahmulah, Rep of Maldives

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Dear Sir / Madam

This letter is to inform you that we at Fuvahmulah Atoll Council acknowledge the receiving of documents sent by you for the Final Draft Report of the EIA for Coastal Protection Project at the beautiful Island of Fuvahmulah.

We are glad at your prompt action and we hope to entertain all your requests as convenient.

Yours Sincerely,

Abdulla Palah Shareef
President



ANNEX 4: LIST OF PARTICIPANTS (STAKEHOLDER CONSULTATIONS)

Attendance Table

Consultation Meetings (July 2016)

Objective: Consultation meetings for the development of EIA and Design Option Analysis

#	STAKEHOLDER MEETINGS July 2016		
1	NAME	POST/ORGANIZATION	CONTACT NUMBER
Date: 11th July 2016/ EPA			
2	Ahmed Shan	Social Surveyor/EPA	7905899
3	Mohamed Hamdhan Zuhair	Environment and social safeguards officer/ Ministry of Environment and Energy	7768606
4	Aishath Farhath Ali	Wetlands Coordinator	9998750
Date: 11th July 2016/ Fuvahmulah Police			
5	Moosa latheef	Fuvahmulah Police	9991710
6	Hussain Niha	Fuvahmulah Police	9791526
Date: 11th July 2016/ ESIA FVM Protection			
7	Ajfaan Jawad	Conservation officer/ CCAP/ MEE	9975558
8	Hawwa Rasheed	Protected Area Manager/ CCAP/MEE	7996694
Date: 11th July 2016/ MHI			
9	Nafha Aujaz	Environment Analyst/ Ministry of Housing and Infrastructure	7721554
Date: 13th July 2016/ FVM Hospital			
10	Yameen Saeed	GN. Hospital	7669989
11	Hassan Abdulla	Computer technician/ GN. Hospital	7717131
12	Wisham Ahmed	Accounts/ GN. Hospital	9711417
13	Ali Hassan	Maintenance/ GN. Hospital	7786450
14	Khadeeja A. Majeed	GN. Hospital/ NM	7993494
15	Hassan Samir	GN. Hospital/ Admin	7970010
16	Abdul Hakeem Hassan	SCHO/ PHO	9933454
17	Hawwa Shiuna	CHO/ PHO	7778704
18	Ibrahim Mohamed	Maintenance Officer	9194033
Date: 13th July 2016/ FVM Atoll Council			
19	Ali Shameem	Dhadimagu.Council/ Island Council	7834372
20	Abdullah Nasir	Hoadhadh Council	7793234
21	Hussain Fahmy	Dhadimagu Council	7791663

#	STAKEHOLDER MEETINGS July 2016		
22	Ibrahim Mohamed	Dhoodigan Council	9912174
23	Ahmed Hamdhan	Dhoodigan Council	9723080
24	Mohamed Lirar	Malegum Council	7981626
25	Ali Abdulla	Malegum Council	7782413
Date: 13th July 2016/ Education			
26	Nasih Mohamed	Manager/ Villa College	7797739
27	Ahmed Hussain	Manager/ Zikura Institute	7795415
28	Mohamed Ibrahim Didi	HAS LI	7735667
29	Abdulla Naeem	Villa College	7781564
30	Munah Ahmed	Admin Officer/ Zikura Institute	9908993
31	Aniyath Mohamed	Finance Officer/ Zikura Institute	9663778
32	Aishath Anees	Coordinator/ Kangaroo Kids	7783264
33	Aminath Moosa	Hafiz Ahmed School	7971920
34	Salma Anees	Fuvahmulaku School	7784690
35	Shazmeena Shakir	MJM/ LT	7938628
36	Hawwa Zuhaira	MJM/ LT	7951222
37	Ahmed Ali Didi	Zikura School	7794534
38	Mohamed Hassan	Kangaroo Kids	7783912
Date: 12th July 2016/ FVM Atoll Council			
39	Aminath Nafia	Fuvahmulah Atoll Council	7996035
40	Ali Maseeh	Fuvahmulah Atoll Council	7959787
41	Ahmed Isam	Fuvahmulah Atoll Council	7971028
42	A.F. Shareef	Fuvahmulah Atoll Council	
43	Margriet Hartman	Royal HaskoningDHV	
44	Ali Hammad	MEECO	
45	M.P Dirial Shalika	MEECO	7486313
46	Ahmed Hassan	Environment Analyst/ Ministry of Environment and Energy	7886707
47	LARS Hoogduin	Royal HaskoningDHV	
Date: no date/ Womens Committee			
48	Ashiyath	dhadimagu	9931037
49	Nasfa Mohamed	dhadimagu	7611214
50	Mizna Waheed	dhadimagu	9973450
51	Aishath Hudha	dhadimagu	7763975
52	Aishath Zuhaira	Malegam	7723362
53	Dhiyama Ahmed	Malegam	7873722
54	Aminath Abdulla	Malegam	7836964
55	Aishath Abdul Razzaq	Dhoodigan	9934807
56	Khadeeja Ahmed didi	Dhoodigan	7581744
57	Fathimath Rasheeda	Dhoodigan	7736261

#	STAKEHOLDER MEETINGS July 2016		
58	Fathimath Nasira	Hoadhadh	7440378
59	Hawwa Thahira	Hoadhadh	7995640
60	Khadheeja Waleedha	Hoadhadh	7513838
61	Mariyam Ibrahim	Hoadhadh	7631349
62	Khadheeja Ahmed	Hoadhadh	7603331
63	Shakeela Ali	Dhoodigan	7781362
64	Mariyam Zuneeyra	Dhoodigan	9196777
Date: 13th July 2016/ FVM Community			
65	Hassan Ahmed	Community	7971122
66	Mohamed Waheed	Community	7797250
67	Abdulla Mohamed	Community	7788087
68	Ibrahim Sabree Mohamed	Community	9996452
69	Shafiyya Ibrahim	Community	7937820
70	Mohamed Nizam	Community	9781087
71	Nasheed	Community	7904056
72	Falah	Community	7776498
Date: 14th July 2016/ MRDC			
73	Ibrahim Asglar	Asst. Manager/ MRDC	7995370
74	Ibrahim Rasheed	Asst. Manager/ MRDC	7774021
75	Ibrahim Hassan	Site Manager/ MRDC	7783731
76	Ahmed Ali	Asst. Manager/ MRDC	7791713
77	Abdulla Ibrahim	Regional Manager/ MRDC	7782290
Date: 14th July 2016/ FVM NGOs			
78	Ibrahim Hussain Didi	President/ DZJ	7783731
79	Ibrahim Hisan	Branch Coordinator/ Maldivian Red Crescent/ GN	9906727/ 9704793
80	Ahmed Shafiu	Vice President	7999494
Farmers			
81	Aishath Aabidha		7843831
82	Ali Shafeeg		7721930
83	Aminath Hafeeza		7724200
84	Naahidhaa		9799060
85	Khadheeja Husnu		7494642
86	Hawwa Ahmed	Moosunbahaaruge	
87	Fathimath Bishaaraa		7631479
88	Ahmed Abulllah		7652025
89	Hussain Ali Mohamed		7688539
90	Mohamed Hussain		7788705
91	Mohamed Hussain		7841745

Attendance Tables**Consultation Meetings (October 2016)****Objective:** Presentation of Findings and Outcome of Design Phase

Meeting 1: Atoll Council			
Date: 17 Oct 16			
Time: 10:00 - 11:00			
	Name	Post	Contact
1	Ahmed Anwar	Assistant Director	7995080
2	Ali Maseeh	Assistant Director	7959787
3	A. Falah	President Atoll Council	
4	Ahmed Isam	A Council	7971028
5	Sofoor Kawsar Usman	MEECO	
6	Maartje Wise	Royal Haskoning DHV	
7	Lars Hoogduin	Royal Haskoning DHV	
Meeting 2: Community			
Date: 17 Oct 16			
Time: 8:30 - 9:30			
	Name	Post	Contact
1	Ahmed Anwar	Assistant Director	7995080
2	Sofoor Kawsar Usman	MEECO	
3	Maartje Wise	Royal Haskoning DHV	
4	Lars Hoogduin	Royal Haskoning DHV	
5	Ali Maseeh	Assistant Director	7959787
6	A. Falah	President Atoll Council	
7	Ahmed Isam	A Council	7971028
8	Ali Saeed	Maalegan Council	7792436
9	Ibrahim Hashim Didi	Anoanaage	7724200
10	Abdulla Mohamed	Aanuveli	7788087
11	Mohamed Ibrahim Didi	HAS	7735667
12	Ahmed Hussain	Saadhaage	7795405
13	Ibrahim Hassan Didi	Sir,age	7783731
14	Abdul Hakeem	Gn. Hospital	9933454
15	Nasih Mohamed	Villa College	7797739
16	Mohamed Liraar	Miskimagu	7981626
17	Waheed	Dhiguvaandu	9904554
18	Hawwa Rasheed	CCAP	7996694
19	Ajfaan Jawad	CCAP	9975558
20	Arifa Abdulla	MJM	9920061

21	Majeed	MJM	
22	Nahidha Ahmed Solih	MJM	7983320
23	Shazmeena Shakir	Leading teacher	7938628
24	Aminath Ahmed	D. Principal	7993086
25	Mumthaz	Teacher	7430176
26	Abdulla Mohamed	A. Director	7775638
27	Fathimath Nasira	Hoadhandu committee	7440378
28	Aishath Zuhaira	Malegan Committee	7711817
29	Waleedha	Hoadhandu committee	7513838
30	Aneesa	Teacher	9920302
31	Aishath Ali	Miskimagu Council	7412272
32	Yaameen Saud	Hospital	7669989
33	Shamsul Jabeen	MRC	7688497
34	Muslima Ibrahim	MRC	7519534
35	Abbas Ahmed	Fuahmulah School	7785474

ANNEX 5: CVs

1. **Position:** Assistant Team Leader
2. **Name of Firm:** Maldives Energy and Environmental Company (MEECO)
3. **Name of Staff:** Ali Hammadh
4. **Date of Birth:** 5th April 1991 **Nationality:** Maldivian
5. **Education:**

<i>Institution</i>	Macquarie University, Australia
<i>Date:</i>	January 2012 – February 2015
<i>Degree(s) or Diploma(s) obtained:</i>	Bachelor of Environment Majors: Chemistry & Environmental Management

6. **Membership of Professional Associations:**
Registered Temporary EIA Consultant (2015 – Present)
MQ University Alumni
7. **Other Training:**
8. **Countries of Work Experience:**
 - Maldives.
 - Australia

Management and Organisational experience

Ongoing Projects

1. Regional Solid Waste Management Feasibility Study (Northern Region), Project Coordination, Client: MEE
2. Gn.Fuvahmulah Shore Protection Project ,Coordination, Client: DHVRoyalHaskoning
3. Development of Maldives Energy Act, Project Coordination and assistance, Client: MEE
4. Islandway Iru Tourish Hotel Development Preliminary studies and EIA, Project Leader, Client: Islandway Hospitality Group.
5. L.Gan Seacucumber Facility Development, Preliminary studies and EIA, Project Leader. Client: SeaHouse

Environmental Assessment Experience (Conducting surveys, studies and writing of the following EIA reports):

1. Saleem, A and Hammadh, A. (2016). N.Felivaru Construction phase monitoring report 1.
2. Saleem, A and Hamdhoo, M. (2016). Environmental Impact Assessment (EIA) for the Construction of Huivani Resort Project
3. Saleem, A. and Hammadh, A. (2016). Environemntal Impact Assessment for Planned Reclamation at A.Dh. Fenfushi Island.
4. Saleem, A. and Hammadh, A. (2016). Environment Impact Assessment for Sewerage System Development at S. Feydhoo, Maradhoo, Maradhoo-Feydhoo and Hulhudhoo Islands.
5. Saleem, A. and Hammadh, A. (2016). Bathymetry Survey and Report for Gulhifalhu
6. Saleem, A. and Hammadh, A. (2016). General and Technical Proposal for Reclamation of Guarantee Fibreglass Fabrications Plot at K.Thilafushi.
7. Saleem, A. and Hammadh, A. (2016). Environmental Impact Assessment for Reclamation of Guarantee Fibreglass Fabrication Plot at Thilafushi.
8. Hammadh, A. (2016). Environmental Monitoring reports 1&2 for Baresdhoo Intergrated Resort Project, MPRC.
9. Hammadh, A. (2016). Environmental Monitoring reports 1&2 for Dhonmaagaa Resort Project, SeaHouse Resorts.
10. Saleem, A., Hammadh, A and Muslih, M (2016). Coral Relocation Report at K.Donmaagaa, SeaHouse Resorts.

11. Saleem, A. and Hammadh,A. (2016). Impact Assessment Report for the land reclamation at G.Dh Thinadhoo, MHI.
12. Saleem, A. and Hammadh,A. (2016). Impact Assessment Report for the land reclamation at K.Hinmafushi, MHI
13. Hammadh.A and Muslih.M, (2015). Coral reef and fish survey report at west coast of G.Dh. Thinadhoo, MHI
14. Saleem, A. and Hammadh,A. (2015). Impact Assessment Report for the Construction of K. Villingili West Harbor and Slipway.
15. Saleem, A. and Hammadh,A. (2015). Proposed Construction of a Small Quay Wall and Marine Ramp at Thilafushi Industrial Zone Project.

9. Languages:

<i>Language</i>	<i>Reading</i>	<i>Speaking</i>	<i>Writing</i>
English	V.Good	V.Good	V.Good
Dhivehi	Mother tongue	Mother tongue	Mother tongue

10. Employment Record:

<i>From</i>	<i>To</i>	<i>Employer</i>	<i>Positions held</i>
2015	Present	Maldives Energy and Environmental Company (MEECO), Maldives	Assistant Director, Assessments.
February 2014	December 2014	Townsville Atmospherically deposited Dust Metal Study by MQ University	Data Analyst
June 2014	December 2014	MQ University	Laboratory Demonstrator
February 2013	September 2013	MQ University	Note Taker for the special needs student.
February 2012	March 2013	RMC College	Waste Collector
February 2011	March 2011	Ministry Of Tourism	Assistant Planning Officer

[illegible]

مَدَّوْرِي وَدَمِ لَا سَوْحَ سَرْجَسَ مَسَرَّتْ

د ١۶ مه د وږي مياشتې په ۲۰۱۲ ز کال د ۱۶ مې د وږي مياشتې (ر) تر نېټې

اَللّٰهُمَّ صَلِّ وَسَلِّمْ عَلٰى سَيِّدِنَا مُحَمَّدٍ

EIA T12/15: سرسبز سرفروش

[illegible]

۱۴۰۵ : د. م. پښتو / دو

A111201 : ۱۳۸۵ سدری اکتبر ۲۴

31 : 31 ستمبر 2015

31 : 2016

مجلس شورای اسلامی
مجلس شورای اسلامی



1. **Position:** Social and Poverty Specialist
2. **Name of Firm:** Maldives Energy and Environmental Company (MEECO)
3. **Name of Staff:** Sofoora Kawsar Usman
4. **Date of Birth:** 23 January 1982 **Nationality:** Maldives.
5. **Education:** Masters of Health Economics and Policy

<i>Institution</i>	The University of Adelaide, SA - Australia
<i>Date:</i>	July 2013 – Dec 2014
<i>Degree(s) or Diploma(s) obtained:</i>	Masters of Health Economics and Policy
<i>Institution</i>	The University of Adelaide, SA - Australia
<i>Date:</i>	Jan 2013 – July 2013
<i>Degree(s) or Diploma(s) obtained:</i>	Graduate Certificate in Economics
<i>Institution</i>	Staffordshire University – United Kingdom, Asia Pacific Institute of Information Technology (APIIT), Sri Lanka.
<i>Date:</i>	July 2006 - July 2008
<i>Degree(s) or Diploma(s) obtained:</i>	Bachelor of Arts (Honours) in Business Administration
<i>Institution</i>	Associations for Business Executives Modern Academy for Professional Studies (MAPS), Maldives
<i>Date:</i>	January 2004 – June 2005
<i>Degree(s) or Diploma(s) obtained:</i>	Diploma in Business Administration
<i>Institution</i>	Youth and Sports Development Centre, Ministry of Youth and Sport, Maldives
<i>Date:</i>	June 2001 – Nov 2001
<i>Degree(s) or Diploma(s) obtained:</i>	Certificate Course in Youth Counselling

6. **Membership of Professional Associations:**

- Executive Board Member
General Secretary, The Vibe – NGO, Maldives, Dec 2012 to date
Maldives National Chamber of Commerce and Industries (MNCCI), Dec 2008 – Jan 2011
(www.mncci.org.mv)

7. **Other Training:**

- Qualitative Methodologies, Data Collection and Analytic Approaches
Australian Consortium for Social and Political Research Incorporated (ACSPRI)
Brisbane, Australia
- Health Technology Assessment
University of Adelaide
Adelaide, Australia
- Training on Arc Desktop
Ministry of Housing & Environment, Group FIT, Maldives
- Training Course on Cooperative Management
Bangladesh Academy for Rural Development (BARD)
Comilla, Bangladesh
- Psychological Interventions

- NNCB, Cyprus consultants, Maldives
- Establishing a Vulnerability and Poverty Monitoring System in Maldives.
MPND, UNDP, Maldives.
- Second Asian Youth Congress on Drug Abuse Prevention
Colombo Plan Drug Abuse Advisory Programme, Maldives
- Country Course on Social Statistics
Statistical Institute for Asia and Pacific, Maldives.
- Commonwealth Regional Training programme on Poverty Focussed Rural Development.
Commonwealth Secretariat, Bangladesh, Comilla.
- Course on Policies and Regulation for Rural Energy Access and Integration with Rural Development Programs
US Aid/SARI Energy CORE International, Nepal, Kathmandu.
- Workshop on Project Preparation & Management and Windows of Opportunities.
MPND, British Council, Maldives.

8. Countries of Work Experience:

- Maldives (*related works and trainings are listed below*):
- 2015 – Review of National and Local level Institutional and Governance Arrangements and Legislative Frameworks concerning Low Emission and Climate Resilience Development including local development planning and environmental planning, Laamu Atoll Capacity Assessment and Capacity Development Plan and Local Language Advocacy Materials. UNDP, Maldives.
- Oct 2013 – June 2014: Conduct an Outcome Impact Assessment and Project Completion for Post-Tsunami Agricultural and Fisheries Rehabilitation Programme (PTAFRP), IFAD, Maldives.
- Nov 2013 – May 2014: Conduct a Baseline Study for Youth Health and Wellbeing Pilot Project, Maldivian Red Crescent, Maldives.
- Sept 2012 – Mar 2013: Conduct a baseline study/analysis on Rights to Information, UNDP, Maldives.
- Dec 2011 – Dec 2012: Establishment of a Hospitality Training Institute and Training Twenty Youth under ADB Private Sector Development Program, Ministry of Economic Development, Maldives.
- Nov 2011 – July 2013: Technical assistance to develop a Baseline Assessment/Report for Fisheries and Agriculture Diversification Project (FADiP), IFAD, Maldives.
- Aug – Sept 2012: Conduct a Training and Community Needs Assessment for Ga.Gemanafushi, Fisheries and Agriculture Diversification Project (FADiP), IFAD, Maldives.
- Jan – May 2012: Marketing Expert on Soft Toys Souvenirs under ADB Private Sector Development Program, Ministry of Economic Development, Maldives.
- Oct 2011 – Mar 2012: Rapid Assessment on the Sexual and Reproductive Health and HIV Linkages in Maldives, IPPF-EU funded, Society for Health Education (SHE), Maldives.
- Jan 2012 – Mar 2012: Aquaponics Training, Demonstration and Study Tour to Baa. Atoll under ADB Private Sector Development Program, Ministry of Economic Development, Maldives.
- Aug –Dec 2011 - Marketing, Branding and Packaging Services for Virgin Coconut Oil for A11 Cooperative of Ha. Filladhoo under ADB Private Sector Development Program, Ministry of Economic Development, Maldives.
- Aug to Oct 2011: Field Coordinator for data collection and cleaning of ‘Rights Side of Life-Maldives’ survey for Human Rights Commission of the Maldives (HRCM), Maldives.
- Sept 2011: Conduct data collection and cleaning (Survey & FGDs) in Maldives on Gender Analysis for the WASH project of USAID and UNOPS (ARU, Sri Lanka).

- Aug 22 – 29, 2011: Proofreading and layout/design of ‘The HIV and AIDS situation of related policy and programmatic responses of Maldives 2011. Ministry of Health, Maldives.
- May to Aug 2011: Primary (Survey & FGDs) and Secondary Research to produce a Skill Inventory and Training Needs Analysis for employees of Human Rights Commission of the Maldives (HRCM).
- Jan to Jul 2010: Primary (Survey & FGDs) and Secondary Research on Major Risk-factors of Tobacco, producing a report for Centre for Community Health and Disease Control, Maldives.
- Aug 2009 to Jan 2010: Primary (Survey & FGDs) and Secondary Research, producing a Training Needs Analysis for Department of National Registration, Maldives.
- May 2009 – July 2009: Developed a Baseline Assessment (Secondary Research) for Post-Tsunami Agricultural and Fisheries Rehabilitation Programme (PTAFRP), IFAD, Maldives.
- Jan 2009 – Mar 2009: Social Sector Researcher in Water and Sanitation sector (Secondary Research for Post Tsunami Impact Assessment – UNICEF, Maldives.
- Jan 2009 – Mar 2009: Social Sector Researcher in Health and Nutrition sector (Primary Research Survey & FGDs) for Post Tsunami Impact Assessment – UNICEF, Maldives.
- Sept 2008: Training senior staff of Trans Maldivian Airways on Managerial Skills.
- Aug 2008: Training staff on Office Skills for Ministry of Fisheries, Agriculture and Marine Resources, Maldives.
- July 2008: Training senior staff of Wataniya on Performance Appraisal Systems, Maldives.
- July 2008: Development of a Performance Appraisal System for Wataniya, Maldives.
- Jun - Dec 2008: Conducting Induction Programmes for newly recruited staff of Bank of Maldives, Maldives.
- Feb to Apr 2008: Final work of Drug Prevention Master Plan, Maldives.
- Jan - Jun 2005: Preparatory work for Seventh National Development Plan (7th NDP).
- Jan - Jun 2005: Preparatory work for Second Vulnerability and Poverty Assessment of Maldives.
- Jan - Jun 2005: Preparatory work for Tsunami Impact Assessment Survey, Maldives.
- May 2005: Training of Community Level Workers (Psychosocial Workers), Tsunami affected sites, Maldives.
- Jan 2005: Psychological Interventions and Building an Emotional Support Brigade, Laamu, Gaaf Alif, Gaaf Dhaal Atoll of Maldives.
- Dec 2004: Facilitation of Focus Group for qualitative market research conducted by MAPS/DHIRAAGU, Maldives.
- Dec 2003: Maldives-Singapore Youth Exchange Programme, Singapore.
- Sept 2002: Population and Reproductive Health Advocacy aimed at Influential Groups, Alif and Faafu Atoll, Maldives.
- Dec 2001 to Jan 2002: Conducting a Participatory Rural Assessment (PRA) of all inhabited islands of Shaviyani atoll under Atoll Development for Sustainable Livelihoods (ADSL) -UNDP, Maldives.
- Jun 2001 to date: Life Skills Facilitator for various population groups.

9. Languages

<i>Language</i>	<i>Reading</i>	<i>Speaking</i>	<i>Writing</i>
English	Excellent	Excellent	Excellent
Dhivehi	Mother tongue	Mother tongue	Mother tongue

10. Employment Record:

<i>From</i>	<i>To</i>	<i>Employer</i>	<i>Positions held</i>
September 2008	January 2013	Maldives Environment Management Project (MEMP)-World Bank, Ministry of Environment and Energy.	Technical Assistance Coordinator to Environmental Monitoring and Management Component.
Jun 2008	Dec 2012	MAPS College, Maldives.	Lecturer.
May 2008	Aug 2008	Dhiraagu, Maldives	Senior Human Resource Officer
Jun 2005	Jun 2006	Tsunami Emergency Assistance Project (TEAP), Asian Development Bank, Ministry of Fisheries Agriculture and Marine Resources, Maldives	Community Development Specialist
Sep 2001	Jun 2005	Ministry of Planning and National Development, Maldives	Planning Officer
Jan 2002	Jun 2005	Youth Centre, Maldives	Youth Counsellor

1. **Position: Deputy Team Leader**
2. **Name of Firm: Royal HaskoningDHV (RHDHV)**
3. **Name of Staff: Margriet Hartman ()**
4. **Date of Birth: 6 June 1966 Nationality: Netherlands.**
5. **Education: MSc. in Geography**

Margriet Hartman has an MSc. in Geography and a Postgraduate Certificate in Social Impact Assessment. She has more than 20 years working experience in the field of environmental and social aspects of a variety of water management, infrastructure and policy projects and programmes.

She worked in a wide range of multidisciplinary and multi-country projects for private (Inter-American Coal, Chevron, Shell, VAE, InfraCo Asia, various port authorities) and International Financing Institutes and Donors (ADB, AfDB, EIB, EU, World Bank, Inter-American Development Bank, FMO and Dutch Development Programmes, like ORIO and ORET). She worked in numerous countries in Europe, Asia, Africa and Latin America, including long-term assignments in Poland, China and Thailand.

1. **Position: Hydraulic and Coastal engineer**
2. **Name of Firm: Royal HaskoningDHV (RHDHV)**
3. **Name of Staff: Lars Hoogduin**
4. **Date of Birth: 14 May 1984 Nationality: Netherlands.**
5. **Education: MSc. in Civil Engineering (speciality Coastal engineering)**

Lars Hoogduin has an MSc. in Civil engineering, specialized in Coastal morphology and hydrodynamics. He has 7 years of professional international experience in the design of coastal structures, including the assessment of the hydraulic design conditions (including numerical modelling) and their impact on the environment.

He worked in a wide range of multidisciplinary and multi-country projects, among which The Netherlands, Senegal, Qatar, Gibraltar, Belgium, Mozambique, Colombia, China and the USA. Projects mostly focus on the design of coastal structures to prevent erosion of flooding.

ANNEX 6: GHG CALCULATION TABLE

CO2 footprint Coastal protection at Gn. Fuvahmulah			
<i>Main source: Report coastal protection at Gn. Fuvahmulah. Deliverable 2e: Technical Design, d.d. 25 September 2016 ("report")</i>			
Key calculation factors	Unit	Value	Source
<i>CO2 emission factors</i>			
Production natural rock	kg CO ₂ / t material	4.30	Primum, ketenanalyse Breuksteen oeverbescherming Van Oord, 7 augustus '12, Reference CSM/006/111374 from the EcoInvent 2.0 database. Only extraction and production (TBE: very low factor)
8,000 t bulk carrier	kg CO ₂ / tonkm	0.028	co2emissiefactoren.nl
550 t barge (worst case)	kg CO ₂ / tonkm	0.05	co2emissiefactoren.nl
Dump truck	kg CO ₂ / tonkm	0.21	RHDHV: Ketenanalyse stabilisatie tijdelijke rijbanen, 9W7365/R00002/902741/Rott d.d. 26 juli 2012. Factor dumpers t.o.v. vrachtwagens
Diesel	kg CO ₂ / l	3.14	Handboek CO ₂ -prestatieladder
Cleaning, profiling	kg CO ₂ / m	1.30	Experience number from Ketenanalyse dijkbekleding met waterbouwasfaltbeton Van Oord Nederland B.V. BD4591-101-100 d.d. 2 december 2014
<i>Energy factors</i>			
Energy consumption bulk (un)loading	kWh / t	1.30	CE Delft, STREAM International Freight 2011
Energy content Diesel	MJ/l	36.0	http://nl.wikipedia.org/wiki/Benzine_en_diesel
<i>Exceuator</i>			
Bucket capacity	m ³	2.09	Liebherr R954C
(Un)loading time per bucket	h	0.05	expert judgment
Diesel usage	l/h	35	Experience number from Ketenanalyse dijkbekleding met waterbouwasfaltbeton Van Oord Nederland B.V. BD4591-101-100 d.d. 2 december 2014
<i>Diesel generator</i>			
Power	kW	25	Table 5-3 report
Efficiency	%	50%	expert judgment, https://nl.wikipedia.org/wiki/Dieselmotor
Load factor	%	50%	expert judgment
<i>Other</i>			
Natural rock density (no voids)	t/m ³	2.65	page 28 report
Natural rock density (including voids)	t/m ³	1.64	page 28 report
Transport distance from quarry to Fuvahmulah	km	1,350	page 57 report
Capacity large bulk carrier	DWT	7,500	Table 5-3 report
Capacity barge	DWT	1,000	Table 5-3 report
Transport distance barge	km	2.0	
Distance from harbour to stockpiling	km	0.5	Figure 5-6 report
Distance from stockpiling to site	km	2.8	Figure 2-3 and 5-6 report
Site length	km	2.65	Figure 2-3 report

Total amount of natural rock			
<i>Source: Table 5-4 report: Bill of Quantities for the envisaged seaward rock revetment (preferred alternative)</i>			
Item	Volume	Weight	
	[m ³]	[t]	
Primary armour layer: Rock boulders 300-1,000 kg	68,024	111,764	
Filter layer: Rock boulders 40-200 kg	21,817	35,846	
Core material: Quarry run	7,753	12,738	
Toe protection: Rock boulders 300-1,000 kg	27,661	45,447	
<u>Total</u>	<u>125,255</u>	<u>205,795</u>	
Excavation	9,813		
CO ₂ emissions per phase			
<i>Source: § 5.3.1 report: Construction phasing</i>			
Code	Construction phase	CO ₂ emission	
		[t CO ₂]	[%]
C4a	Sourcing of natural rock in quarry	885	9%
C4b(1)	Loading from quarry to bulk carrier	84	1%
C4b(2)	Transport from quarry to Fuvahmulah	7,779	81%
C4c(1)	Loading from bulk carrier to barge	84	1%
C4c(2)	Transport barge	13	0%
C4c(3)	Loading from barge to dump trucks	84	1%
C5(1)	Stockpiling with dump trucks	13	0%
C5(2)	Loading from dump trucks to stockpile	84	1%
C6/C7	<i>Transport to site and on-site processing</i>		0%
(1)	Excavation	26	0%
(2)	Cleaning of revetment footprint	3	0%
(3)	Loading from stockpile to dump trucks	84	1%
(4)	Transport to site with dump trucks	71	1%
(5)	Loading from dump trucks to site	84	1%
(6)	Placement of materials	329	3%
(7)	Profiling	3	0%
-	Genset for onsite electricity	25	0%
	<u>Total</u>	<u>9,650</u>	<u>100%</u>

ANNEX 7: MWSC LAB REPORTS

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
 FSN Building 5th Floor, Fuvahmulah, Ariyachimungu, Male', Maldives
 Tel: +9603333885, Fax: +96033384268, Email: wqa@mwsc.com.mv



WATER QUALITY TEST REPORT
 Test Report No: 301032/2016/07

Date: 22/08/2016

Customer Information:

Meeeco,
 G. Aachalange-1, 2nd Floor,
 Alif Nopafanu Mogu,
 Male'

Rep. of Maldives

Sample Description / Location	TEST NAME	UNIT
Sample Type: Sea water Sample Date: 17/7/2016 Sample Received Date: 19/7/2016 Test Acquisition Form No.: 042856/44 Sample No.: 825370 Date of Analysis: 22/7/2016	TEST NAME	UNIT

PARAMETER	ANALYSIS RESULT	UNIT
Physical Appearance	Clear	
Odour	3200	

Method: 100% (100% of the sample is tested)

Checked by:

[Signature]
 Alim Farooq
 Laboratory Executive

Approved by:

[Signature]
 Mohamed Eymen
 Senior Technical Officer

Notes:

Sampling Authority: See plating was not done by MWSC Laboratory
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 This test report is ONLY FOR THE SAMPLES TESTED
 - Information Supplied by the customer

*****END OF THE REPORT*****

Page 2 of 2

WQA/LAB/F-14, REV 05

Male' Water & Sewerage Company Pvt Ltd
Water Quality Assurance Laboratory
27B, FALGOL, 5th FLOOR, MALDIVIAN BUILDING, FALGOL, FALGOL, MALDIVES
 TEL: +960 432 1212, 2005 4458455 FAX: +960 432 1204 EMAIL: wqa@mwsc.com.mv



WATER QUALITY TEST REPORT
The Report No: 201002/016/NS

MOEWS
G. Abdulhameed, Eng. Officer,
Atoll Engineering Division
Min. of Fisheries

Customer Information:

DATE: 01/08/2016

Sample Description / Location	TEST METHOD	UNIT
Sample Type: Sea water Sample Date: 28/07/2016 Sample Location: 12°12' N 72°15' E Test Report Number: 201002/016/NS Sample No: 122576 Date of Analysis: 27/07/2016 PARAMETER: ANALYSIS RESULT	Total Suspended Solids (TSS) (mg/L)	mg/L
Method: Gravimetric Revised Method: 2010/01/01 Revised Method: 2010/01/01	Total Suspended Solids (TSS) (mg/L)	mg/L

Checked by:



Ahsan Farooq
Laboratory Executive

Approved by:



Mohamed Eymen
Senior Technical Officer

Notes:

1. Sampled water is analyzed by the laboratory.

2. This report shall not be reproduced without written permission.

3. This report is valid for 12 months from the date of issue.

4. Information supplied by the customer.

*****END OF THE REPORT*****

Page 1 of 1

WQA/NS/16, Rev 05



WATER QUALITY TEST REPORT
Test Report No: 301032/2016/08

Test Report No: 301032/2016/08

Customer Informations :

Meeco,
G. Apakage-1, 2nd Floor,
Alikilegefaanu Magu,
Male'
Rep. of Maldives

Rep. of Maldives

Date: 02/08/2016

Sample Description / Location"		Fuwahmulah ID- G-FU-0210	TEST METHOD	UNIT	Date:	02/08/2016
Sample Type"		Ground water				
Sample Date"		15/7/2016				
Sample Received Date		29/7/2016				
Test Requisition Form No.		900165447				
Sample No.		825571				
Date of Analysis		19/7/2016-24/7/2016				
PARAMETER		ANALYSIS RESULT				
Physical Appearance		Clear				
Biological Oxygen Demand (BOD ₅)		2				
		Visual				
		Water Method Code				mg/L

UNITS: mg/L: Milligrams per litre

Checked by:

Afnan Farooq
Laboratory Executive

Approved by:

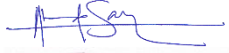
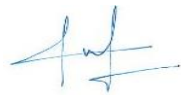
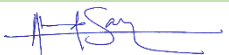
Mohamed Eymán
Senior Technical Officer

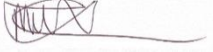
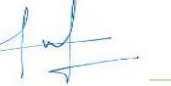
Votes:

Sampling Authority: Sampling was not done by MWSC Laboratory
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 Information Supplied by the customer

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ANNEX 8: DECLARATION OF AUTHORS

Chapter	Page Number	Names of Contributors	Consultant Number	Signature
1. Introduction	1	Ahmed Saleem Margriet Hartman Ali Hammadh	EIA 03/13 EIA T12/15	  
2. Project Description	19	Ahmed Saleem Margriet Hartman Lars Hoogduin Ali Hammadh	EIA 03/13 EIA T12/15	   
3. Legislative/Project Setting	48	Ahmed Saleem Margriet Hartman	EIA 03/13	 
4. Existing Environment	75	Ahmed Saleem Margriet Hartman Lars Hoogduin Ali Hammadh	EIA 03/13 EIA T12/15	   
5. Impact and Mitigation	206	Ahmed Saleem Margriet Hartman Lars Hoogduin	EIA 03/13	  

		Ali Hammadh	EIA T12/15	
6. Stakeholder Consultation	177	Ahmed Saleem Margriet Hartman Sofoora Kawsar Usman	EIA 03/13	  
7. Monitoring and Management Plan	258	Ahmed Saleem Margriet Hartman Lars Hoogduin Ali Hammadh	EIA 03/13 EIA T12/15	   
8. Recommendation and Conclusion	267	Ahmed Saleem Margriet Hartman Lars Hoogduin Ali Hammadh	EIA 03/13 EIA T12/15	   

ANNEX 9: PROPONENTS DECLARATION


ދިވެހިރާއްޖޭގެ ޖުމްހޫރިއްޔާ
ދިވެހިރާއްޖޭގެ ޖުމްހޫރިއްޔާ

Ministry of Environment and Energy
Male', Republic of Maldives.

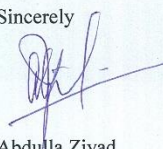
Date: 30 October 2016 No: 438-ECAS/203/2016/100

Mr. Ibrahim Naeem,
Director General,
Environmental Protection Agency,
Male', Maldives

Dear Mr. Naeem,

Sub: Declaration of the Proponent

As the proponent of the proposed project, we guarantee that we have read the report and that to the best of our knowledge all non-technical information provided here are accurate and complete.

Sincerely

Abdulla Ziyad,
Minister of State


Page 1 of 1

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