First Addendum

August 2018

EIA for the Proposed Sewerage Facilities at Maradhoo, Maradhoofeydhoo, Feydhoo, Hulhudhoo and Meedhoo, Addu City

PROJECT SYNOPSIS

Name of the Project: Proposed Sewerage Facilities at Maradhoo, Maradhoofeydhoo, Feydhoo, Hulhudhoo and Meedhoo, Addu City
Report Name: First Addendum to the EIA for the Proposed Sewerage Facilities at Maradhoo, Maradhoofeydhoo, Feydhoo, Hulhudhoo and Meedhoo, Addu City
Project Proponent: Ministry of Environment and Energy
EIA Consultant: Ahmed Saleem (MEECO)
EIA Addendum Date: August 2018

WEIGHTS AND MEASURES CONVERSIONS

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

LIST OF ABBREVIATIONS

ESIA	Environment and Social Impact Assessment
EMP	Environmental Monitoring Plan
EPA	Environmental Protection Agency
ES	Environmental Score
EPZ	Environmental Protection Zone
GHG	Green House Gas
GoM	Government of Maldives
IUCN	International Union for Conservation of Nature
MCA	Multi Criteria Analysis
MEE	Ministry of Environment and Energy
MHI	Ministry of Housing and Infrastructure
MMS	Marine Monitoring Station
MOFA	Ministry of Fisheries and Agriculture
MPA	Marine Protected Area
MSL	Mean Sea Level
MRC	Marine Research Centre
PPE	Personnel Protective Equipment
TOR	Terms of Reference

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PROJECT PROPONENT

The Project is proposed by Ministry of Environment and Energy, Maldives (hereinafter referred to as the Proponent). The proponent as the competent authority of the Project will be responsible for the implementation as well as post-project monitoring in accordance with the EIA addendum report.

The contact details of the Proponent is given below;

Ministry of Environment and Energy,
Green Building,
Handhuvaree Hingun, Maafannu,
Male', 20392,
Republic of Maldives.

DECLARATION OF THE CONSULTANT AND PROPONENT

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

Ahmed Saleem (EIA 03/13)
Signature:

Proponent
The Proponent’s declaration and commitment to undertake the mitigation and monitoring is given in **Annex 1**.

ސާރާ ޚުލާސާ

1. މި ރިޕޯޓަކީ އައްޑޫ ސިޓީގެ ފަސް ރަށް ކަމުގައިވާ ފޭދޫ، މަރަދޫ، މަރަދޫފޭދޫ، ހުޅުދޫ އަދި މީދޫގައި އެޅުމަށް ފަށާ ފާޚާނާ އިންޓަރނޭޝަނަލް ޑިވެލޮޕްމަންޓް (އައިޑީއޭ) ގެ އެހީގެ ދަށުން ނަރުދަމާ ނިޒާމް ޤާއިމް ކުރުމަށްޓަކައި، މަޝްރޫއުގެ އެދިހާރު މިނިސްޓްރީ އޮފް އެންވަޔަރަމަންޓް އެންޑް އެނަރޖީ އިން ތަޢާރަފްކުރެވުނު މަޝްރޫއުގެ ސަބަބުން ތިމާވެށްޓަށް އަސަރު ފޯރާނެ މިންވަރު ދެނެގަތުމަށް އެންވަޔަރަމަންޓަލް އިމްޕެކްޓް އެސެސްމަންޓް ރިޕޯޓެއް (އީ.އައި.އޭ ރިޕޯޓް) ހުށަހެޅުން ބައެއް އިތުރު މައުލޫމާތު ހިމަނައިގެން ތައްޔާރުކުރެވިފައިވާ އީ.އައި.އޭ އެޑެންޑަމް ރިޕޯޓެވެ. މި ރިޕޯޓް ތައްޔާރުކުރެވިފައިވަނީ، މަޝްރޫއުގެ އަމަލީ މަސައްކަތްތަކުގެ ތަފްސީލް ބަދަލުވުމާ ގުޅިގެން ކުރިން ހުށަހެޅި ޓެކްނިކަލް ސްޕެސިފިކޭޝަން (އެސް.ޓީ.ޕީ) އިމާރާތަށް ބޭނުންވާ ބިމުގެ ދައުރު ފަރާތަށް އިތުރު ގެނެސް، އެ އިމާރާތް ކުރިއަށް އޮތް ތަނުގައި ރިވަރސް އޮސްމޯސިސް ޕްލާންޓެއް ޤާއިމްކުރުމާއި މަސައްކަތްތަކާއި ފަރާތްތަކުގެ ބަދަލުތަކާ ގުޅިގެން ކުރާ ބަދަލުތަކަށް ޙާއްޞަ މަސައްކަތްތަކާއި ފަރާތަށް ކުރުމާއި، މިއާމެދު ތަފްސީލު ހުށަހަޅާ ރިޕޯޓަކަށް ދެކެވޭ.

2. މި ރިޕޯޓް ތައްޔާރު ކުރެވިފައިވަނީ އެންވަޔަރަމަންޓަލް ޕްރޮޓެކްޝަން އޭޖެންސީއާ އެކު 24 ޖުލައި 2018 ގައި ބޭއްވުނު މީޓިންގ ކުރުމުގެ ބައްދަލުވުމުގައި މަޝްވަރާކޮށް ތައްޔާރު ކުރި އަދި އިޖާޒަތު ދޭން ފެނިފައިވާ ޓާރމްސް އޮފް ރިފަރެންސާއި އެއްގޮތަށް ގެންދެވޭ މަސައްކަތެވެ.

3. މަޝްރޫއުގެ ދަށުން އިތުރަށް ކުރުމަށް ރާވާފައިވާ މަސައްކަތް ތަކަކީ ސަރުކާރުގެ ކަމާބެހޭ ސިޔާސަތުތަކާއި، ޤާނޫނާއި ގަވާއިދުތަކާއި ގައިޑްލައިންތަކަށް ފުރިހަމައަށް ފެތޭ ގޮތަށް ރާވާފައިވާ މަސައްކަތް ތަކެކެވެ.

4. މަސައްކަތް ހިންގުމަށް ރާވާފައިވާ ސަ ފޭދޫ އަކީ މަޝްރޫއު ކުރިއަށްދާ އައްޑޫ ސިޓީގެ ފަސް ރަށުގެ ތެރެއިން އެއް ރަށެވެ. ރަށުގެ ބިމުގެ ދަތިކަން ބޮޑުވާ ގޮތެއް ރަށުގެ ދުވާލުން ވަރަ 50 ހެކްޓަރުގެ ބިމެއް ހިއްސާވެއެވެ. ފޭދޫ އެސް.ޓީ.ޕީ ގެ މަސައްކަތް ކުރިއަށް ދަނީ ހިއްޔާ ސަރަހައްދުގެ ދުވަސް ފަރާތުގަވެއެވެ.

5. ބޮޑު ލުމުގެ މަސައްކަތަށް ހަރަދުވާނެ ކަމަށް ބެލެވިފައިވަނީ 45 ދުވަހެވެ.

6. ބޮޑު ލުމަށް ހަމަޖެހިފައިވާ ބަޖެޓް ހިލަ ބޭނުން ކުރެވޭން، ފޭދޫ އެސް.ޓީ.ޕީ އާ ދިމާލުން ފަރު ތެރެގައި 125 މީޓަރުގެ ދިގު މިނަށެވެ.

7. މި ރިޕޯޓް ތައްޔާރު ކުރުމަށް ކުރެވުނު ދިރާސާތަކުން އެސް.ޓީ.ޕީ އިމާރާތުގެ ދުވަން ގޮސްދޭތެރެ އުދައެގެ އަސަރު ފާރާ، ގޮސްދޭ ތަރުގެ ބޭއް ޖިރުމަށް ފަހު، ވެލިގަނޑު ބޯޅަ ފައިވާކަން ފާހަގަ ކުރެވުނެވެ. ފާރުގެ ދުވަން ފަރާތުން ބިން ހިއްކުމުގެ ކުރިންވެސް އެ ރަށު ލަނޑާ ގޮވާލި ގާތުން އުދައެގެ އަސަރު ފާރާ، ފުރަ ބޭރުވާ ރަށަށް ކަން ފާރަގަ ކުރެވިފައެވެ. ރަށުގެ ދުވާލުން ބިން ހިއްކާ ގުޅިގެން ހިއްލި ސަރަހައްދަށް ވަނީ އުދައެގެ އަސަރު ކުރަން ފަށާފައެވެ. ފޭދޫ އަށް ބޮޑުކަންކުރުވާ ޖީބީއިލޭ އައިލެންޑް ރިސޯޓް އެސޯސިއޭޝަނުން ރިޕޯޓުގައި ވެސް ވަނީ، ރަށް ހިއްކާ ގުޅިގެން އުދައެގެ އަސަރު ކުރުމުގެ ފުރުސަތު ބޭޖެ ވާނެ ކަމަށް ފާރަގަ ކުރަން ކޮށްފައެވެ. މިހެން ކަމުން، ނަރުދަމާ ނިޒާމުގެ އެންމެ ބުރިއަކު އެއް

ކޮމްޕެނީތަކަށް ކަމަށްވާ އެސް.ޓީ.ޕީ އިމާރާތަށް ކުރިއަށް އޮތް ތަނުގައިވެސް އުޅުމުގެ އަސަރުކުރާނެ ގޮތުން ފިޔަވަޅު ކަމަށް ބޭނުންވެއްޖެ. މިގޮތުން އެސް.ޓީ.ޕީ ގެ ހިންގުމަށް ބޭނުންވާ އަގުބޮޑު އަސަރުކުރެވޭ ތަން، ބޯޅަ ގޮތުން ތިމާވެށި، ފާރަވެރިކަމާއި ނިޔަލަތް ހިފެހެއްޓުމުގެ މަސައްކަތް ކުރާނެ ކަމަށް ބަލައިފައެވެ.

8. މި މަޝްރޫޢުގެ ދަށުން އިތުރަށް ކުރަން ރާވާފައިވާ ތިން ބުރުގެ މަސައްކަތާ ގުޅިގެން ތިމާވެށްޓަށް ނުރައްކާ އަސަރު ކުރާނެ ކަމަށް ވަނީ ފާހަގަ ކުރެވިފައެވެ. މަސައްކަތަކީ ބޭނުންވާ ބޮޑު ހިލަ ރަށްގަޅުކޮށްވަޑައިގަތުން ހިތަދޫގެ ސަރަހައްދުގައެވެ. އެހެންކަމުން ހިލަ ފުދޭ އެއް ގެންދިއުމަށް އެއްގަމު މަގުން އެއްޗެހި ލިބޭނެ ކަމަށް ދަނޑު ފަޅު ކުރަން ޖެހޭއެވެ. އެކަމަށް ބޭނުންވާ ހަމަ އުފެއްދުމަށް އެންމެ ތަކެތި މުސްތަޤުބަލްގައި ބަދަލުއައުމަށް ގޮތުގެ ރާމާ، އަޅާ، ހިމާޔަތް އުފެއްދުމެވެ. އެހެން ކަމަށް ތިން ފަރުމާ ކުރުމުގައި ތިމާވެށީގެ މިސްރާބު ހޯދައިދޭ މަޝްވަރާ

ދަށުން ހިފަހައްޓާނެ ގޮތަށް ތަނަވަސް ގޮތުން މާލީ ފަރާތުން. ހިމާ ބައްލަވައި މުސްތަޤުބަލް ފަރުމާކުރާ ވިޔަފާރިތައް ދެމެހެއްޓުމަށެވެ. ދަށުގައި ހިމާ ޖަމާކުރާ ސަރަހައްދަށް މިތަން ޤާނޫނީ އަދި ހިންގުމުގެ ބޭނުންތަކަށް މުއްދަތު ދުވަސް އެދި މަޝްރޫޢު ހިންގާ ސަރަހައްދު ދުރުގައި ހިސާބަކަށް ވުރެ މުއްދަތު ކަމެއްވެ. މަސައްކަތްގެ ތަޖުރިބާ އާންމު ކުރުމާއި،

ނަރުދަމާ ކުރީގައި އަދާކުރަން ބޭނުންވާ އަގުގައި ހަމަޔަށް، އަދި ކުރި ކުރި މުޤައްރަރު ނިޔަލަތް ގޮސްގެން ފައިދާ ހުރުމަކީ ނަތީޖާ ބަލާ މަސައްކަތުގެ ސަރަހައްދު އަސްލު ހިސާބު ދަށުން ގުޅުމާ ބޭރު ހިފާ ސަރަހައްދު ގައިޑްލައިން ރިޢާޔަތްކުރާ ވަސީލަތް

މުޤާރަނާ ސަރަހައްދު ގޮތަށް ނިޒާމީ ގޮތުގެ ޙައްލުތަކެއް ޤާނޫނީ ފަރާތަކީ ދަށުއެވެ. ތިން ބުރުގެ ސަރަހައްދު ގޮތުގެ ރައްޔިތުން ހިމެނޭ ގޮތަށް ވިޔަފާރި މުއައްސަސާ ދަށުން ހުށަހެޅުނެވެ. މިކަން ވިސްނުމާ ދެކެމުން

ގޮތުގައި ތިރީގެ ފަރުމާކުރެވޭ ބަޔާ ނިޒާމީ ތިމާ ބޭނުންތަކަށް ޙާލަތު ހިސާބުގެ ގޮތާއި ރަށްތަކުގެ ވިޔަފާރިތަކާއި ގުޅިގެން ހިންގާނެ ތަރައްޤީއެވެ. ނަމަވެސް މަސައްކަތު ކުރުމަށް ދަތިވާ ސަރަހައްދުގައި ހިފެހެއްޓި ފަރުމާ ދަށު

ކުރުން މިކަމުގެ ސަރަހައްދު ތިމާވެށްޓާ ކުރި އަސަރު ކުރާ ކަމަށް ފާހަގަ ކުރެވެއެވެ. ތިރީގެ ސަރަހައްދު ގޮތުގެ ދަތުރު، ތިރީގެ މަސައްކަތް ގޮތުގެ ފުރިހަމަ ސަރަހައްދު މުދާ އެއްވަރުގެ ބޮޑު ކުރެވޭނެއެވެ. ތިރީގެ ސަރަހައްދު ތިރީގެ މަސައްކަތުގައި ހުރި މުޤާރަނާ ތިމާވެށީގެ ގޮތުގެ ފަރުމާކޮށް ދާއިރާ އެކަށީގެންވާ ކަމުގައެވެ.

ތިރީގެ ސަރަހައްދު ދަށުގެ އެއްސޮރުކުރުމަށް ދުރު އާއިލާތަކުން ބޮޑުވާ ސަރަހައްދު ހިމާޔަތް ނިކަން އެއް ގޮތުގެ ސަރަހައްދު ދަށުން ކުރުމަކަށް ނިވާކަން ކަމަށް ގެނެސްދިނުމަށް ނިޒާމުތައް ފުރުޞަތު ނިކުމެއެވެ. ތިރީ ފަރުމާގެ ގޮތުގެ ސަރަހައްދު ގޮތުގެ ބެލެހެއްޓުމަށް ސަރަހައްދުގެ މުއައްސަސާތަކާ ކަމަށް ތިރީ ފަރުމާ ކުރުމުގައި ވިޔަފާރި ބޭނުން ފުރިހަމަ ދަށު ފަރުމާކުރުމަށް ދެކެނެވެ. ފަރުމާކުރާ އެއްގަމު ސަރަހައްދު ކުރުމަށް ފަރުމާގައި ގައުމީ މުސްތަޤުބަލް، ދާއިރާގައި މަސައްކަތުގެ މުޅިރަށުގެ ހިމާޔަތް ސަރަހައްދު ބަޔާން އެހެނިހެން ގެ ދުރުކުރާ ބޭނުމަށެވެ.

9. ފާހަގަކުރެވިފައިވާ ތިމާވެށީގެ މަސްއޫލިއްޔަތު ގެންދާ ކުރެވޭ މިންގަނޑުތައް ބެލެހެއްޓުމުގެ ހިދުމަތްތަކުން އެކަށީގެންވާ ފިޔަވަޅު އެޅުމަށް ބާރުދޭ މަސްއޫލިއްޔަތު ކަމަށް ފެންނަނީ، ރައްޔިތުން ފާހަގަ ކުރެވިފައިވާ ތިމާވެށި ރައްކާތެރި ކުރުމުގެ ފިޔަވަޅުތައް އަޅައިގެން މަޝްރޫޢު ކުރިއަށް ގެންދިޔުން ކަމަށް މުރާޖަޢާކުރުން ނިންމާފައިވެއެވެ.

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1. INTRODUCTION

1.1PURPOSE OF THE EIA ADDENDUM REPORT

Following the approval of the EIA by the Environmental Protection Agency (EPA) of the Maldives, the proponent is in the process of conducting the construction works of the titled project. The proposed Sewerage Treatment Plant (STP) in one of the project islands, S. Feydhoo, is being constructed on the southern end of the island at the newly reclaimed area. The site is located east of the uninhabited island Dhigihera which is now part of the reclaimed land of Feydhoo. Currently the coastal protection of coastal region of the reclaimed land is a network of groynes, with the western side of the reclaimed land protected by onshore revetment. Due to the reclamation bringing the land closer to the reef edge, the proposed STP site is in the flooding zone of offshore swells and *udha* events. The STP being one of the critical components of the sewerage system, damage from wave induced flooding on the premises can lead to loss of critical infrastructure and investment, jeopardising the smooth operations of the sewerage system.

Therefore, the proponent has proposed to construct a detached breakwater along the coastal region adjacent to the STP site as shown on **Annex 3** to provide protection from future swell surges and *udha* events.

Since construction of a breakwater as a shore protection method had not been previously included in the scope of project, this EIA addendum report is prepared to incorporate additional works in the project's impacts assessment and to obtain approval for the proposed additional works and to meet the EIA regulation 2012/R-27. Upon evaluation of the proposed works, a scoping meeting was held at EPA to finalise terms of reference for the impact assessment as a result of construction of the shore protection at the shoreline adjacent to S. Feydhoo STP. Since the proposed works are limited to only shore protection and confined to the coastal areas the TOR was approved to reflect it as detailed in **Annex 2** of the report.

The EIA addendum report aims to document most up-to-date condition of the project area and assess the impacts associated with construction of the breakwater by exploration of alternatives. As such, all activities and impacts has been explored in the report in line with the approved TOR.

The report shall be interpreted as an extension of the approved EIA report for the project. It shall not be considered as a standalone document. As such, it encompasses only data and evaluations with regard to the additional works proposed in the report.

2. DESCRIPTION OF THE PROJECT

2.1 COASTAL PROTECTION WORKS

The proposed coastal protection works under the project for Provision of Sewerage Facilities at Maradhoo, Maradhoofeydhoo, Feydhoo, Hulhudhoo and Meedhoo, Addu City, is located in the island of Feydhoo. S. Feydhoo island (00° 40' 57" S 73° 08' 07" E) lies in the most southern atoll of Maldives, Addu Atoll and is the southernmost inhabited island of Maldives (See **Figure 1).**

The coastal protection works proposed at the S. Feydhoo STP site include construction of a submerged rock boulder breakwater of 125 m length in the area illustrated in **Figure 2.** The proposed breakwater is an emerged breakwater with a crest 0.5 m from the sea level and a slope of 2:3 at the seaward side and a slope of 1:1 at the landward side. The width of the crest is proposed at 4 m. See **Annex 5** for details.

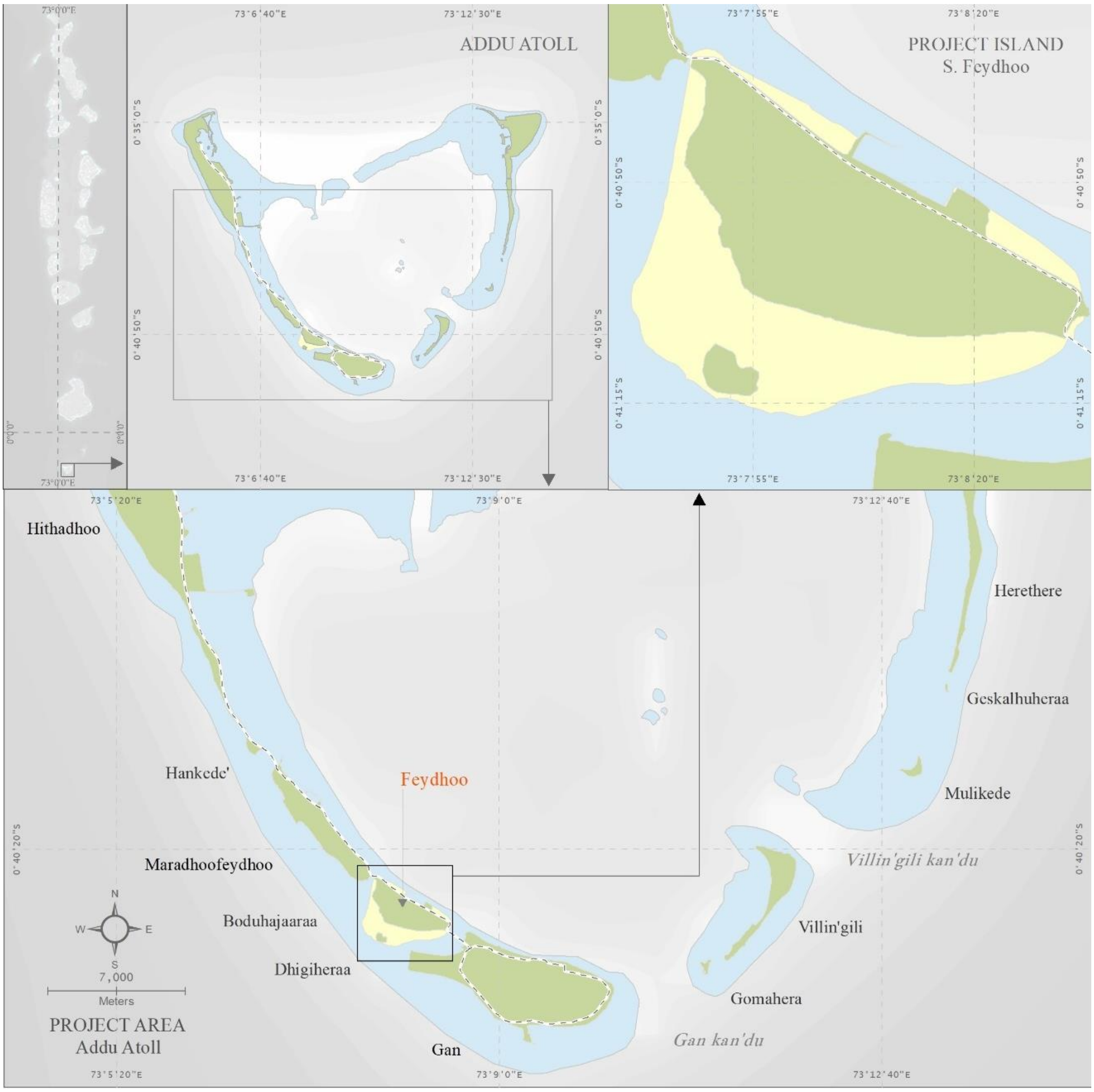


Figure 1 Project Location

2.2 SITE LOCATION

The proposed coastal protection works is located at the southern end of the newly reclaimed area of S. Feydhoo. The works are to be conducted at the south of the STP at 0°41'16.39"S, 73° 7'53.96"E. See **Figure 2** for details.

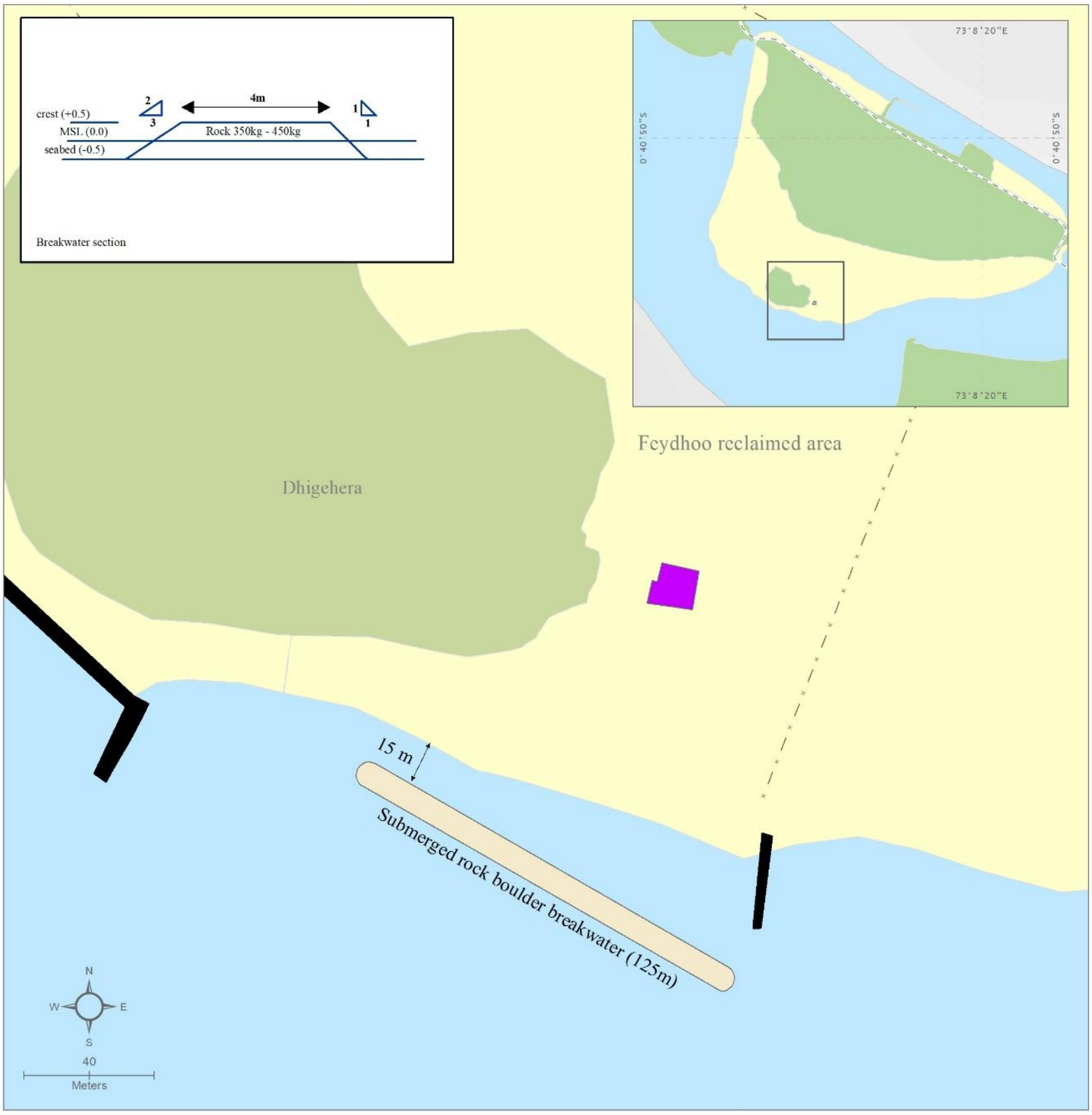


Figure 2 Coastal Protection Works Site Location and Proposed Concept

2.3 PROJECT BOUNDARY AND IMPACT ZONE

The primary impact zone of the proposed additional works will be the immediate coastal zone of the STP location including the beach, adjacent STP as well as the surrounding marine areas as shown in **Figure 3.** In addition, due to transportation of rock boulders for the purpose of this project from S. Hithadhoo port area, the roads used for the transportation are included in the primary impact zone.

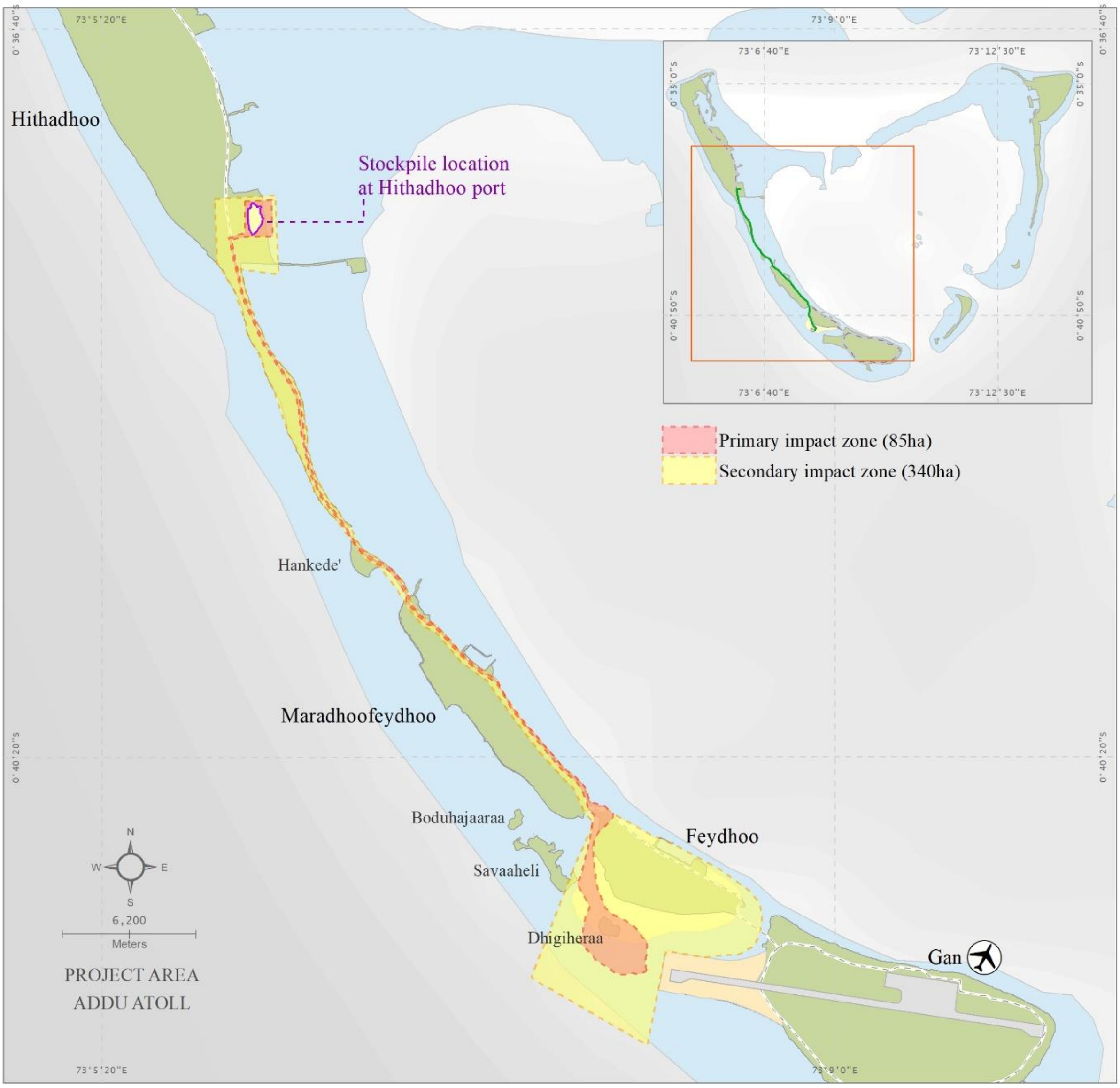


Figure 3 Coastal protection works impact zone

2.4 DURATION AND SCHEDULE

The proposed coastal protection works is planned to be carried out in 45 days, within the duration of the main project. Proposed works include transport of rock boulders from Hithadhoo port area to Feydhoo STP site, conducting in-survey to set out the location of the breakwater, construction of the steel frame and placing of armour rocks. A tentative schedule of the work is found in **Table 1.**

Table 1: Tentative schedule for the proposed coastal protection works

	Duration (Weeks)						
	1	2	3	4	5	6	7
Mobilization							
In survey							
Transport of rock boulders							
Preliminary site works							
Construction of steel frame							
Armor rocks levelled and placed to given profile							
Out survey							
Demobilization							

2.5 WORK METHOD FOR COASTAL PROTECTION

Following is the proposed work method for the proposed coastal protection works. The contractor shall follow the given methodology as complete the construction as per final detailed design provided.

2.4.1 Machinery

Due to the small scale of the proposed works, a high number of machinery or vehicles are not required. Contractor will utilise existing machinery on the work site for the purpose of this additional works. The following machinery will be used for the additional works:

- 1 Excavator
- 2 Dump trucks

2.4.2 Transport of Materials

First part of the coastal protection works will involve transporting the rock boulders from Hithadhoo port site to Feydhoo STP site. The main material needed for this work is rock boulders and the required material quantity is now available on Hithadhoo port site. The excavator will load the rock boulders to truck and the truck will transport the material to Feydhoo STP site. Once all the rock material is delivered to Feydhoo STP site, the excavator will move to Feydhoo STP and start construction of the breakwater.

2.4.3 Material unloading, stockpiling and storage

Material unloading will be done using excavator. Health and safety measures stated in **Section 2.7** shall be followed during unloading and stockpiling. Location to be used for stockpiling of the material is shown in **Figure 4.**

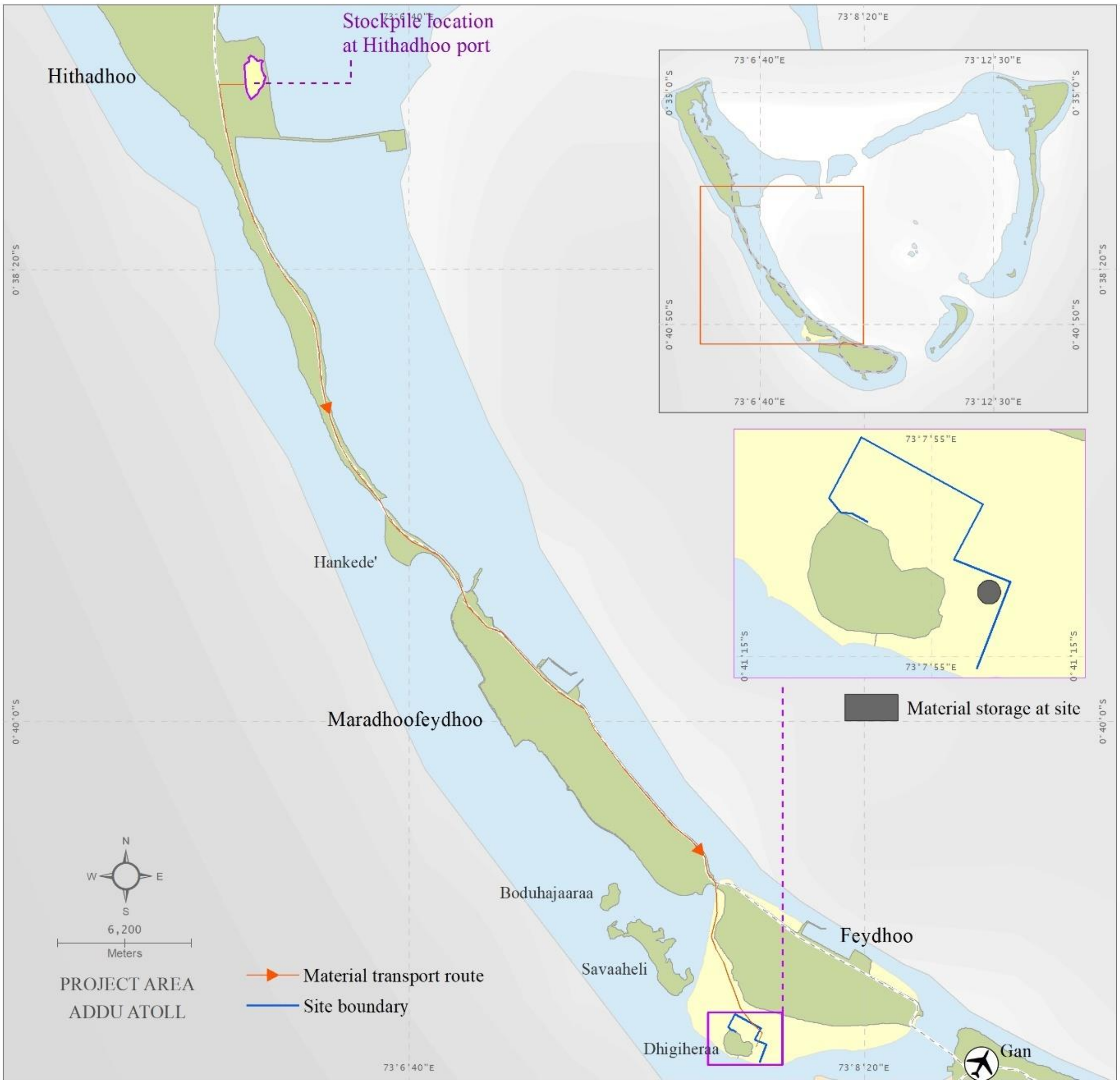


Figure 4 Material transport route and stockpile location for coastal protection works

2.4.4 Steel Frame

Steel frames using G.I pipes will be welded and formed according to the shape of the breakwater. The welded frame will represent the cross section of the breakwater with accurate crest width, crest height and side slopes. The frame will be installed at 10m intervals and rock boulders will be filled between the frames until a uniform cross section is completed between each frame. Once all the rock boulders are placed in position, levels will be measured at 3m intervals and any deviations will be corrected.

2.4.5 **Core Rock**

Core rock will be placed on the geotextile according to the lines, levels and dimensions shown in the drawings. Core rock will be placed with care in order to not cause any tear of the geotextile.

2.4.6 **Toe Rock**

Toe rock will be placed into position according to the lines, levels and dimensions shown in the drawings. Each toe rock will be individually placed in such a manner that each rock firmly rests upon the layer below and is in contact with adjacent armour, toe or core rock such that it is securely held in place.

Rocks will be lowered into place and not dropped. When working on the beach, machine operatives will take awareness of ground conditions. All works will be carried out at low tide.

2.4.7 **Armour Layer**

Armor rocks will be placed progressively beside and on top of core and toe rocks to the lines, levels and dimensions shown in the drawings. The hydraulic excavator is provided with a sling or chain in which the armour unit can be lifted into place. Each armour rock will be individually placed in such a manner that the rock firmly rests upon and does not displace the layers below.

Placement will commence at the toe and proceed upwards towards the crest. The assistance of divers will be used for the placement of rocks under water. Placement above the water line is visually by the operator and a rigger, done without physical interaction between the rigger and the armour rock.

2.4.8 **Temporary Facilities**

No temporary facilities will be constructed for the purpose of the proposed coastal protection works. Equipment not in use will be stored inside the existing Feydhoo STP work site. Additional workers required will be housed in existing facilities.

2.6 WASTE MANAGEMENT

As the proposed coastal protection does not involve major construction works, construction waste generated are anticipated to be low. Typical construction waste is anticipated. Sections below describes management of biodegradable, non-biodegradable and hazardous waste generated during construction phase. Waste will be temporarily stored inside the work site, before being transported to the nearest waste management facility in S. Hithadhoo (See **Figure 5**). The vehicle transporting the waste shall follow the route shown in the figure and avoid transportation within the residential zone of the islands.

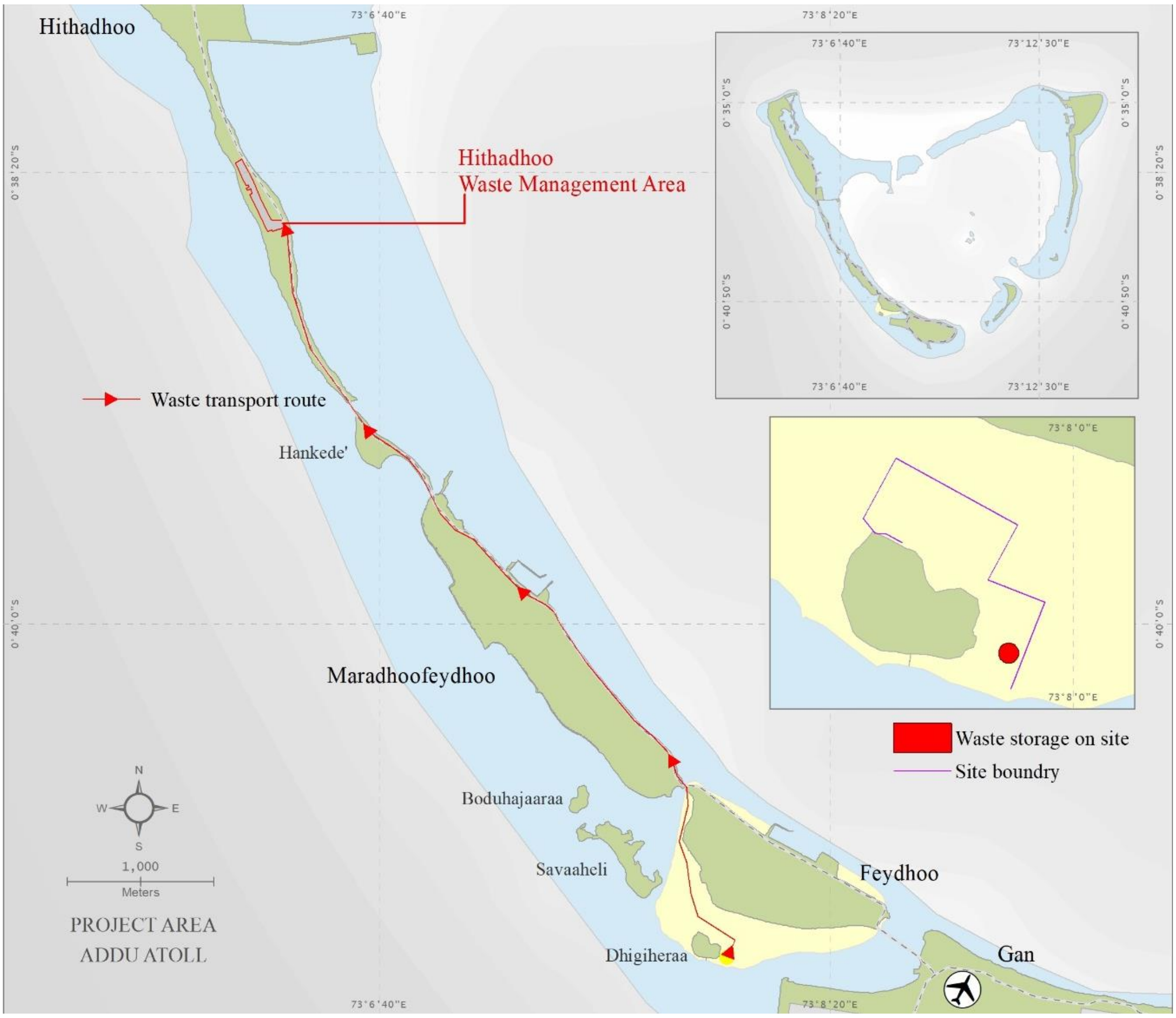


Figure 5 Waste storage and transport route for the coastal protection works

A. ***Biodegradable waste***

A large amount of biodegradable waste is not expected to be produced during construction work. There is no vegetation clearance within the scope of works therefore no green waste will be produced.

Food waste (which has been identified as the main component of municipal waste generated in the island) generated during construction is expected to be low. Food waste shall not be discarded into coastal areas as this could attract pests.

The next form of bio-degradable waste generated during construction phase includes human waste. These waste shall be managed using the existing septic systems of S. Feydhoo.

B. ***Non-biodegradable waste***

The amount of non-biodegradable waste generated during the operational phase is expected to be low. These will most likely be wrappings, steel/glass leftovers and other municipal waste generated at the construction site.

All non-biodegradable waste will have to be collected and transported to the nearest waste management facility for proper disposal. These waste shall not be buried on the island and shall not be discarded into the lagoon or coastal area.

F. Hazardous waste

During construction hazardous waste will mostly come from machineries, vehicles and tools in the form of waste oils, solvents, used batteries mainly used for the heavy machineries and vehicles. The quantity of hazardous waste generated will be moderate. In order to manage these, waste will be sealed in labelled containers and will be stored on a hard surface before being transported to the nearest waste management facility. It is essential to ensure that hazardous waste is fully contained and transported as quickly as possible. It is recommended to install signs identifying hazardous waste storage area and to seal it to prevent access.

2.7 HEALTH AND SAFETY MEASURES

In addition to general occupational safety and health guidelines set in the EIA, specific risks and mitigation actions for the proposed coastal protection works are detailed below.

Table 2: Health and Safety Risks and Mitigation for Coastal Protection Works

Health and Safety Identification	Action
Operator and machinery fall into water	• Ensure all machinery operators are suitably qualified, experienced and familiar with site
Tipping rock / armour	• Identify flat, firm and secure area for tipping / unloading rock • Tip / unload rock in the nominated secure area from flat firm surface with a spotter • Inspect truck trays for visible damage during works
Lifting and placement operations	• Implementation of safe working practices for the proper lifting and placement of rocks and armour units.
Slipping on rock / armour	• No site personnel to walk on rock unless placed and secure • All site personnel to take reasonable caution on wet rocks
Falling of rock / armour	• No site personnel to be beneath or below rock • Ensure all rock stockpiles stable during the works and secure at the end of the day • Limit stockpile of rock on site
Traffic accidents	• Ensure all machinery operators are suitably qualified, experienced and familiar with the site • Secure the load during transport • Fencing and signing of the site area • Ensure appropriate Personal Protective Equipment on site • Induction of all workers and accompaniment of all site visitors

2.8 PROJECT RISKS

This section addresses foreseeable risks that may be associated with the project. Project risks have been detailed in **Section 5.10** of the EIA document.

Table 3 below summarises the additional project risks related to the proposed coastal protection works.

Table 3: Additional project risks and management

Type of risk	Risk	Risk significance	Cost driver	Description	Risk Management
Administrative risks	Approvals and environmental clearance	Moderate	Overall project cost	Obtaining necessary approvals have been found to be time consuming which may cause delays to projects. Required approvals for the current project include, approval of the EIA addendum.	Ensuring that the proponent, consultants and designers fully comply with regulations and ToR set forth by the EPA.
	Access risks	Low	Overall project cost and duration	The proposed site is highly accessible.	N/A
	Social	Low	Overall Project	Noise complaints, risk of accidents during transport and construction	Following mitigation measures proposed in **Section 7**
	Cultural/archaeological/ heritage	Low	-	N/A	-
	Environmental impact on the project	Moderate	Construction cost	Prolonged unfavourable weather conditions, incidents of swells, high winds. The proposed works are in the coastal zone of the island.	Weather related impacts are difficult to completely avoid. However, given the nature of the works, weather factor shall be seriously taken into account to minimise the risk. Work could be planned to avoid months of strong wind and wave conditions. Following mitigation measures proposed in **Section 7**

Construction Risk	Quality of work	Low	Construction cost	Careless workmanship and poor quality, could have economic and environmental implications. However, since the proposed work has a simple construction method, risks related with work quality are low.	Qualified site supervisors shall be on site at all times when the work is in progress. Quality control measures should be implemented during construction. Environmental monitoring and site monitoring shall be undertaken routinely as describe in **Section 9.** Construction standard and specifications shall be met by the contractor.
Construction Risk	Labour and material availability	Low	Overall Project Cost	These risks may arise due to unavailability of spare parts, replacements, input materials for the operation, labour etc. The major resource of the project which is rock boulders are already available in Addu City. Therefore this is deemed a low risk.	All major resources shall be made available on site before the work commences. Materials shall be ordered beforehand and inventory of materials shall be monitored. Work sequence proposed in **Section 2** shall be followed

2.9 PROJECT INPUTS AND OUTPUTS

The table below elaborates the approximate amount of additional resources that will be required for the proposed coastal protection works and estimated output. The main inputs include workers, fuel, water, construction materials and machinery as well as chemicals.

Table 4: List of additional inputs into the project

Input	Type	Use	Estimated Amount	Means of obtaining the resources
Workers	Local and foreign	Vehicle and excavator operators. Construction of breakwater	5-10	Procured from project island
Fuel	Diesel	Used for equipment and machinery	Approx. 50 l/day	Procure from local suppliers
Water	Groundwater from existing wells for non-potable use	Temporarily used for cleaning purposes	Average 100 l/p/d	Groundwater wells present in the island

Rock boulders	Rock boulders of single size / weight ranger	Construction of breakwater	Approximately 625 m^3	Rock boulders are currently stockpiled at S. Hithadhoo port area
Steel	Steel GI pipes	Construction of breakwater frame	Approximately 50 m steel GI pipes	Procure from local suppliers.

Table 5: List of additional outputs from the project

Output	Source / Type	Use	Amount	Means of managing
Breakwater	-	Provide coastal protection to STP from swells and *udha*	1	N/A
Waste	Construction waste	Pollutant	Moderate amount of waste	Transported to nearest waste management facility
	Sewage	Pollutant	Approx. 180 l/day/person	Existing septic tanks in the island
	Municipal waste	Pollutant	1.7 kg/person/day	Transported to nearest waste management facility.
Hazardous waste	Empty fuel/lubricant drums, used oil/air filters, scrap batteries, vehicle parts and waste oils/grease, spent solvents and possibly spent acid/alkali from batteries maintenance.	Pollutant	Approx. 10 -20 l	Shall be sealed and stored and transported to nearest waste management facility.
Municipal waste	Workers	These are classified as human waste generated by the workers.	Approx. 180 l/day/person	Existing septic tanks will be used to manage municipal waste.
Green House Gases	Transport of rock boulders and construction of breakwater	-	Direct and indirect emissions from transport, machinery and material production	See **Section 7**.

Noise	Construction work. Equipment such as excavators produce noise in the range of 73-96 dBA	-	60-80 dbA eq within 5 m of construction site	See **Section 7**.

3. LEGISLATIVE AND REGULATORY CONSIDERATIONS

2.5 INTRODUCTION

This Chapter highlights relevant legislative framework applicable to the proposed project. An institutional mapping and analysis was conducted in **Section 4** of the EIA document, and as this addendum is considered part of the initial document, the analysis has not been included in this report. Relevant policies and conventions are also highlighted in the EIA document. No additional permits will be required to undertake the works. All legislative and regulatory conditions described in **Section 4** of the EIA report shall be fully complied during construction phase.

The chapter describes any additional legislation, regulations, and standards that are relevant and applicable to the Project. 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.

Table 6: Additional 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
Regulation on Sand and Aggregate Mining (2000)	No locally mined sand or aggregate will be used for the construction purposes.
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 2.6** 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	No minors will be allowed to work in the Project

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	

4. EXISTING ENVIRONMENT STUDY METHODOLOGY

4.1 INTRODUCTION

This section of the report provides descriptions of the methods deployed to collect data regarding the existing natural and socio-economic environment. 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. A team from MEECO travelled to S Feydhoo from 28th to 29th July 2018 for conducting surveys for the EIA addendum report.

4.2 SEAWATER QUALITY AT COASTAL PROTECTION SITE

Water quality was measured in situ using *Horiba* Multi Parameter Water Analyser Parameters tested include Temperature, pH, Turbidity(NTU), Dissolved Oxygen (mg/L), Electrical Conductivity (µs/cm), Salinity (ppt). The locations seawater quality are given in **Figure 6.**

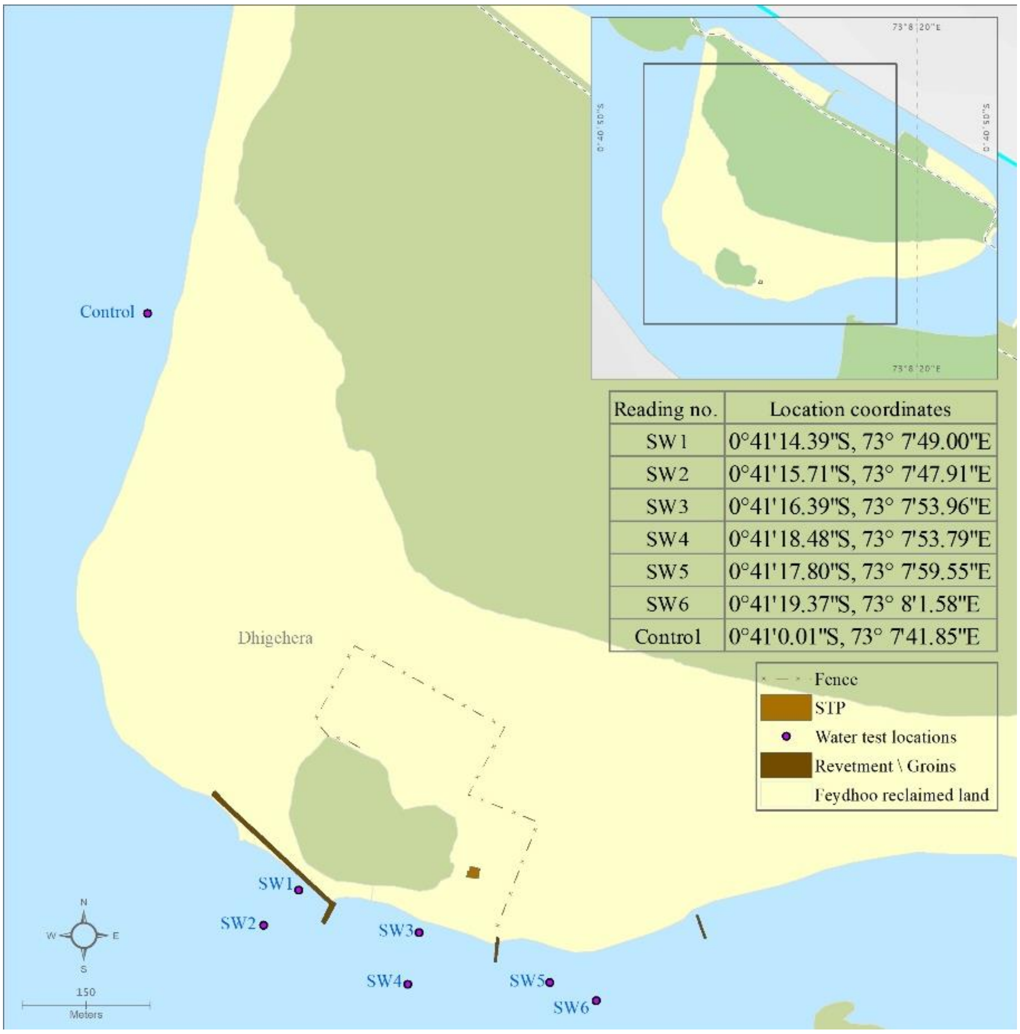


Figure 6: Sea water sampling locations

4.3 CLIMATE CONDITIONS

Climate conditions at the project site was assessed after compiling 37 years of weather data for the period1978-2015 for S. Gan International Airport obtained from planning.gov.mv, (2016). Gan was chosen as it was the nearest weather station to Feydhoo. The weather station at Gan is maintained by the Maldives Meteorological Service (MMS)

The statistical data was analysed for the following:

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

4.4 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. Bathymetry of the area was also done using GNSS RTK system with spot heights taken on the shallow reef flat of the project area. Handheld echo sounder with dinghy was not used in the case of this study, as the reef flat was too shallow for such an exercise.

4.5 CURRENTS

Lagoon current was measured by conducting drogue tests at the project site. Drogue tests were carried out using a GPS tracker placed inside purposely built case which was left at the sea for at least 20 minutes. The tracker recorded the speed and position data which was later analysed using software to determine surface current direction and speed at the time of data collection. To obtain more concrete data, measurements need to be taken for a longer period of time. Current measurement locations are given in **Figure 7.**

4.6 WAVES

The offshore wave data for the study was obtained from National Ocean and Atmospheric Administration, US (NOAA). NOAA uses a third-generation wave model named WAVEWATCH III developed by NOAA and National Centres for Environmental Prediction (NCEP). WAVEWATCH III is based on models developed by TU Delft and NASA Goddard Space Flight Center, which are WAVEWATCH I and II respectively.

Current and hindcast data is available for download at the NOAA website as gridded binary (GRiB) files. The data was extracted and analysed using Matlab. The wave data obtained from NOAA include significant wave height Hs, Peak wave period Tp, Peak wave direction θw.. This hindcast data is available as a 3 hourly time series. The data was obtained for a 1 year period, which was then be used to analyse the various aspects of offshore waves for the region.

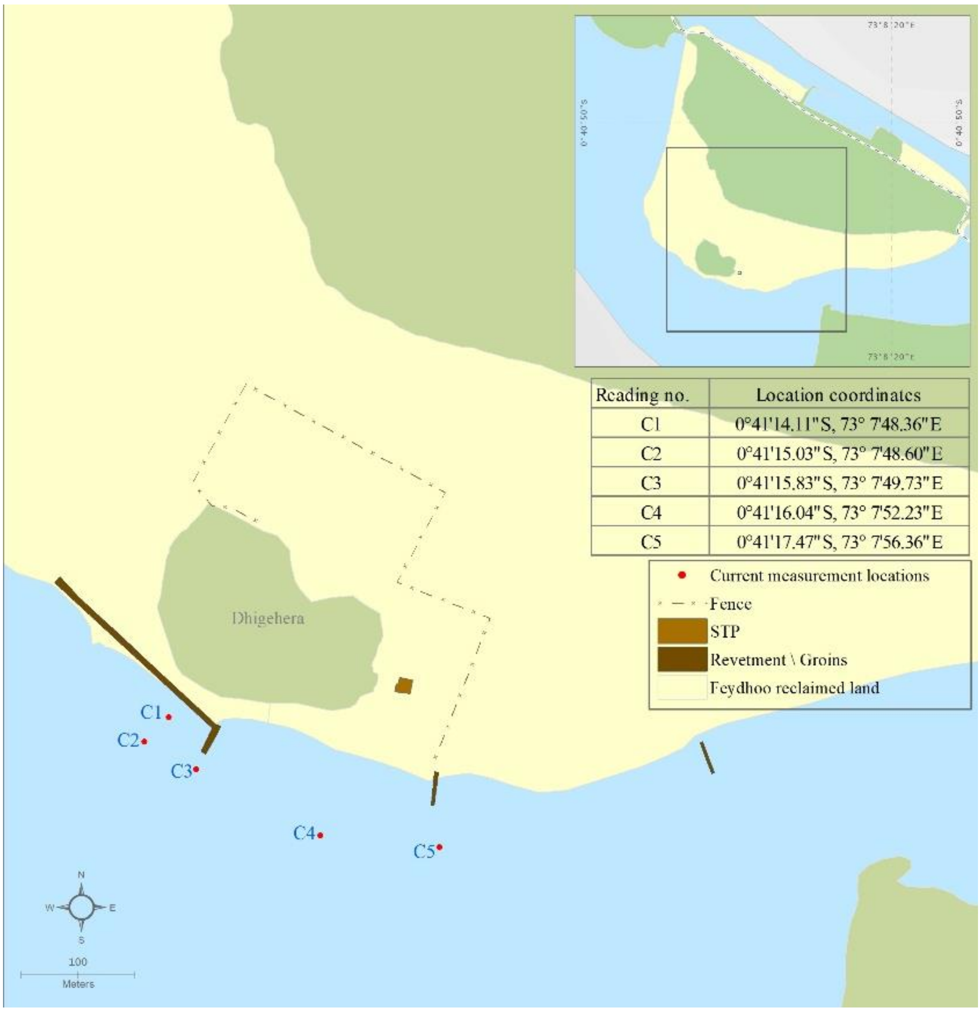


Figure 7: Current measurement locations

4.7 MARINE SURVEYS

Marine environment was surveyed to assess and obtain baseline data of the existing marine environmental conditions. Major components of the marine ecosystems surveyed are the reef-flat, benthic dwelling and the fish communities. The findings of the surveys were used for impact evaluation and mitigation during the proposed development.

Marine environment at the project area was studied via visual observations carried out during the site visit. The site was studied during hightide and low tide across a span of two days.

Qualitative studies of various fish species were studied by filming timed swims carried out in the area. The camera was held at a uniform angle during the timed swim. The videos taken were later analysed to assess fish species and their relative abundance. Qualitative categories were assigned to the identified fish species.

The photographs and videos obtained from the survey location were later analysed to identify the type of fish species using (Kuiter, 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 7**

Table 7: 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.

5. DESCRIPTION OF THE ENVIRONMENT

5.1 PHYSICAL ENVIRONMENT

5.1.1 Climate

Detail descriptions of the existing study methodology are provided in **Section 8** of the EIA report. This report will further study the coastal protection works related components of the climate, which include wave climate and especially look into studies done on S. Feydhoo. This includes the Detailed Island Risk Assessment (DIRAM) study done on Feydhoo.

As is the norm in Maldives, Addu Atoll experiences two major monsoons, North East and South West. As per data from Maldives Department of Meteorological Service. The direction of the wind during North East monsoon is predominantly from the north east and changes to south west direction during the South West Monsoon. As the site location is at the south western side of the Feydhoo, the STP location would be the most vulnerable from wind waves during this monsoon. In addition, works conducted during South West monsoon would require careful planning in order to avoid the health and safety as well as project risks detailed in the **Sections 2.7** and **2.8**.

Data collected at the airport island S. Gan between 1992 and 2012 shows that mean annual rainfall for S. Gan is at 2,218 mm. This is higher than the mean annual rainfall for Male' and Hanimaadhoo for the same period, which are at 1,966 mm and 1,799 mm respectively. The highest mean rainfall recorded includes October, December and May.

The northeast monsoon is classified as the dry season and brings less rainfall and higher, high temperatures and higher low temperatures while the opposite is observed for the Southwest monsoon which is the wet season. The average high and low temperature was found to be extremely similar between the southern, northern and central atolls of the Maldives. (See **Figure 8)**.

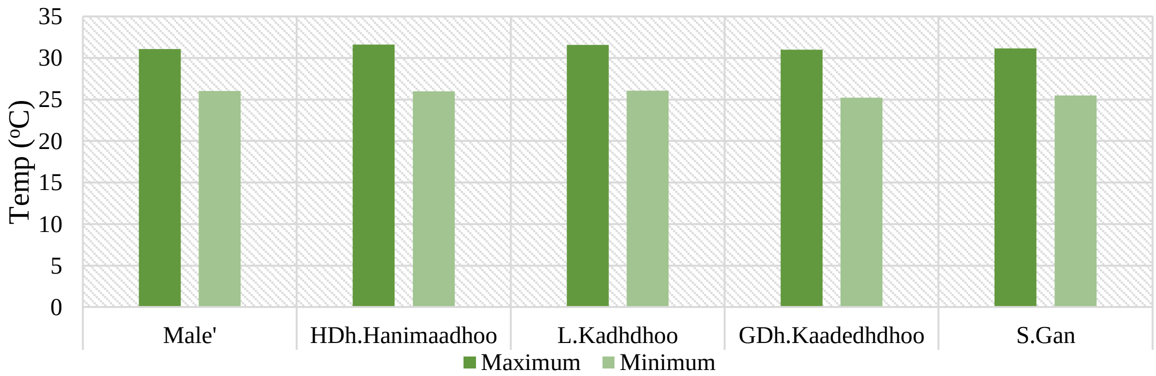


Figure 8 High and low temperature variance between atolls of the Maldives

Maximum high temperature and minimum low temperatures logged for the past 38 years at Hulhule' island is used for the purpose of this study. The daily mean high and low temperature throughout the thirty-eight-year period was found to be very consistent with fairly small variations. Temperature analysis of the past 38 years showed that temperature gradually increases at the start of northeast monsoon and reaches a peak at around April, and the mean yearly high temperature for the past 38 years was 30.9 ^{0}C**.** The mean yearly low temperature for the past thirty eight years was 24.7 ^{0}C.

A. Waves

Wave propagation and wave patterns in Addu Atoll is shown in **Figure 9.** For the purpose of this study, wave data was extracted from NOAA GRiB files for the year 2015. The wave rose plots produced for the data show that the waves predominantly approach from the South South West as well as South East directions, with a small proportion of waves from the North Eastern direction. The significant wave height for the region ranged from 0.5m to 3.5m with the majority of the wave heights being between 1 and 2.5m. The wave mean period shows that the wave periods range from as short as 4 seconds to as long as 24 seconds. It is seen that the shorter wave periods (4 – 8 seconds) occur in waves approaching from South East and North East Directions. These waves can be classified as locally generated wind waves. The waves from South South West show a longer period ranging from 10 – 24 seconds. Such waves are swell waves generated from the Indian Ocean.

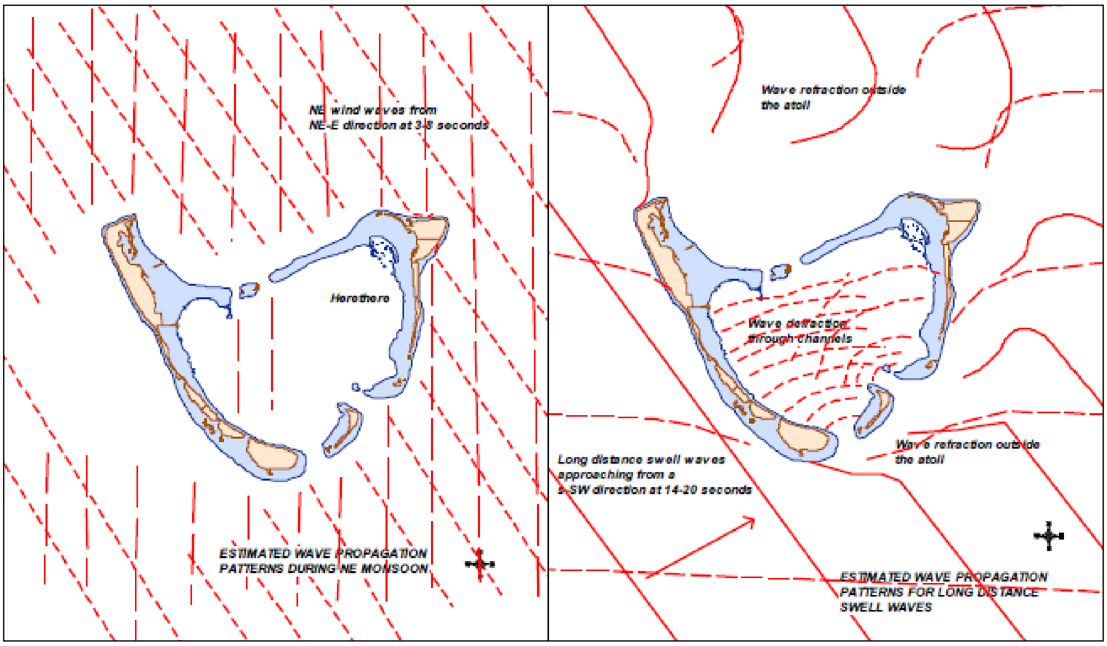


Figure 9 Estimated wave propagation pattern during SW and NE monsoon in Addu Atoll (Source: EIA report for Water Supply and Sewerage in Hulhudhoo Meedhoo, Addu City, 2012)

The North East monsoon occurs from December to February. As seen in **Figure 11**, wave direction is predominantly from the South South West direction in the three months. These SSW waves have a time period of between 10 and 20 seconds. They can be classified as long swell waves. Shorter, locally generated waves of time periods between 4 and 10 seconds have directions of South East as well as North East. The percentage of NE waves increase from

December to February. The wave heights during these three months range from 0.5 to 3m, with the majority of wave heights between 1 to 2m.

There is a difference in the wave direction as well as distribution and wave characteristics during the South West monsoon. The longer swell wave directions persist although the shorter wave directions change predominantly to South West. There is an increase in wave heights in waves from both directions. The wave heights range from 1.5 to 3m. During the months of August and September, the waves from SW increase significantly.

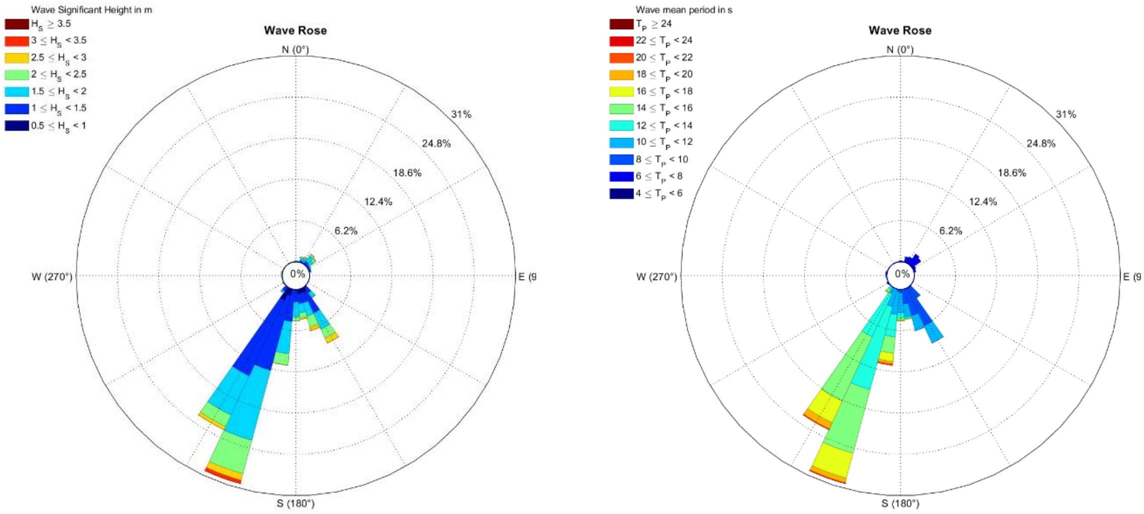
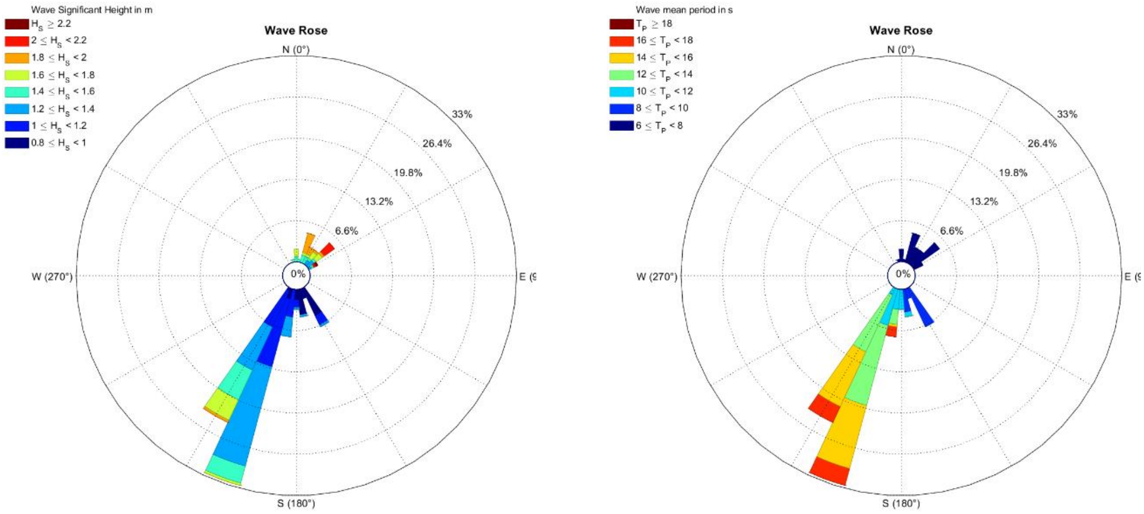


Figure 10 Wave Rose for the year 2015



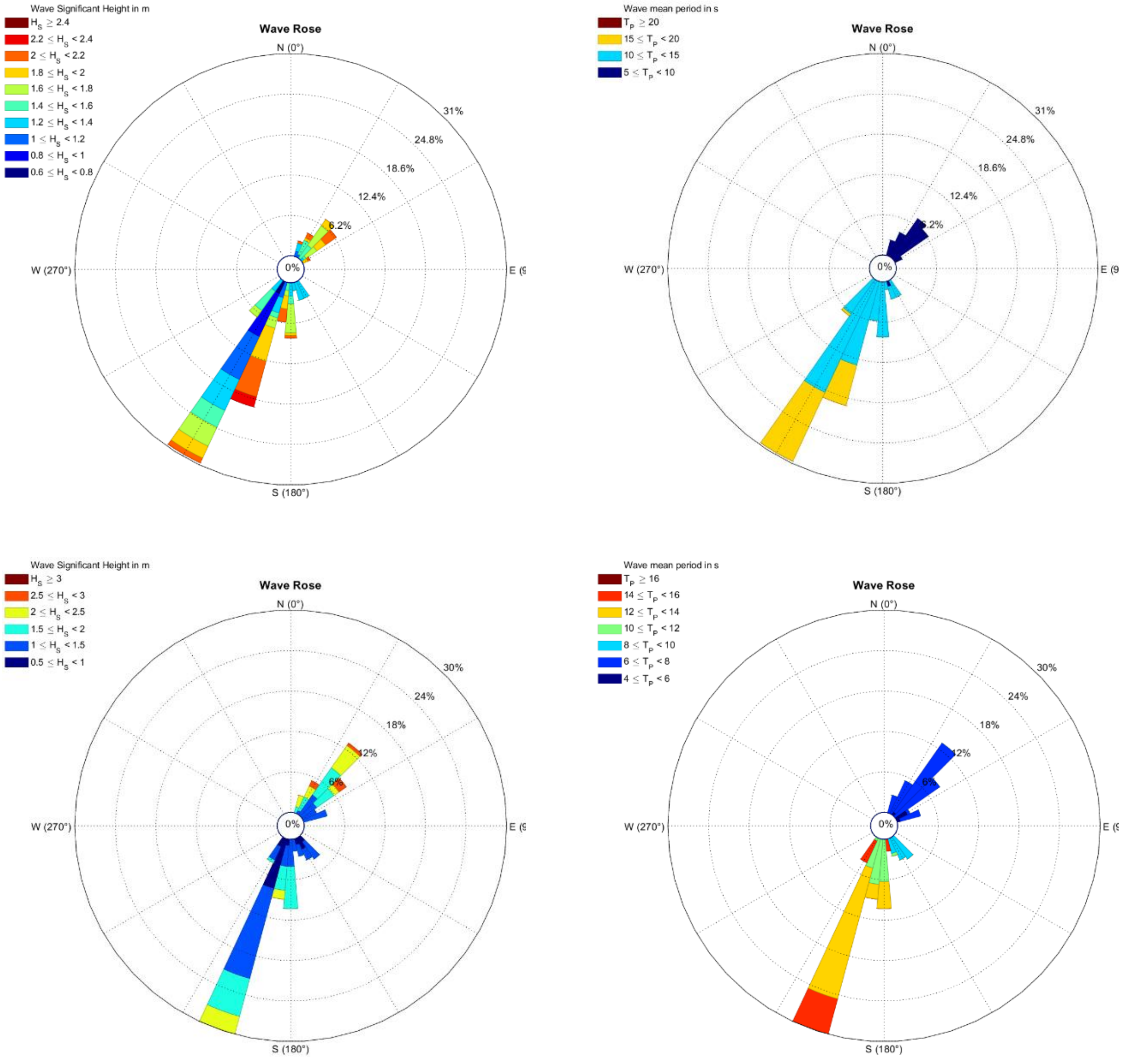
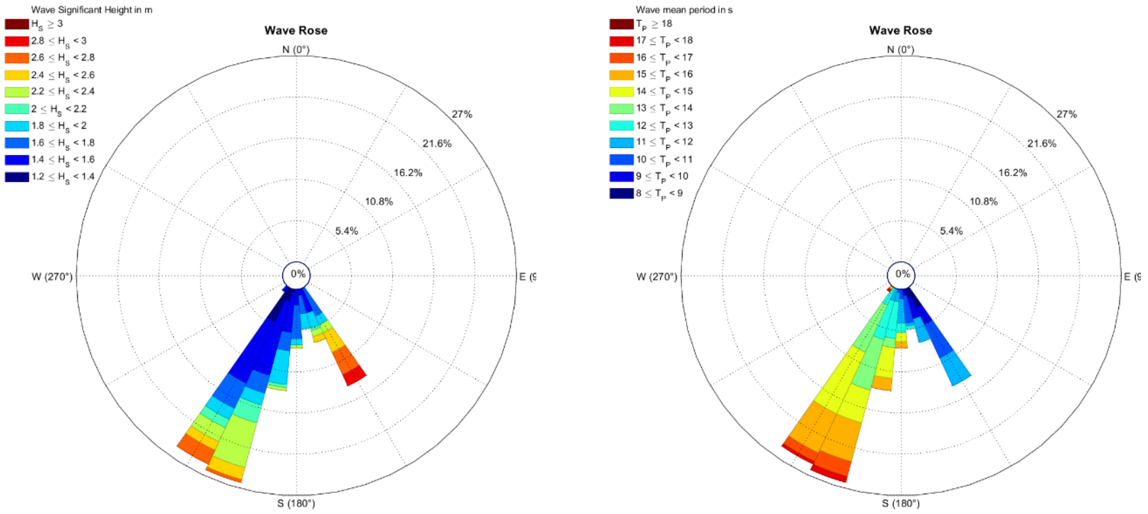


Figure 11 Wave Rose by months of NE Monsoon. top to bottom: December, January February 2015



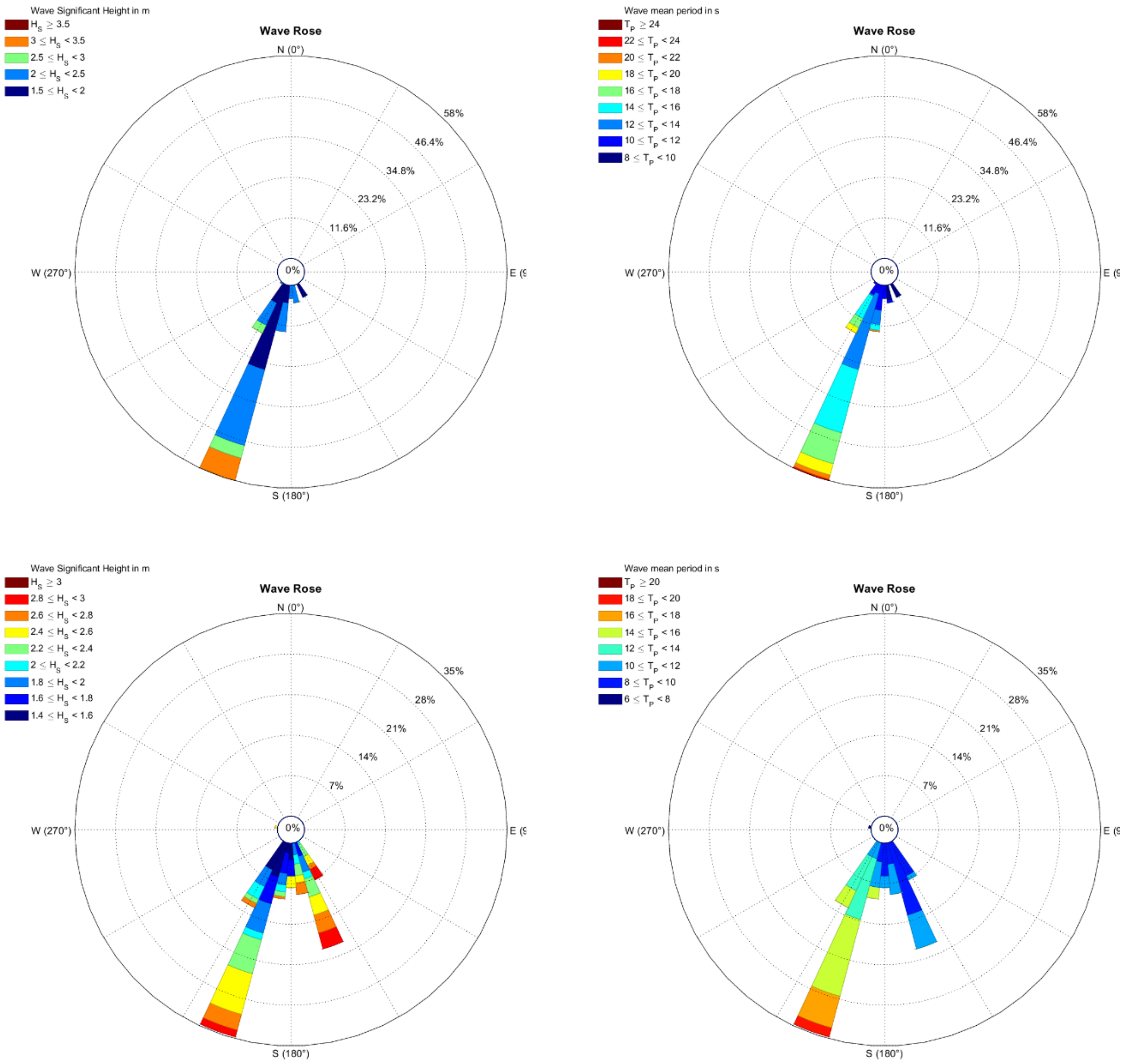


Figure 12 Wave Rose by months of SW Monsoon. Top to bottom: May, June, July 2015

DIRAM study on Feydhoo states that the island experiences abnormal swell and storm surges frequently, with the primary factor being the geographic location of the project island. Feydhoo is exposed oceanic swell waves as it is the southernmost inhabited island in Maldives, and thus one of the closest islands to the southern Indian Ocean. The island is also located on the western rim of Addu Atoll which exposes the island to long distance swell waves approaching from SW direction. Past studies on Maldives stated earlier as well as the NOAA data analysis of offshore waves show that these swell waves are present year round. In addition to the island location, reef geometry, geomorphology and wave interaction with reef are factors that control the exposure of the island to swell waves. DIRAM report states that according to Kench and Brander (2006) Reef Energy Window Index model, the estimated occurrence of gravity wave energy on Feydhoo reef flat is approximately 30%. This is considered moderate.

Analysis of past events by DIRAM showed that the ocean ward coastline of Feydhoo is the main inundation zone for surges and swell waves (See **Figure 13**). The report states that the maximum inundation depth reported in Feydhoo from swell or surge related events is 1.0 m.

Flood events were reported to have been controlled on the north-western part of the island (prior to reclamation) due to the erection of a 1.5 m artificial sand ridge. A swell wave event of May 2007 was controlled from this ridge while natural beach areas experienced flooding. The report predicts that the main hazard that will be experienced by Feydhoo in the future will also be swell and storm surge events, from the south and south west direction. The report forecasts a probability of major swell or surge events occurring every five years with inundation depths of less than 1.0 m. The report also highlighted that the reclamation of the island would result in an increase of occurrence of gravity wave energy by 43% and flooding by surges by 13%.

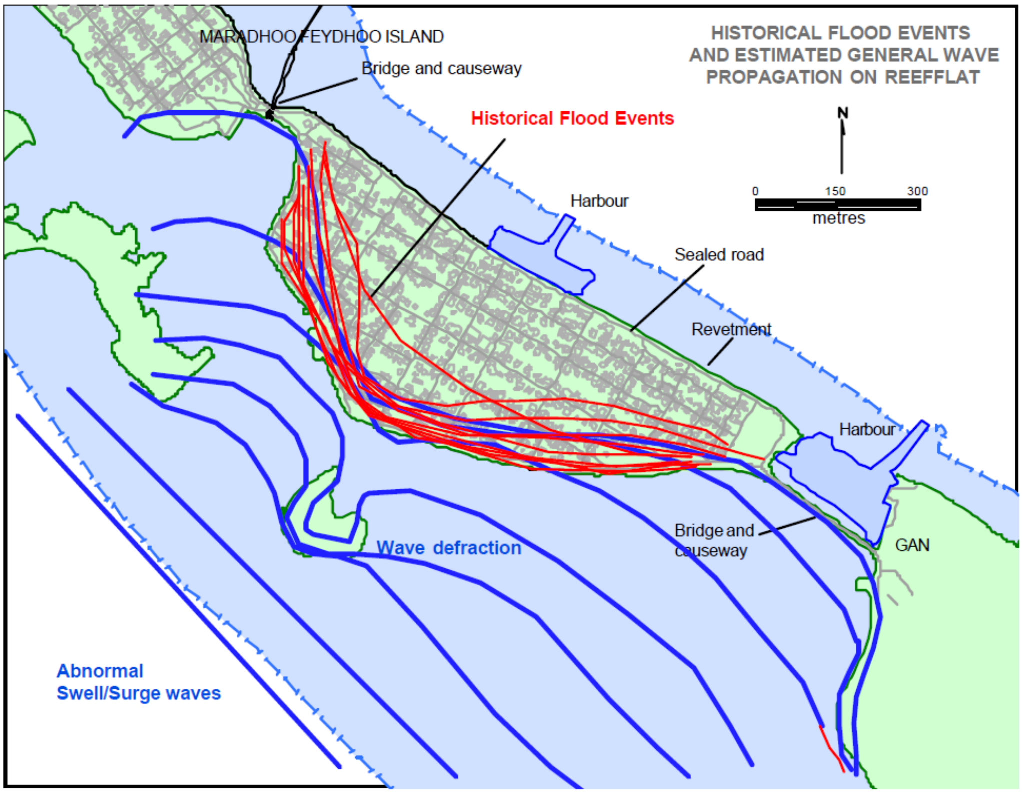


Figure 13 Historical flood events and estimated general wave propagation on reef flat. (Source: Detailed Island Risk Assessment Report on Feydhoo)

Findings from this study give further strength to the need for additional coastal protection at the Feydhoo STP site, as the site is in risk of wave related flooding events with the current site conditions.

5.1.2 Geology and Geomorphology

Bathymetry of the coastal protection site

Lagoon and reef bathymetry of the area was conducted during the field survey to study the bottom topography of the area.

The bottom topography of the south west lagoon was observed to be fairly shallow, with the depths varying between 0 m and -0.4 m until the reef edge. Detailed bathymetry of the coastal protection area is provided in **Annex 3.**

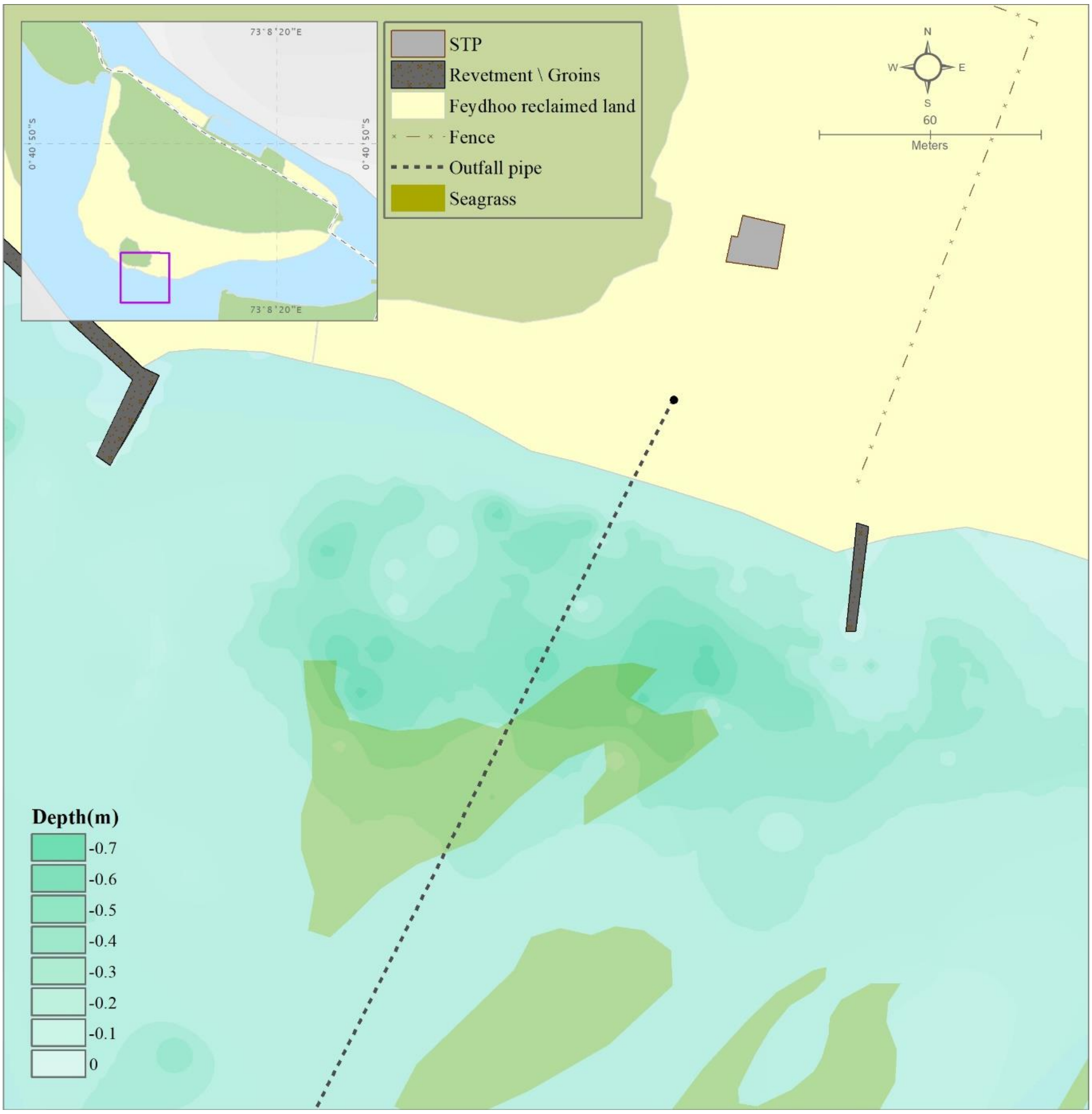


Figure 14: Bathymetry of the area

<u>Shoreline of the coastal protection site</u>

The shoreline of the area has been protected with groynes to control the erosion of the area. As the time of visit, the HWL was 56 m from the STP, while the LWL was 64 m from the site. Observations and consultations showed that the area had previously eroded up to 34 m from the STP site and accreted back to the current position. During the erosion, the groynes were detached from the shoreline. During the site visit, it was observed that the groyne east of the groyne adjacent to the STP site was still detached due to erosion.

Beach profiles taken at the site are seen on **Annex 3.**

<u>Vegetation line of the coastal protection site</u>

As the site has been reclaimed, there is no defined mature coastal vegetation at the Feydhoo south west coastal area, except for the natural island Dhigihera which is now part of the reclaimed land. Young coconut palms have been planted along the shoreline.

5.1.3 Hydrodynamics of the coastal protection site

Surface currents were taken on 28th July 2018 using drogue method. Analysis of the data showed that the currents propagated in an easterly direction. Current speeds varied from 0.2 m/s to 0.4 m/s, with an average of 0.31 m/s. It was observed that the current speeds increased east of the groyne adjacent to the STP site, towards the channel created by the Feydhoo reclaimed land and the Gan airport strip. (See **Figure 23**)

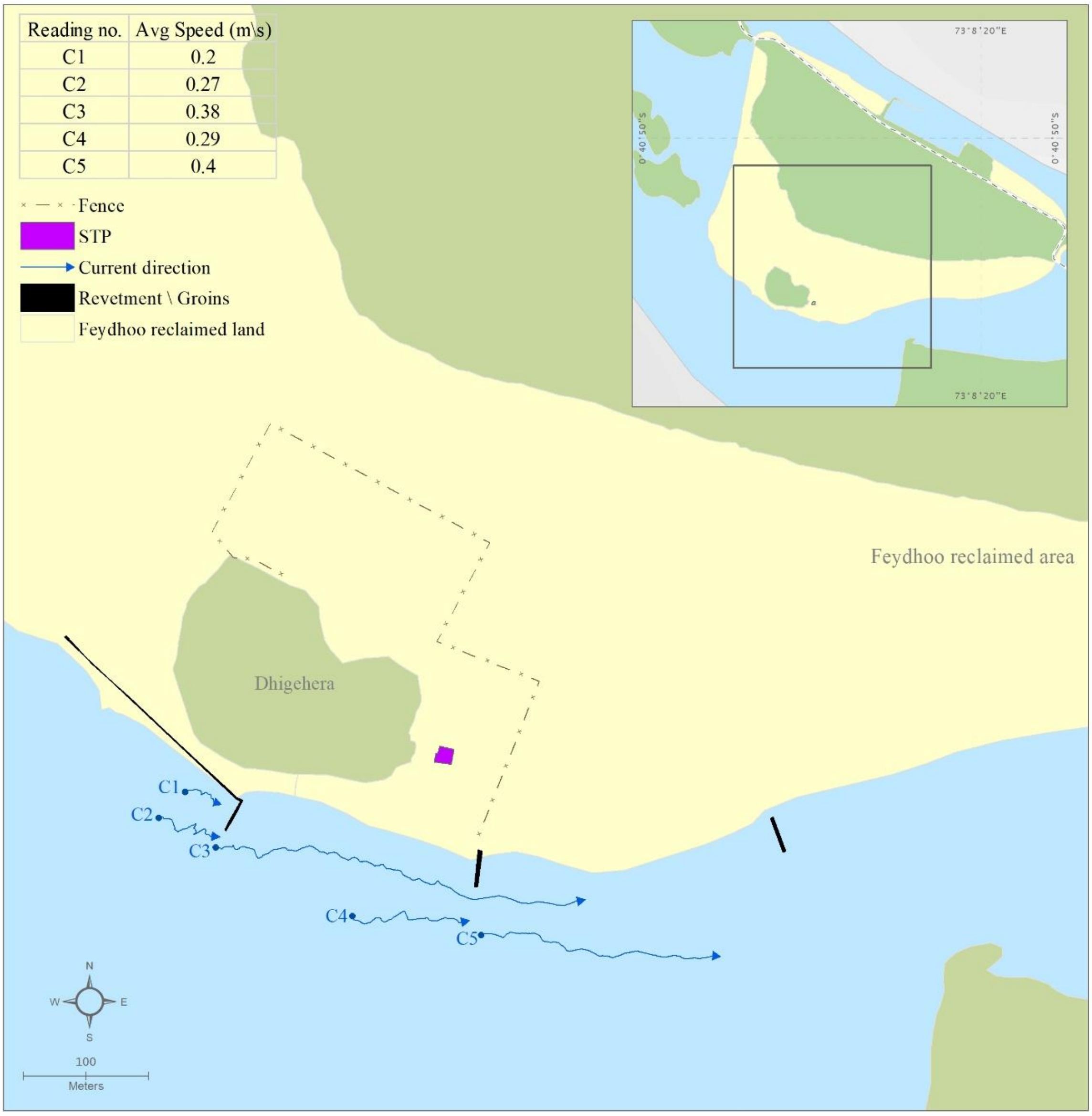


Figure 15: Surface Currents

5.1.4 Water quality of the coastal protection site

Baseline water quality assessments were done for sea water. Sea water quality tests were also conducted in a control location. Chemical parameters tested include, temperature, pH, conductivity, turbidity, DO, total dissolved solids and salinity. **Table 8** shows water quality results of seawater.

Table 8: Water quality results

ID	Temp /°C	pH	Cond/ mS/cm	Turb/ (NTU)	Sal/(ppt)	DO/(mg/L)
SW1	29.78	7.62	53.1	7.6	35.1	20.53
SW2	29.46	7.98	53.3	0	35.2	17.39
SW3	29.54	8.32	53.2	7.9	35.1	12.68
SW4	29.34	8.17	53.8	0	35.4	11.84
SW5	29.52	7.89	52.2	0	34.4	10.47
SW6	29.58	8.07	53.4	0.4	32.1	9.97
Control	30.82	7.09	53.6	0	35.4	19.59

Temperature

The seawater temperature was between 29.34 – 30.82 °C, which is within the characteristic range for the Maldives.

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye. The lower the value, clearer water is. Turbidity of samples tested at SW1 and SW3 showed a value of 7.6 NTU. These samples were tested at locations closest to the reclaimed area and onshore revetment (See **Figure 6**)

The remaining samples showed a turbidity of 0-0.4 NTU which is normal for undisturbed clear sea water. The turbidity of the control site also tested at 0 NTU.

pH

Seawater is naturally alkaline, with an average pH of 7.6. The normal pH range for seawater is 7.2-8.4. The pH measured at the sample points ranged from 7.62 to 8.32, which are within the normal pH range for sea water. pH measured at control point was at 7.09, lower than the normal range for sea water. A pH lower than 7.4 may likely cause stress to live corals. Inputs of sewage into seawater has been reported to be one of the factors that lower pH levels in seawater due acidification.

Salinity

Salinity for all sampling points were also found within the normal range. Seawater in the world's oceans has a salinity of about 3.5% or 35‰. Salinity affects marine organisms because the process of osmosis transports water towards a higher concentration through cell walls. A fish with a cellular salinity of 1.8% will swell in fresh water and dehydrate in salt water. Thus, saltwater fish drink water copiously while excreting excess salts through their gills. Freshwater fish do the opposite by not ingesting but excreting copious amounts of urine while losing little of their body salts.

Dissolved Oxygen

This parameter measures dissolved oxygen that can be utilized by aquatic life for breathing. The measured values were found to be within the normal range. When water is nutrient rich, microorganisms tend to increase and consume dissolved oxygen, resulting in low level of dissolved oxygen. When the level of dissolved oxygen is too low, it can threat the survival of aquatic life. This parameter is temperature specific, and needs detailed calculation. The level of DO for the samples ranged from 9.97 to 20.93 mg/L in the sampled locations. The DO at the control site measured at 19.59 mg/L.

5.2 MARINE ENVIRONMENT

5.2.1 Reef and lagoon environment

Marine environment of the area was studied via visual observations made during the site visit. Benthic features, fish population and abundance were assessed during high tide and low tide. Bathymetric surveys carried out in the area showed that the shallow reef flat was formed with

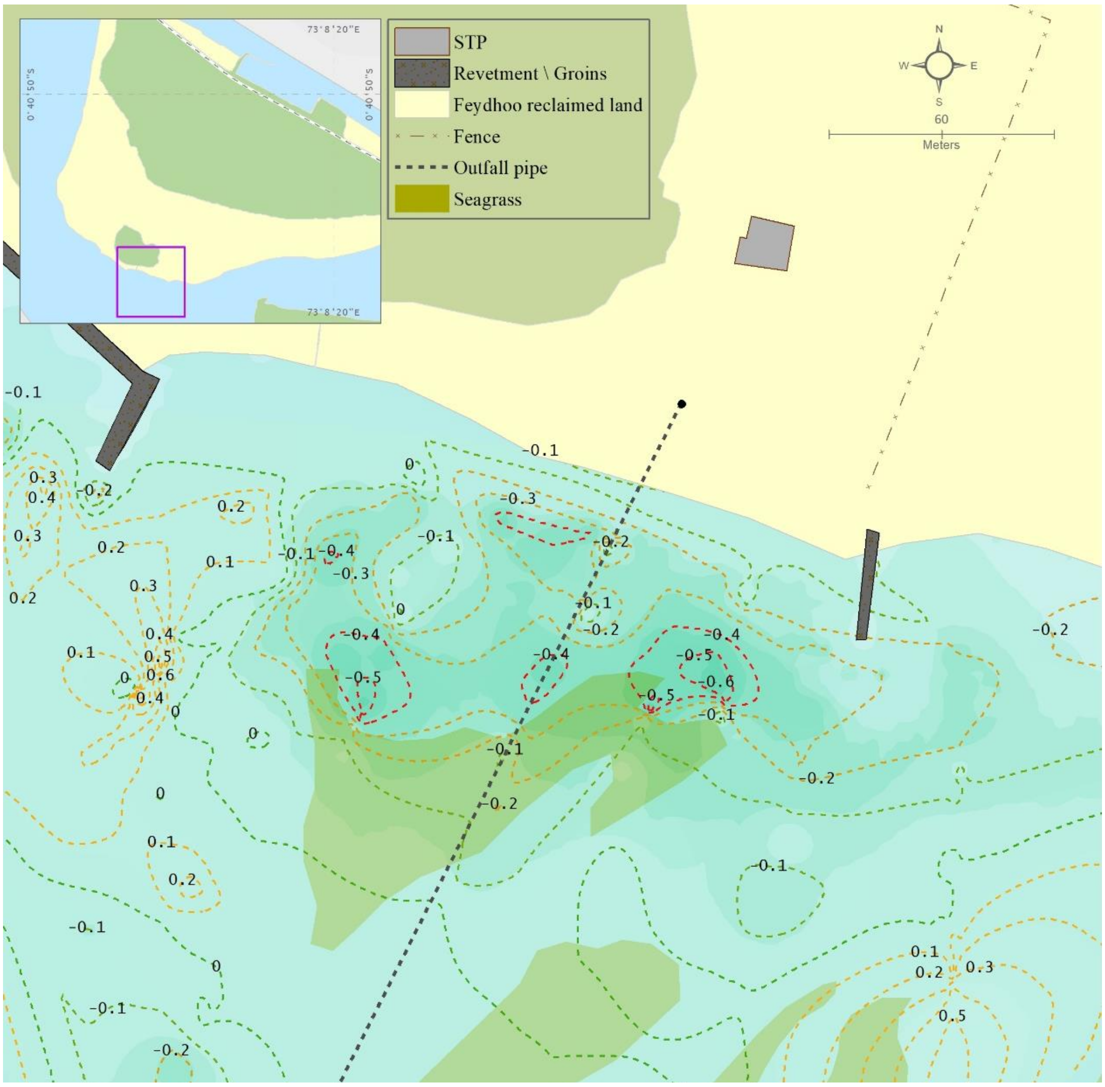


Figure 16: Marine environment at the project site

fairly uniform depths. However, areas close to the reclaimed shoreline have been modified. These areas were observed to be slightly deeper than the rest of the reef flat (see **Figure 16**).

Observations of the benthic environment showed that live corals were scarce in the area, with live corals only being spotted in areas close to the reef edge. Benthic cover of areas close to the reclaimed shoreline were made up entirely of sand and rubble (See **Figure 17**). Seagrass patches and stony bed rocks that are completely exposed above water during low tide made up the rest of the reef flat (See **Figure 16**). Sea grass beds at the area were made up of *Thalassia* *hemprichi*. The seagrass beds to the east of the area, covering most of the reef between Feydhoo and Gan were observed to be the thickest.

Effects of sedimentation were seen on most of the sea grass observed.

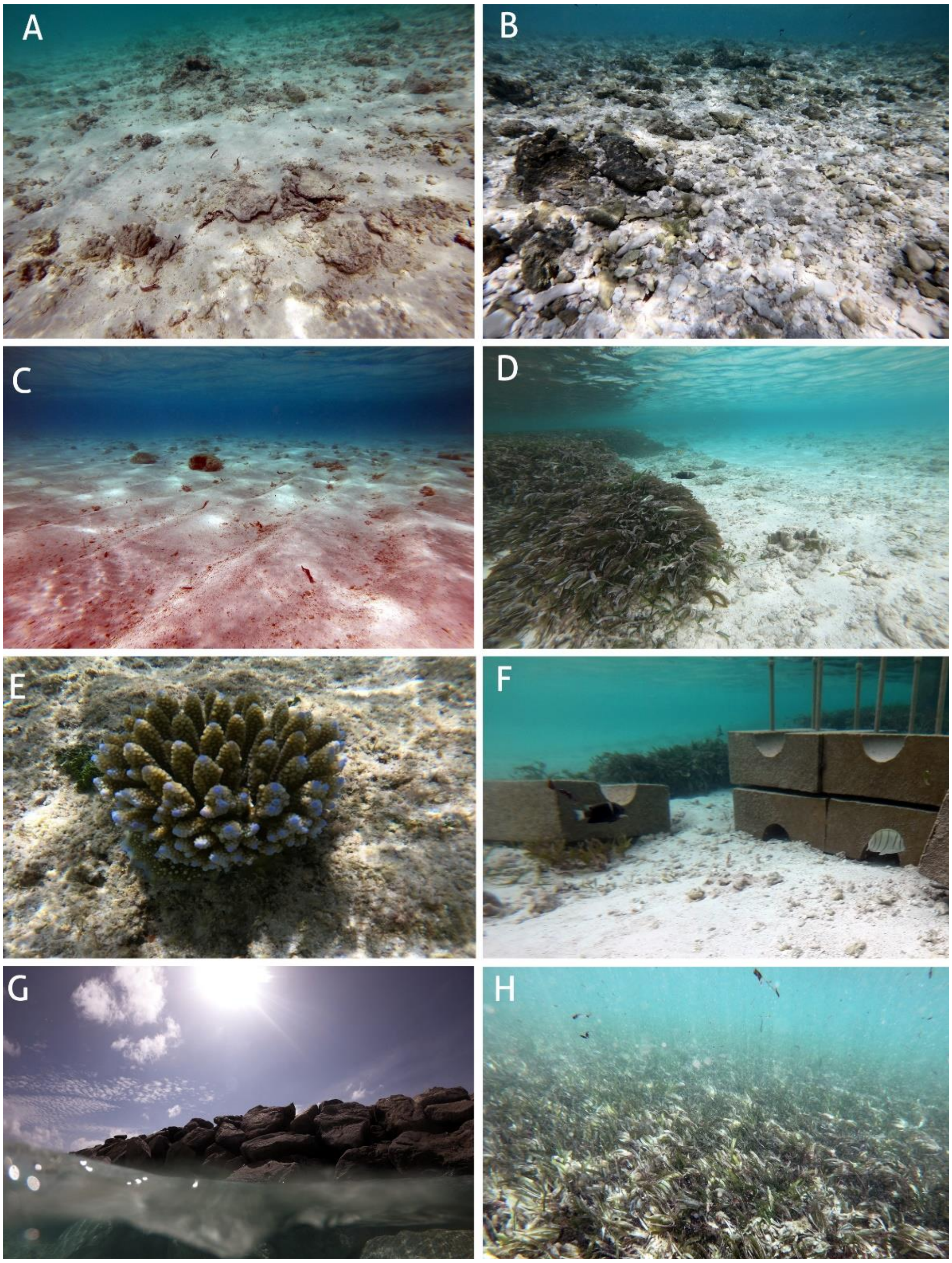


Figure 17: Marine photo profile (A) to (C) Benthic cover at the project area near reclaimed shoreline (D) Seagrass beds close to the project site (E) Live coral observed near the reef edge (F) Fish observed near concrete outfall blocks (G) Fish observed near the existing groyne (H) Sea grass bed between Feydhoo and Gan with visible effects of sedimentation.

Species of fish observed during the survey and their relative abundance is shown in **Table 9**. Fish sightings were low. Various species of juvenile fish reside within the seagrass patches, while some fish have taken refuge inside the stone blocks installed in the lagoon for construction of the outfall pipe. Majority of fish observed were spotted at the submerged parts of the existing groynes (See **Figure 17**). Other species observed in the area include sea urchins and sea cucumbers. Juvenile black tip reef sharks were spotted near the reclaimed shoreline. Moray eels were also observed in the area. The only commonly observed species of fish were Pomacentridae (*Abudefduf vaigiensis*).

Table 9: Results of fish abundance study

Common Name	***Scientific Name***	**Abundance**
Family: Pomacentridae		
Sergeant major White saddled damsel	*Abudefduf vaigiensis* *Chrysiptera biocellata*	Common Rare
Family: Acanthuridae		
Powder blue surgeonfish Convict surgeonfish	*Acanthurus leucosternon* *Acanthurus triostegus*	Rare Rare
Family: Chaetodontidae		
Threadfin butterflyfish	*Chaetodon auriga*	Rare
Family: Labridae		
Six bar wrasse Zig zag wrasse	*Thalasomma hardwicke* *Hemitautoga scapularis*	Rare Rare
Family: Mullidae		
Long barbell goatfish	*Parupenus pleurostigma*	Rare
Family: Carcharhinidae		
Blacktip reef shark (juvenile)	*Carcharhinus melanopterus*	Rare
Family: Muraenidae		
White eyed moray	*Siderea thrysoidea*	Rare

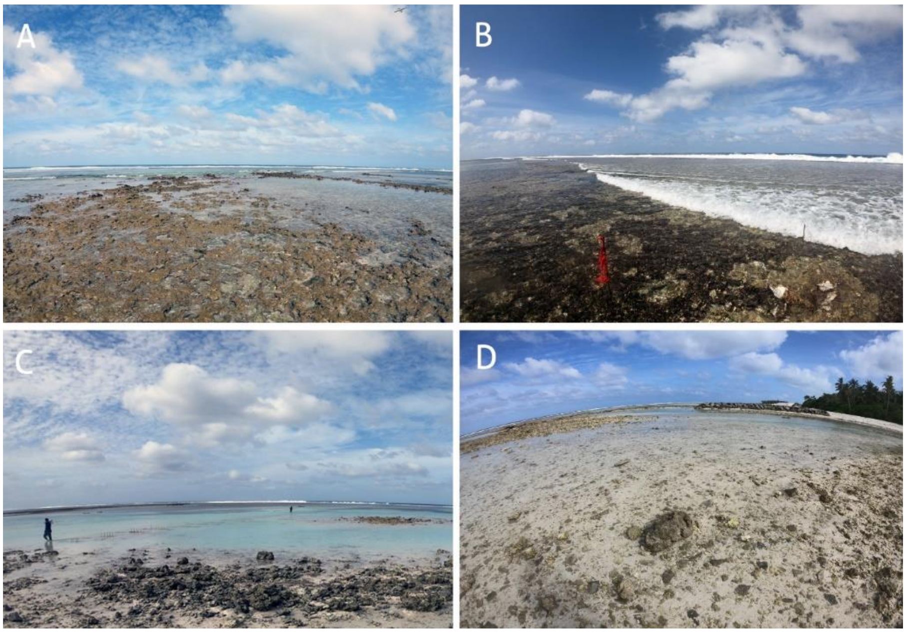


Figure 18: (A) Exposed rock bed near the site (B) Near the reef edge at low tide (C) and (D) site during low tide

5.2.2 Protected Areas

The protected areas declared by Environment Protection Agency states that Addu City has one protected area; the Hithadhoo Protected Area. This area is known as Eidhigali Kilhi and Koattey **(Figure 19).** The protected area is not expected to be impacted by the construction of the breakwater. There are no protected areas declared in Feydhoo.

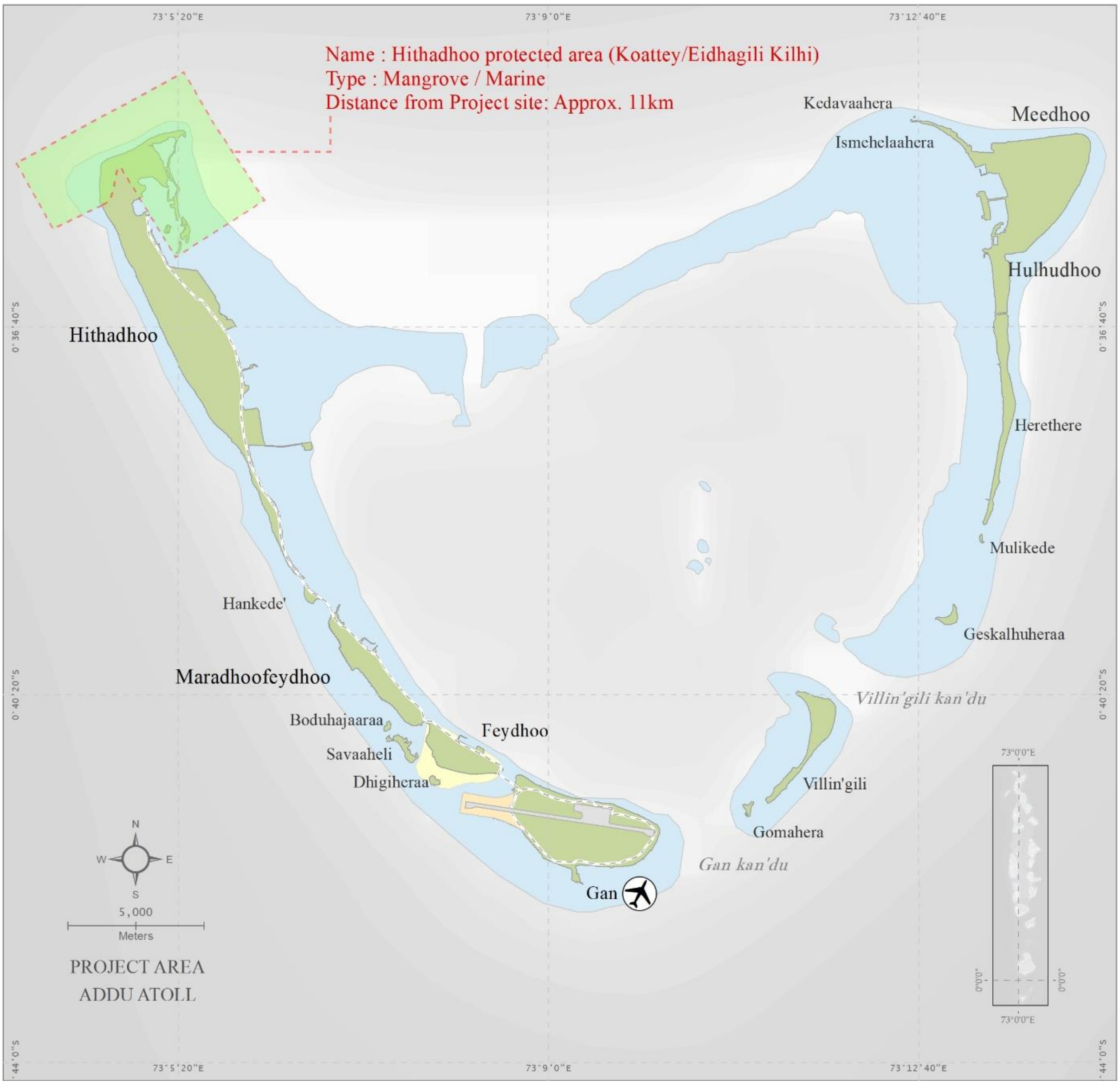


Figure 19: Hithadhoo Protected Area

5.3 SOCIOECONOMIC ENVIRONMENT

5.3.1 Introduction

This chapter covers socioeconomic environment of S Feydhoo as required in the ToR for the EIA addendum study. The demographical, economic situation, land use planning, accessibility, and transport services of the local population is covered in the chapter.

5.3.2 Population

City Council statistics show that a total of 5,547 people have been registered in S. Feydhoo as of June 2018. This includes 2,850 males and 2,697 females, which constitutes to a ratio of 0.95.

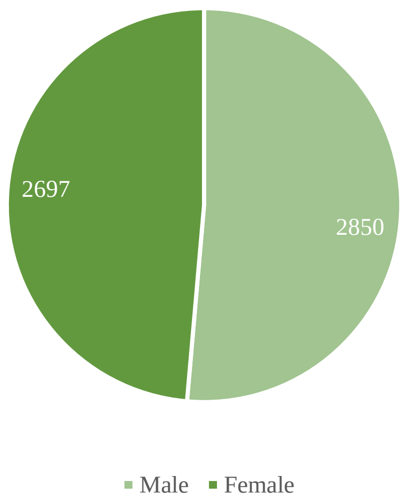


Figure 20: Population of S Feydhoo (Source: Addu City Council, 2018)

According to Census 2014 results the average growth rate in the six administrative islands of Addu City is 1.16, while in Feydhoo it is at 2.6.

5.3.3 Land Use

S. Feydhoo is a highly urbanised island with a high population density in the original 50 ha of the island. The settlement footprint covers more than 90 % of the original island size including areas allocated for industrial zone. The additional 50 ha reclaimed at the southwestern side of the island has provided additional space for well-planned land use. According to data from City Council for the period of January – June 2018, total number of plots allocated in Feydhoo are 941, of which 878 are occupied houses. 63 houses are vacant.

A Land Use Plan (LUP) has been formulated for S. Feydhoo although this LUP was not approved at the time of survey (See **Figure 21**). Therefore, the LUP is subject to changes in the future. Currently, the newly reclaimed land is mostly empty except for developments such as the Feydhoo STP as well as the temporary site for the sewerage project contractor. The STP is located in a zone surrounded by a proposed light industrial zone. West of the STP where Dhigihera is located is reserved for future use, as well as a green zone. Residential areas are proposed north and north west of this area, in addition to the land east of the residential area proposed for housing units. A 3.2 ha area has been proposed for tourism related activities which is in the western end of the reclaimed land. The proposed land use plan shows that the proposed construction of the breakwater would have minimal disruption of the future land use of the area.

5.3.4 Economic Activities

Economic activities conducted on Feydhoo include small businesses such as shops, carpentries, tailors, cafés and restaurants, workshops, salons, hotels and warehouses (See **Table 9**). Other economic activities include construction works. From January to June 2018, 3 farmers were registered in Feydhoo, along with 8 fishermen and 1 fishing vessel. Although commercial fishing on the island is minimal, it is very common for people to go recreational reef fishing and sell part of their catch to someone of the community. Reef fishing is conducted in the deeper areas west of Feydhoo, away from the site. Civil servants and tourism industry workers are the most common jobs among the locals at Feydhoo. Furthermore, local tourism industry is developing on the island with 8 guesthouses currently in operation.

Until September 2017, the total employed population of Feydhoo was 3,967. The majority of this population work in places other than Addu, while a total of 670 people are employed residing in Addu.

Table 10: Economic establishments registered in Feydhoo July-Sept 2017 (Source: Addu City Council)

Economic Establishment	Nos.
Shops	120
Carpentries	3
Tailor shops	7
Café's, Restaurants	14
Workshops (Garage)	9
Salons	3
Warehouse	1
Other	2

5.3.5 Accessibility and transport

While Feydhoo is the southernmost inhabited island in Maldives, the island is highly accessible to the rest of the country. The nearest airport is the Gan International airport which lies just south east of the island, and can be reached by the link road connecting the islands of Hithadhoo, Maradhoo, Maradhoofeydhoo and Feydhoo. Direct flights are available to Male' in addition to international flights. A post office is present in the island.

Ferry services are provided with a total of 32 trips a week. The passenger movement in ferry for the period of January to June 2018 is 765 passengers in and 946 passengers out.

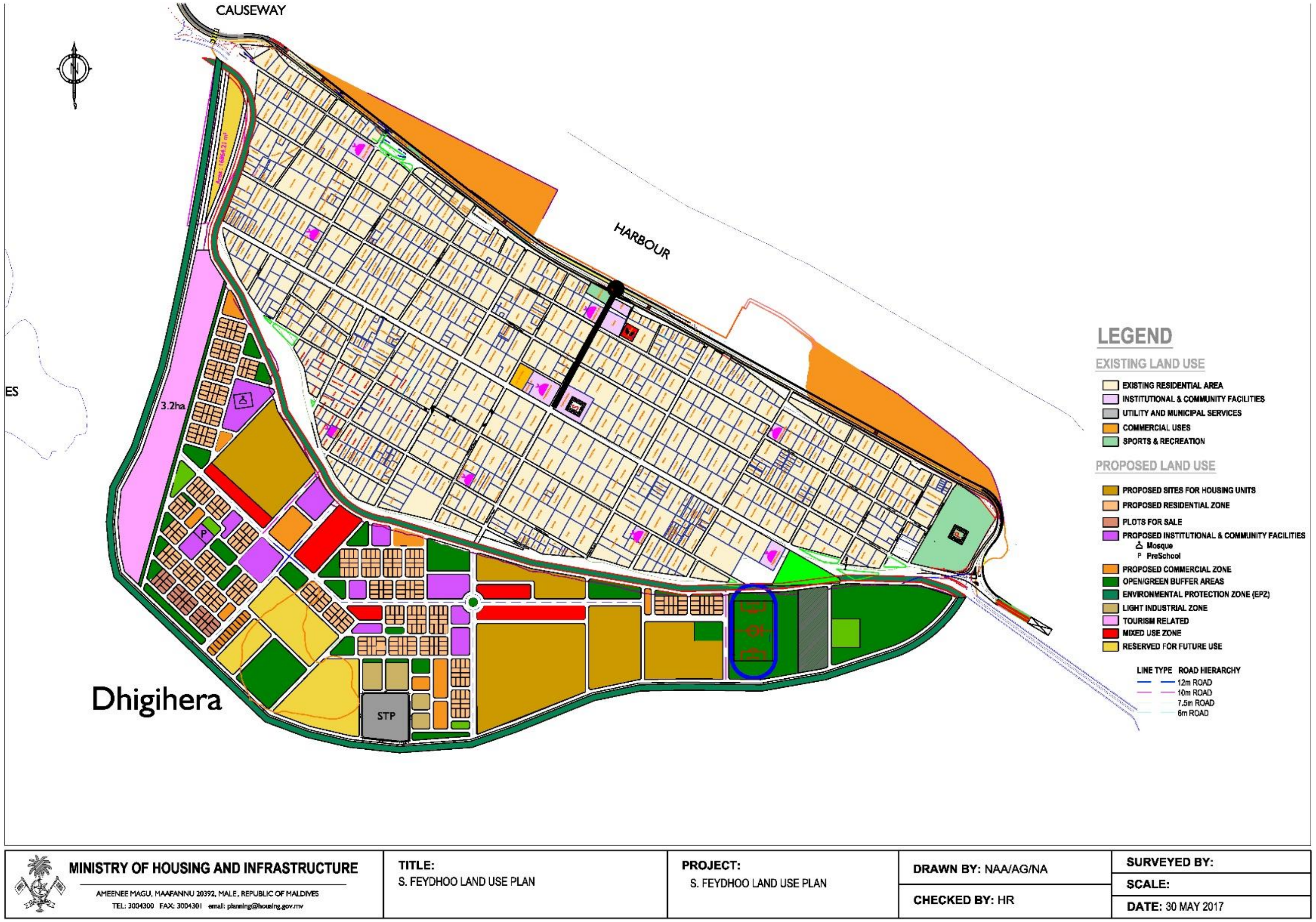


Figure 21: Land use plan of S. Feydhoo

Modes of land transport used in the island include bicycles, motorcycles, cars, Lorries and pick-ups. Earlier there were many bicycles on the island and many have used it as an ideal form of transportation. According to data for the first half of 2018 from City Council, the transport system within Feydhoo is now heavily dependent on private cars, which take up 79% (See **Figure 22**) of the total registered vehicles in the island. There are 6 taxis operating on the island. Due to the size of the atoll and the link road connecting the populated islands in the western rim of the atoll, land transport through cars is the preferred method of transportation for the population of Feydhoo.

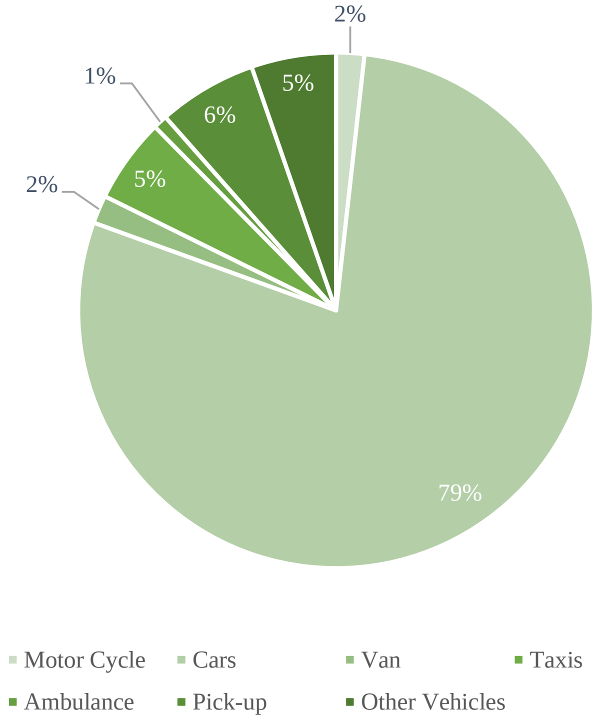


Figure 22: Method of transport used within S Feydhoo

6. STAKEHOLDER CONSULTATION

Stakeholder consultations were held regarding the proposed coastal protection works with the EPA as well as Noonu Atoll Council. Highlights of the meetings are presented below.

6.1 SCOPING MEETING

Scoping meeting was held on **24/07/2018** at EPA. Proponent, Consultant, EPA as well as Addu City Council was present at the meeting. Details of attendance is attached in **Annex 4**

- Proponent stated that the additional work is proposed in order to protect the STP in Feydhoo from swell waves and *udha* which has impacted the area in the past. Materials required for the construction of the breakwater is available in Addu.
- EPA recommended to conduct consultation regarding existing coastal protection plans by MHI, as well as existing land use plan for the reclaimed area.
- EPA recommended to study alternative methods for the proposed coastal protection, and possible scouring and erosion due to the proposed construction of the breakwater.
- Addu City Council stated that as the proposed development is being conducted in an area close to the City's airport, it is imperative to ensure the development is sustainable and long lasting, in addition to being aesthetically pleasing.
- EPA proposed few changes to the submitted TOR, and the Proponent agreed with the changes.

6.2 MEETING WITH ADDU CITY COUNCIL (FEYDHOO)

Meeting with Addu City Council (Feydhoo) was held on **29/07/2018**. Details of attendance is attached in **Annex 4.**

- Transportation of materials should be done in a safe manner and at convenient times where locals do not gather in areas along the transport route.
- There is a school and harbour located along the transport route in Maradhoofeydhoo, which may be impacted from noise during transportation.
- There have been cases where large vehicles transporting construction materials go over the speed limit. Speed limit should be strictly followed during transportation
- Cases where materials dropping off of vehicles and onto the road have also been reported. Loads should be properly secured.
- The sewerage project is a much-needed project for the island's community.
- Swells usually effect the island's northern and southern coastal areas.
- The newly reclaimed land at Feydhoo is used by locals for various recreational purposes including swimming, fishing, kite flying, school field trips, picnics, holiday celebrations wedding receptions, driving practice. Etc. As the MTCC worksite is fenced and demarcated with all of their materials inside the demarcated area, there have been no complains by locals due to the site being located in this area.

6.3 MEETING WITH MINISTRY OF HOUSING AND INFRASTRUCTURE, ADDU CITY

Meeting with MHI in Addu City was held on **28/07/2018**. Details of attendance is attached in **Annex 4.**

- The newly reclaimed area at Feydhoo was heavily eroded during bad weather conditions that caused massive swells to reach the land in April 2018. Sand has accumulated in the area afterwards, however, there was some loss off land that was not recovered.
- Erosion of the area where STP is being constructed was extensive. Sand has accumulated at the area since then and is almost completely back to normal in the STP area. The groyne to the east of the STP area is still detached from the land (groyne was constructed on land)
- Transportation within Addu atoll is very convenient, especially for the islands connected by the link road. Daily ferries are operated to Hulhudhoo and Meedhoo.
- Construction materials are available on the island. Two main parties proving construction materials at Feydhoo are S.T.O and Apollo. It was concluded that the materials needed for the proposed works could be easily procured locally.
- Waste management Feydhoo is done by WAMCO, waste collected at Feydhoo is transported to the waste management centre in Hithadhoo.

6.4 MEETING WITH MINISTRY OF HOUSING AND INFRASTRUCTURE

A meeting was held with MHI in Male' regarding the future plans for coastal protection along the Feydhoo reclaimed coastal area. This meeting was held on **31/07/2018**. Details of attendance is attached in **Annex 4.**

- MHI official stated that coastal protection has been constructed in the area west of the STP location, with the remaining coastal zone stabilised by groynes.
- MHI official stated that they do not have any issue with the coastal protection proposed by the proponent as it would aid in providing additional protection to the adjacent coastal region from swells and erosion.

7. DETERMINATION OF POTENTIAL IMPACTS AND MITIGATION MEASURES

7.1 IMPACT METHODOLOGY, NATURE AND IDENTIFICATION OF IMPACTS

A modified Leopold matrix was applied in evaluating the impacts identified. The Leopold matrix, which is widely applicable in carrying out an EIA for different types of projects has been chosen as a suitable method for predicting impacts of the proposed project. This method has been detailed in **Section 12.1** of the EIA report.

The significance of impacts is based on the calculated magnitude score for total impact area and impact activity. The significance is assigned based on the following total impact magnitude ranges. For ease of identification these ranges have been colour coded as shown in the (**Table 13**)

The steps involved are briefly summarised below:

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

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

Importance

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

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

Magnitude

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

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

The scores obtained for the magnitude of each of the impacts (both positive and negative) were categorised as given in **Table 11**.

Table 11: 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 is defined as explained in **Table 12**.

Table 12: 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 13.

Table 13: Colour codes used for distinguishing positive and negative impacts

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

Cumulative Impacts

Cumulative impacts which may be defined as impacts that result from incremental changes caused by other past, present or reasonably foreseeable activities together with the project are generally considered in the impact assessment studies.

Impact Mitigation

EIA regulation requires practical and appropriate mitigation measures for significant impacts identified to be proposed in the EIA addendum. The Proponent is required to submit a letter of commitment in the addendum 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 addendum 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.

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

Gaps in Baseline Information

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

Understanding of the baseline conditions in studying existing environment was limited to a short period of time. Collecting all necessary environmental information is rarely possible due to time and cost constraints and therefore, the data captured is representative of the conditions at the time of the surveys. In the case of the present study, the data gaps have been adequately filled by experiences and lessons learnt from similar projects carried out in the Maldives.

Gaps in Understanding Impacts

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

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

7.2 POTENTIAL IMPACTS AND MITIGATION MEASURE FOR KEY IMPACTS

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

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

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

Table 14: Impact Matrix for Construction Phase

	Envisaged impact factors	C1 Worker Influx and Settlement	C2 Transportation of materials	C3 Site Demarcation & Fencing	C4 Construction	C5 Waste Generation	C6 Resource Consumption	Total (Impact Area)
Physical Components	Seawater	-3	-2	-3	-5	-3		-16
		1	3	2	6	4		16
	Ground water	-2				-4	-5	-11
		1				4	5	10
	Air	-2	-5	-1	-3	-5	-3	-19
		2	5	2	3	4	3	19
	Noise	-2	-5	-1	-5			-13
		1	6	2	3			12
	Coastal Zone	-1		-2	-5	-5	-1	-14
		2		3	5	4	1	15
Biological Components	Flora	-1	-1		-1	-4	-3	-10
		2	3		2	5	2	14
	Endangered species/protected areas							0
								0
	Coral Reef	-1		-2	-2	-1		-6
		1		3	2	1		7
	Fauna	-2	-2		-3	-3		-10
		2	2		3	3		10
Socio-Cultural Component	Aesthetics	-2	-3		-2	-2		-9
		2	3		3	3		11
	Accidents	-1	-8	-4	-8	-2	-1	-24
		1	6	5	8	2	1	23
	Landscape				-6		-4	-10
					4		3	7
	Health/Well being	-1	-4	-1	-5	-5		-16
		1	5	2	3	6		17
	Local economy	4	4	1	7		2	18
		1	4	2	5		2	14
Total (Construction Activity/Risk)		-14	-26	-13	-38	-34	-15	
		17	37	21	47	36	17	

Summary of the multi-criteria analysis is given in **Table 15**

Table 15: Summary of multi-criteria analysis for construction phase impacts

Activity	Impact Score	Overall Impact
C4 Construction	**-38**	**Moderately negative**
C5 Waste generation	**-34**	**Moderately negative**
C2 Transportation of materials	**-26**	**Moderately negative**
C7 Resource consumption	**-15**	**Minor negative**
C1 Worker influx & settlement	**-14**	**Minor negative**
C3 Setting out	**-13**	**Minor negative**

7.3.1 Impacts and Mitigation from Construction Phase

7.3.1.1 C1 Worker Influx and Settlement

A large number of work force is not expected for the project. An estimated 5-10 workers will be required for this project. Since resource consumption, waste generation and behavior related impacts on the environment are likely to have an incremental increase with additional people to the island. However, even though minor workers related negative impacts can range from damage to flora and fauna of the island, impacts associated with resource utilization, waste generation and potentially negative social impacts. On the other hand, even though small, more people to the island could have a positive effect on the local economy. Multi-criteria impact analysis shows that this activity will have an overall minor negative impact with a score of -14.

For the duration of the project, the workers related waste output is detailed in **Section 2.9.** For this project, worker related impacts can be reduced through the following mitigation measures.

Mitigation for impacts on flora and fauna

- The contractor is required to keep the workforce as minimum as possible, and to not bring in any surplus workers for the project;
- no new facilities will be made for the accommodation of the workers in order to avoid clearing of land or spending resources unnecessarily for making worker quarters. New workers will be based in the worker's quarters currently being used by the contractor;
- all construction workers and persons on site must be given specific instructions not to catch or harm birds and animals allow them to retreat into undisturbed areas and prohibit damaging vegetation that are not;
- rules shall be formulated by the contractor and workers shall be oriented on the rules and conduct during the project works;
- enclosed containers shall be provided to dispose of waste oil and other hazardous waste;
- littering shall be prohibited; and
- waste bins shall be placed within the site.

Mitigation for impacts on resource use

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

Mitigation for sociocultural impacts

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

7.3.1.2 C2 Transportation of Materials

Transportation of construction materials from the source to the project island is identified as an activity with climate impacts, through the transportation of sea vessels, as well the transportation of the materials on land. As a general rule the longer distance would mean more fuel burnt and more GHGs produced. As the resource sourcing hierarchy in **Figure 23** shows, the greatest importance shall be placed on sourcing any available materials from within the island, with the next option being from within the Atoll, from islands such as S. Hithadhoo. Next in the hierarchy is Male' and the industrial areas in the zone, from where majority of the remaining materials can be sourced. Lastly, in cases where a proposed material cannot be obtained from within the country, only shall the contractor procure the material from a neighbouring country which is not likely due to readily available materials for this project. It should be noted that the major component of the project, rock boulders are currently available stockpiled in S. Hithadhoo port area. Therefore the major transportation of materials will occur on land, from Hithadhoo to the project site at Feydhoo. The multi-criteria impact magnitude for this activity was -26, which meant that it will have a moderately negative impact.

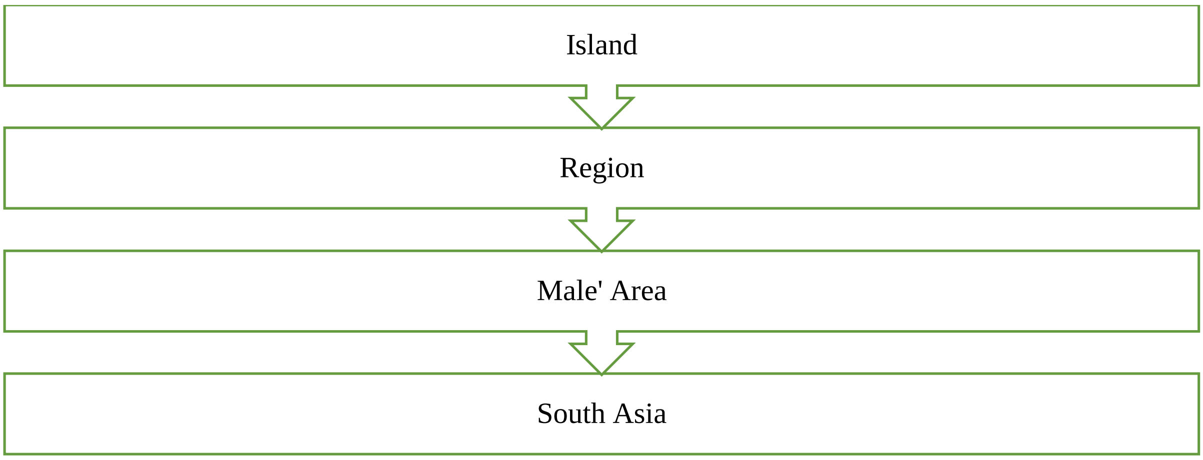


Figure 23: Material sourcing hierarchy proposed for the project

The inputs of the project elaborated in the **Section 2.9** show the estimated amount of resources that will be used for the project. The use of resources for the project can have indirect impacts of GHG emissions from the production process.

The use of heavy vehicles on unpaved roads can cause compaction of the soil by the force applied by the tires of the vehicles. This can lead to the destruction of the soil structure, reduction of porosity, and thus reducing the water and air infiltration into the soil. The resulting soil is dense with few large pores and poor internal drainage (Wolkowski & Lowery, 2008.). Roads impacted with the traffic from heavy vehicles can thus result in undulations and puddling.

Figure 24: Impact on roads from heavy vehicle transport in an island in Maldives

A truck will be used to transport the construction materials to the site, in addition to construction waste from the site.

A hydraulic excavator of 20 tons will be used to load and unload the truck with rock boulders, in addition to the construction of the breakwater. The movement of the excavator through the roads of the island can incur damage to the roads as stated above. It should be noted that the movement of the excavator will not occur frequently through the public roads.

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

During transportation of the rock boulders from Hithadhoo port area, noise and vibration needs to be considered and potential concerns of nearby populations taken into account for smooth implementation of the work schedule. As per consultations, there is a school and harbour in Maradhoofeydhoo in the transport route which may be impacted from noise and vibration from transport. 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 20 m to 75 m to achieve an acceptable annoyance criterion (strongly perceptible) of 2.5 mm/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.

Mitigation for climate impacts

- Sourcing of materials shall be done according to the hierarchy presented in **Figure 23**. Materials shall be obtained from the closest source;
- The materials shall be bought in bulk and transported to the island within a single trip where possible;
- The breakwater shall use the least amount of material possible while creating sufficient protection against waves;
- Detailed BOQ shall be produced by the Proponent, which shall be followed by the contractor when purchasing materials in order to reduce wastage of materials as well as the number of trips;
- The materials shall be stored on the project site to eliminate transportation of vehicles within the island throughout the construction phase;
- Idle time of the vehicles shall be avoided in order to reduce emissions;
- contractor shall use serviced vehicles and plant equipment for the project;
- contractor shall only use the needed amount of vehicles and plant for project; and
- vehicle used for the purpose should comply with the roadworthiness requirements of the Transport Authority and display the compliance stickers.

Mitigation for impacts on roads

- The contractor shall only bring in the necessary number of vehicles and plant to the island for the project;
- it shall be stated in the contract that any damages to the roads from transportation of construction materials and machinery shall be assessed after the civil works are completed, and the damages shall be repaired by the contractor;
- use the closest route from the harbor area to the site. The route proposed to transport rock boulders from Hithadhoo to Feydhoo is show in **Figure 4**;
- cover the materials being transported to and from the site; and
- spray water on the road surface during dry periods to suppress dust.

Mitigation for accidents and injuries

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

Mitigation for marine and terrestrial pollution

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

Mitigation for noise impacts

- 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.

7.3.1.3 C3 Setting Out Survey

Setting out survey will be done by the contractor prior to construction works. This will determine the exact locations of the breakwater to be constructed. This activity is considered to have minor environmental impacts with multi-criteria impact analysis score of – 13 as it is largely noninvasive.

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

Mitigation measures

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

7.3.1.4 C4 Construction

There are a number sub-activities that can affect the environment related to construction of the breakwater. Overall, the multi-criteria impact magnitude for this activity was -38, which meant that it will have a moderate negative impact.

Material Storage

At the initial stage all resources required for the construction of the site will have to be procured and stored. These include construction materials, vehicles, machineries, fuels, and tools required for the project.

Stockpiling of rock boulders can damage vegetation, impact soil organisms and dust found on it may be blown away by the wind. Stockpiling of rock boulders are proposed in the location in **Figure 4** where no vegetation is present. Stockpiling operation can also be noisy when rocks grind against each other during stockpiling.

Hazardous and flammable materials (e.g. fuel) improperly stored and handled on the site are potential health hazards for construction workers and spilled chemicals would have the potential to contaminate soil and inhibit plant growth in localized areas.

Mitigation for material storage impacts

- Safe storage area should be identified and retaining structures put in place prior to the arrival and placement of material;
- The 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 4**);
- the stockpiling of construction materials should be done in a such a way that the materials are not exposed to weather conditions and are properly controlled and managed by the site supervisors;
- hazardous chemicals (e.g. fuels) should be properly stored in appropriate containers and these should be safely locked away. Conspicuous warning signs (e.g. 'No Smoking') should also be posted around hazardous waste storage and handling facilities.
- equipment shall be stored in fenced areas and maintained appropriately during the course of the project and no new such facilities shall be developed for the purpose of the project;
- National Fire Code (NFC) shall be strictly followed while handling, transporting and storing fuel. Inflammable goods such as fuel drums, portable fuel containers and cleaning solvents and chemicals will be closed off from public access.
- portable extinguishers placed to be readily available when someone finds a fire;
- fuel should be stored in well contained barrels and place over a concrete. This is to contain oil spills during storage and to prevent infiltration of oil into soil; and
- tool shed shall be locked and all the equipment, vehicles and tools must be accounted for.

<u>Breakwater construction</u>

During construction, re-suspension of bottom sediments will occur. Depending on the current movement, the suspended fine sediments may move to healthy corals and sea grass bed which in turn may get killed due to excessive sedimentation. However, sedimentation arising from such activities will be minimal. The location contain mostly sea grass beds as benthic cover where live coral concentration and fish abundance was very low (See **Section 5.2** for benthic cover analysis).

The placement of footprint of the structure will have little impact on the coral reef or lagoon ecology as the proposed location consists of a sandy bed with no coral cover. Other areas of the reef flat were covered with seagrass *thalassia hemprichii* beds and stony rock beds. No live corals were observed, except in areas closest to the reef edge. The seagrasss beds and rock beds are completely exposed above water during low tide. The risks of oil spills, underwater noise generated, and physical disturbance caused during the placement of rocks and sedimentation can also affect the lagoon ecology.

Visual observations carried out in the area and qualitative analysis done with the data to determine fish diversity and abundance revealed that fish population in the direct project footprint is very low. Most of the fish observed were juveniles residing in sea grass patches near the project site and other areas of the reef flat. Fish close to project areas were found to be residing in the concrete blocks being used for outfall construction and the groynes that have been installed during reclamation. Moray eels were spotted in submerged parts of the groynes and the rock beds of the reef flat, while juvenile sharks were spotted near the reclaimed shoreline. 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. However, the immobile and benthic organisms found directly under the footprint of the breakwater will be the most affected.

Although the residents of S. Feydhoo utilise the reclaimed area of the island for recreation, and the reef for recreational fishing, the proposed project is not expected to have an impact on these activities. There have been no developments on the reclaimed land yet and the fenced work site is the only land currently being used, the rest of the area is utilised by the residents. Access to the southern reef of the reclaimed land close to Gan airport is restricted to locals. Local fisherman mainly use the western side of the reclaimed land where the lagoon is deeper. This area is also preferred by locals going swimming. The work site has already been fenced off from the public, which is where the material and waste will be stored, and the breakwater construction will occur in between the groynes.

Mitigation measures for lagoon ecology and coral reef impacts

- Contractor is obliged to make an environmental action plan (EAP) in which actions and responsibilities are given to spills, waste, emissions;
- construction of the breakwater to be undertaken in segments;
- carryout the work in reasonable weather conditions;
- carryout the work in low tide;
- engage skilled labour with adequate experience; and
- continuous monitoring of environmental impacts during construction period by an independent party.

<u>Noise and vibration</u>

It is important to identify the sources of noise and vibrations and the intensity of such impacts on the project island. The noise and vibration impacts are expected to be minor as the nearest residential area to the project site is more than 390 m away.

The main source of noise from the construction phase of the project will be from the engines used in the machinery and vehicles, as well as noise during stockpiling. Typical noise level of construction machineries are detailed below:

Table 16: 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/ (%)[1]
Excavator	83	81	40
Dump truck	85	76	40
Pickup truck	55	75	40

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

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

[1] 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.

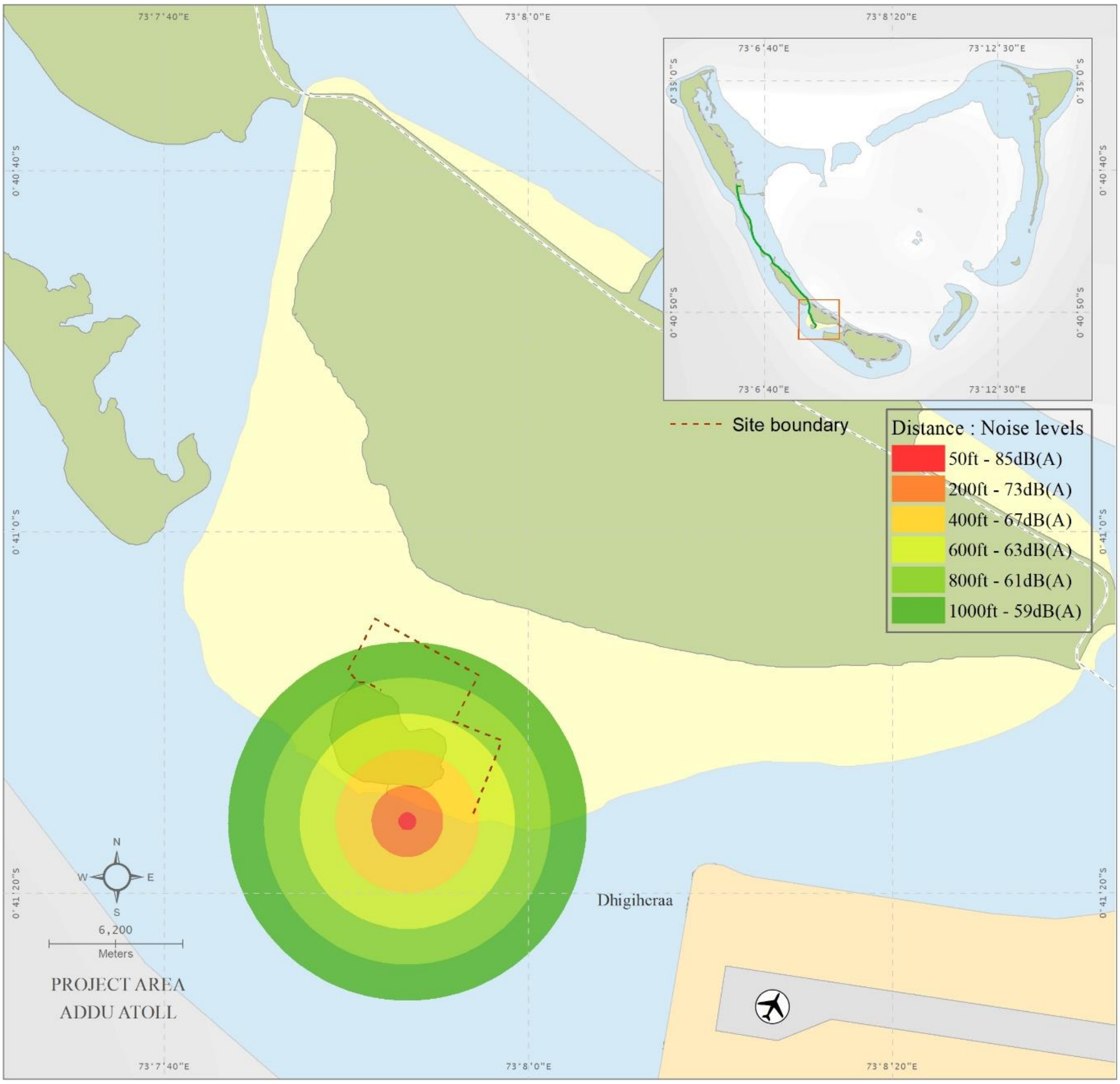


Figure 25: Noise range map for S Feydhoo project site

Mitigation measures for noise impacts

- 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; and
- informing the potentially affected population of the works schedule and record-keeping and addressing to any complaints received.

<u>Impact on vegetation</u>

The project does not consist of clearing vegetation**.** No other structures, temporary, or permanent are proposed to be built for this project (such as workers' camp). Careless workmanship may result in damages to the vegetation during movement of materials and other project related activities during the construction phase.

Mitigation Measures

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

<u>Accidents and injuries</u>

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

Mitigation measures

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

- Health and safety measures stated in **Section 2.7** shall be followed by contractor during construction works;
- Appropriate PPE will be worn at all times. This will typically include hard hats, eye protection,
- protective trousers, gloves and reflective clothing, hearing protection, masks and wet weather clothing as appropriate;
- first aid kit will be on site at all times;
- all plant will be operated by competent certified operators. Plant to be inspected regularly and
- have the appropriate certification;
- manual lifting operations will be kept to minimum by the use of mechanical means;
- site visitors should not be generally allowed to work site except when its essential in such cases shall be accompanied at all times and required PPE shall be provided;
- proper signage and fencing should be provided around the site;
- carry out works during good weather;
- avoid transportation during night; and
- securing any loads on vehicles during transportation.

7.3.1.5 C5 Waste Generation during Construction

Solid waste generated during the construction work would negatively impact the site and surrounding environment if not properly managed and disposed of at an approved dumpsite. Overall, the multi-criteria impact magnitude for waste generation was -34, implying that it will have a moderately negative impact. Solid waste, if allowed to accumulate, could cause localised conditions conducive to the breeding of nuisance and health-threatening pests such as mosquitoes. Poor construction waste management constitutes a short-term, possibly long-term, negative impact.

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

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

However, the amount of chemical and hazardous waste produced will not be significant. Municipal wastes are also expected to be generated during the construction phase by the workers comprising of food wastes, packaging wastes and waste paper.

The amount of human waste generated per person is approximately 125 g/day. Sewage will be managed through existing septic tank systems that have been installed in the island.

Mitigation Measures

- Ensure to manage waste as described in **Section 2.6** of the report;
- avoiding cooking and eating at work site to eliminate food waste and kitchen waste. Hence food for workers can be arranged with existing services on the island;
- reusable inorganic waste should be stockpiled away from drainage features;
- regular sweeping of the worksite to collect litter, empty cans etc which could become breeding ground for mosquitoes and other pests;
- open defecation whether it’s on land or on the beach shall be prohibited;
- appropriate general site cleanliness related signboards could be placed on the worksite to give workers reminders on good waste management practices;
- ensure to reduce waste by following the 3R steps; and
- waste collected shall be transported to nearest waste management facility after the construction works have ended.

7.3.1.6 C6 Resource Consumption

Consumption of goods impacts the environment in many different ways. For instance materials used for the project would contribute, directly or indirectly through the product lifecycle, to climate change, pollution, and biodiversity loss and resource depletion locally or elsewhere in the world.

Placing the breakwater would mean permanently having to give up existing space from the r for placing the footprint of the breakwater. Loss of lagoon space also mean loss of equivalent habitat space for lagoon organisms. The footprint of the breakwater is expected to take an insignificant percentage of the existing lagoon area. Therefore, although this is a non-reversible impact, it is considered to be minor due to minor space lost from the lagoon.

Other resources required would include water, power and construction materials required for the construction. Since the resource utilization is considered to be relatively small, and that it is not expected to significantly contribute to deplete the natural resources or would be a major source of GHG emission, the multi-criteria impact magnitude for this activity was -15, which meant that it will have a minor negative impact.

Since it would be very difficult to precisely determine by how much exactly the current project would contribute to the depletion of each type of various natural resources required for the project at local and global levels and by how much it would have contributed to global climate change, general impacts that are normally associated with natural resource use can be applied in relative terms for the project.

Mitigation

- Design to optimize the base area of the structure;
- Resource conservation shall be given a high priority in all stages of project development through bulk purchasing, putting in place measures to avoid wastage, encouraging reuse and recycling;
- careful store management and record keeping on use of materials;
- reduce idle time for vehicles and equipment and switching off after use;
- use well maintained, energy efficient equipment and lights;
- materials that are locally available shall be obtained as such instead of opting to bring those after a long haulage;
- materials shall be procured in bulk as much as possible;
- utilize day time hours for the construction when plenty of light is available; and
- FENAKA power supply will be used for electricity generating purposes.

Table 17: Impact identification matrix for operational phase

	Envisaged impact factors	O1 Breakwater	Total (Impact Area)
Physical Components	Seawater	-2 4	-2 4
	Ground water	9 7	9 7
	Air		0 0
	Noise		0 0
	Coastal Zone	7 7	7 7
Biological Components	Flora	4 3	4 3
	Fauna	2 1	4 3
Socio-Cultural Component	Aesthetics	-1 2	-1 2
	Accidents	9 7	9 7
	Landscape	-1 2	-1 2
	Health/Well being	8 5	8 5
	Cultural heritage		0 0
	Local economy	5 4	5 4
Total (operational Phase Activity/Risk)		**40** **42**	

7.3.2 Impacts and Mitigation from Operational Phase

Summary of the multi-criteria analysis is given in **Table 24*Table 15***

Table 18: Summary of operational phase impacts

Activity	Impact Score	Overall Impact
O1 Breakwater	40	**Major positive**

7.3.2.1 O1 Breakwater

Reduced risk of flooding as a result of protection provided to the current shoreline by the new detached breakwater structure is considered to be a significant positive impact. The provision of coastal protection works will reduce damage to property, reduce damage to assets, and reduce the ultimate risk of such damage affecting the operation of the Feydhoo sewerage network. Reduced flooding to this area can also prevent the groundwater of the area from future salinization, improving the groundwater quality throughout the operational phase. These are considered significant positive impacts of the project.

As the function of the breakwater is to reduce the incoming wave energy, the construction of this breakwater will result in changes to the hydrodynamics of the coastal region. Reduction of incoming wave energy causes wave attenuation at the leeward side of the breakwater. The littoral transport in the lee of the breakwater decreases due to wave attenuation and weakened longshore currents in the area sheltered by the breakwater. It is not absolutely certain how the changes to the hydrodynamic conditions brought about by the structure can affect the littoral transport system and accretion and erosion of the project area. Such a prediction would require in-depth numerical modelling of the site, which is not within the scope of this report. Due to the uncertainties it is recommended to conduct regular monitoring of the shoreline as directed by this report.

Construction of a breakwater without breaks or with circulation closed off by a groyne in one end may also create stagnation, lowering water quality in the lee of the structure. In order to mitigate this impact, the proposed design is a submerged breakwater which allows more circulation of water compared to an emerged breakwater.

The breakwater will also result in visual impacts on the area. 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. In order to mitigate this impact, a submerged breakwater is proposed. Unlike an emerged breakwater, the negative visual impact would only occur during low tide when the crest is emerged.

Measures to enhance positive impacts

- Conduct monitoring of the proposed development as proposed by the EIA and EIA Addendum

Mitigation for risk of deteriorating lagoon water quality

- Construct a submerged breakwater to allow overtopping of water over the structure.

Mitigation for changes in hydrodynamics

- Biannual monitoring for 4 years of beach profiles, high water line, low water line and vegetation line to understand the cycles of erosion and accretion relating the changes in the hydrodynamics of the area.

Mitigation for visual impacts

- Keep crest height of breakwater as low as possible while creating sufficient protection against waves.

8. ALTERNATIVES

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

8.1 NO DEVELOPMENT OPTION

The no development option for this EIA addendum is considered for the proposed additional coastal protection works at the south of the Feydhoo STP. In the case of no development option, all foreseeable negative impacts as a result of the proposed development can be avoided. However, no development option would also mean continuation of the risk of wave related flooding to the Feydhoo STP (See **Section 5.1.1 A**).

The positive effects of proceeding with the proposed coastal protection works outweighs negative impacts associated with the proposed works which can be managed and kept at an acceptable level. Hence, no development option of the project is rejected. **Table 19** below shows comparison of no development option with the development option at S. Feydhoo.

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

Option	Environmental	Social	Economic
No Development Alternative	All negative impacts associated with works avoided, however, the STP site will be at risk of swell and storm surges without the proposed breakwater.	Benefit to the society by the proposed development will be missed. Residents of S. Feydhoo may experience issues with the central sewerage system due to possible damage of the STP from wave related flooding.	Financial losses borne by STP operator due to wave related flooding. Potential economic uses of the surrounding area may not be feasible with the risk of swell and storm surge related flooding year-round.
Development Alternative	The development will result in changes to the nearshore hydrodynamics of the area. A permanent change to the breakwater footprint area will occur due to construction of the breakwater. Construction phase activities can lead to sedimentation of the project area in addition to loss of biota in the seabed of the breakwater footprint. No protected species or habitat will be lost. All	Possible negative social impacts on S Feydhoo community due to damage to Feydhoo STP can be avoided by proceeding with the construction of the breakwater. The aesthetic qualities of the area will be negatively impacted due construction of a breakwater, and due to stagnation of the water behind the breakwater as well as accumulation of	Potential financial losses borne by operator and island can be avoided by providing protection from wave related flooding.

	impacts can be managed and maintained at acceptable level. The breakwater will control swell and storm surge related flooding to the project area and Feydhoo STP.	litter behind the breakwater. However with the proposed mitigations such impacts are not expected to be significant.	

8.2 ALTERNATIVE METHOD OF COASTAL PROTECTION

Evaluation of alternative methods for coastal protection was conducted using a simple matrix based upon a scoring criteria (**Table 20**) which was applied to four predetermined key parameters. These were namely, the economic, environmental, effectiveness and social factor.

Table 20: Scoring Criteria

Type	Score
Negative	-1
No Change	0
Positive	1

The economic factor encompassed the cost of construction which includes contracting and material costs associated with the breakwater.

The environmental factors encompassed the level of impact on the marine environment by the proposed alternative.

The effectiveness factor encompassed the effectiveness of the proposed alternative in providing coastal protection to the STP site

The social factor encompassed the social impacts of the proposed alternatives, which include danger for locals during construction, visual impacts, and access for locals to the beach area.

8.2.1 Proposed Method: Detached breakwater

The shore protection method proposed is a detached submerged breakwater 15 m from the existing shoreline adjacent to the Feydhoo STP. The detached breakwater is designed to reduce the energy of incoming offshore waves. This in turn cause wave attenuation at the leeward side of the breakwater. The littoral transport in the lee of the breakwater decreases due to wave attenuation and weakened longshore currents in the area sheltered by the breakwater. The exact height of breakwater and length determined by hydrodynamic studies and bathymetry.

Advantages:

- A detached breakwater designed to the proper dimensions can provide sufficient protection from swell wave related flooding.
- The current beach area is preserved by constructing the breakwater as an offshore structure, compared to onshore revetments which will result in the breakwater footprint taking up beach area as well as access to the beach.

Disadvantages:

- An offshore breakwater leaves a permanent footprint on reef flat.
- Construction of the offshore breakwater can cause damage to ecosystem, especially the bottom biota of the breakwater footprint area.
- A detached breakwater can cause negative visual impacts during low tide.

8.2.2 Groyne

A groyne is a structure constructed perpendicular to the shoreline, extending from the shore to the sea. Groynes are mainly used to catch and trap part of the sediment from the littoral drift. Groynes also dissipate wave energy during weak and moderate wave conditions. Although, during storm conditions, groynes are not effective in dissipating wave energy. The Feydhoo reclaimed shoreline is currently stabilised using a network of groynes. Since the construction of the groynes, *udha* incident occurred to the south western coastal region of Feydhoo which resulted in flooding of the area. Therefore the effectiveness of groynes are observed to be low in the case of dissipating incoming wave energy at Feydhoo.

Figure 26: Rock boulder groyne in S Feydhoo

Advantages

- Properly designed and constructed groynes are effective in stabilising the shoreline
- Groynes are effective in dissipating weak and moderate wave energy.

Disadvantages

- Ineffective in dissipating strong offshore waves, therefore ineffective in protecting the coastal region from swells, *udha* and storm surges.

8.2.3 Floating breakwater

Floating breakwaters are an alternative to a traditional rubble mound breakwater. A floating breakwater would be anchored to the reef flat to remain in place. Floating breakwaters are effective in mild environments, and mainly used to protecting harbours or marinas. Floating breakwaters are less frequently used to protect coasts or for erosion control.

The floating breakwater components are made of reinforced concrete which are hollow or fitted with lightweight material. Floating breakwaters are useful in the case of short period waves (4-5 seconds in period). The main use of the proposed breakwater is to offer protection from oceanic swell waves which are longer in period, therefore a floating breakwater is seen as insufficient for this stated use.

Advantages

- A large volume of construction material is not required, compared to a rubble mound breakwater
- The footprint of a floating breakwater is limited to the anchors on the reef, therefore such a structure causes the least amount of disturbance to environment

Disadvantages

- Insufficient in protecting the area from swell wave related flooding, which is the objective of the proposed breakwater.

8.2.4 Onshore revetment

An onshore revetment acts as a solid protection against erosion from incoming wave energy. Newly reclaimed islands in the Maldives have utilised onshore revetments to protect the shoreline from erosion. A rubble mound armour layer over a core layer is constructed. The revetment is sloped according to design parameters.

Advantages

- Impacts on reef less compared to detached breakwater
- Easier construction method due to construction occurring on land

Disadvantages

- Loss of usable beach area
- Visual impacts of breakwater

Figure 27: Onshore revetment at S. Feydhoo

8.2.5 Preferred Alternative

Alternative analysis results were as below in **Table 21**.

Table 21: Alternative analysis matrix, coastal protection method

Parameters	Detached breakwater	Groyne	Floating breakwater	Onshore revetment
Economic	0	1	1	0
Environmental	-1	-1	0	0
Effectiveness	1	-1	-1	1
Social	1	0	0	-1
Total Score	**1**	**-1**	**0**	**0**

The studied alternative options of groynes and floating breakwaters show that they are not as effective against strong wave conditions. As the south western side of Feydhoo is exposed to the open ocean, the area experiences year round swell waves. While the option of an onshore revetment can be designed to protect the area from flooding, a disadvantage of this proposed option is the loss of usable beach area. Therefore the preferred alternative is the proposed method, a detached breakwater.

8.3 ALTERNATIVE TYPE OF DETACHED BREAKWATER

Evaluation of alternative methods for coastal protection was conducted using a simple matrix based upon a scoring criteria (**Table 20**) which was applied to four predetermined key parameters. These were namely, the economic, environmental, effectiveness and social factor.

Table 22: Scoring Criteria

Type	Score
Negative	-1
No Change	0
Positive	1

The economic factor encompassed the cost of construction which includes contracting and material costs associated with the breakwater.

The environmental factors encompassed the level of impact on the marine environment by the proposed alternative.

The effectiveness factor encompassed the effectiveness of the proposed alternative in providing coastal protection to the STP site

The social factor encompassed the social impacts of the proposed alternatives, which include danger for locals during construction, visual impacts, and access for locals to the beach area.

8.3.1 Proposed Type: Submerged Breakwater

A submerged breakwater is designed to cause wave breaking while allowing transmission of waves to the lee of the structure. Unlike an emerged breakwater, submerged breakwaters are only emerged during the low tide. The advantages and disadvantages of a submerged breakwater are given below.

Advantages

- Less visual impact compared to emerged breakwaters
- Less material is required therefore reduces the impact of transportation and direct and indirect climate impacts
- Therefore it is less expensive to construct
- Lower impact on the littoral transportation regime of the area
- Stagnation of water behind the breakwater is avoided due to water overtopping
- As they are similar to natural reefs they attract fish

Disadvantages

- Submerged breakwaters can be dangerous for navigation of small crafts
- Overtopping currents can be dangerous to swimmers

8.3.2 Alternative: Emerged Breakwater

An emerged breakwater is constructed at a height above the high water level (HWL) therefore it doesn't allow transmission of waves to the lee of the structure. The design of an emerged breakwater is comparatively easier compared to a submerged breakwater. The advantages and disadvantages are given below.

Advantages

- Provides a safe swimming area at the lee of the structure
- No danger to small vessels due to visibility at all tides
- Breakwater footprint is narrower compared to a submerged structure, therefore the impact of footprint as well as negative impact on the organisms on the seabed are less than an emerged breakwater

Disavantages

- More negative visual impact compared to submerged breakwaters

- More material required to construct the same length of a submerged breakwarter
- Water behind the breakwater may stagnate if the breakwater is not segmented
- Greater impact on the sediment transport of the coastal region

Figure 28: Alternative concept: emerged breakwater

8.2.6 Preferred Alternative

Alternative analysis results were as below in **Table 21**.

Table 23: Alternative analysis matrix

Parameters	Submerged breakwater	Emerged breakwater
Economic	1	-1
Environmental	0	0
Effectiveness	0	0
Social	1	-1
Total Score	**2**	**-2**

The analysis shows that the preferred option is a submerged breakwater. Economically, a submerged breakwater scores higher as less material is required therefore less costs would be incurred during the stages of construction. Environmentally, both options score similarly. While a submerged breakwater would cause impacts on a larger footprint and thus a greater amount of bottom biota, during the operation phase, a submerged breakwater would have less impact on the littoral transport as well as would not cause possible stagnation of the water at the lee of the structure. Both options score equally for effectiveness as both can be designed to effectively control wave related flooding at the Feydhoo STP. Socially the emerged breakwater scores negatively due to the negative aesthetic impact on the area, which would be less with the construction of a submerged breakwater.

8.4 ALTERNATIVE MATERIAL FOR COASTAL PROTECTION

8.3.3 Proposed Material: Rock Boulder

Rock boulders are proposed to be used as a material for the breakwater. Rock boulders used in accordance with proper design has been successfully implemented in inhabited islands as well as tourist resorts in Maldives. The porosity of a rock boulder structure is effective in dissipating the incoming wave energy.

8.3.4 Geobags

Other options for materials include geotextile bags filled with sand. An excavator is used to fill the geotextile bags. The geotextile bag is filled correctly until the minimum dimensions of the bag are achieved. Geobags are available in different sizes such as 2.5 m^3 bags as well as mega containers up to 20 – 25 m lengths or greater. In the local context, geobags are placed using slings or chains which can exert a high level of stress on the container and cause failure. Geobags used in Maldives have been subject to damage due to UV radiation and therefore would require constant repairs to avoid the sand washing out of the bags. A geobag breakwater would lack the porosity of a rock boulder breakwater, and essentially act as a solid breakwater reflecting wave energy. Another disadvantage with geobags is the possible turbidity of the area caused by the discharge from the damaged geobags. Due to these reasons, geobags are mainly proposed to be used for temporary structures such as protective bunds.

Figure 29: Placement of geobag using excavator (Source: Elcorock)

8.3.5 Preferred Alternative

In comparison, rock boulders are preferred over geotextile bags due to the greater amount of durability provided in addition to its effectiveness in dissipating incoming wave energy due to porosity. The required rock boulders are currently available in Addu City, and would not require use of sand as in the case of geotextile bags therefore is option is environmentally and economically feasible too.

9. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

Monitoring of construction phase impacts shall be followed as provided in **Chapter 12** and **Chapter 13** of the EIA report. The additional impact monitoring plan for the proposed for the Project is given in **Table 24.** 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 1**.

9.1 ENVIRONMENTAL MONITORING PLAN

Table 24: Additional impact monitoring plan

Objective	Activity	Parameters to be monitored	Cost (MVR)	Method	Frequency	Responsible person	Verifiable indicator	Phase
Reducing impacts on the sea water quality of the project area during construction	Work methodology followed. EAP created for spills, wastes and emissions.	Temperature, pH, Turbidity(NTU), Dissolved Oxygen (mg/L), Electrical Conductivity (µs/cm), Salinity (ppt)	20,000	In-situ tests	One month after work begins Halfway into the proposed works	Contractor Environmental consultant	Monitoring data and reports produced.	C
Minimum space from the lagoon is given up to the footprint of breakwater	Boundary of the breakwater footprint established as per the design criteria		Included in the construction cost	Set-out survey Filed measurements	Within one week after mobilisation	Contractor Environmental consultant	Temporary boundary marks	C
Roads are not degraded as a result of the project activities	Identify routes for vehicle operations Placing road signs along the paths. Repair sections of the road damaged after the construction works		Cost included in the contract	Discussions with island authorities, use of island maps, road repair equipment etc.	Before the construction works begin and after the construction work is complete	Contractor Environmental Consultant	Pictures, records, report prepared and submitted.	C

Reducing the risk of erosion in the beach area and adjacent coastal region due to construction of breakwater	Beach profiles with reference to established monitoring stations. High water line and Low water line surveyed.		20,000	Beach surveys Aerial photos	Bi- annually for fours years after construction works. One during NE monsoon, one during SW monsoon	City Council Proponent Environmental consultant	Survey reports Monitoring reports	O

10. CONCLUSION AND RECOMMENDATION

The EIA addendum report was prepared to address the proposed construction of a breakwater at the coastal area of the S Feydhoo STP site. Existing environmental studies showed that the Feydhoo STP site is located in a flood inundation zone from abnormal swell waves, storm surges and *udha* propagating from the south west of the island. Therefore in order to facilitate the proper operation of the STP and provide the much needed sewerage service to the island, the proposed coastal protection of the area is essential.

Benthic assessment of the proposed area for the breakwater footprint showed that the area was mostly covered with sand and rubble. The rest of the reef flat was covered in sea grass patches and live corals were only observed close to the reef edge. Therefore, the proposed additional construction works within this project is not expected to have major negative impacts on the environment.

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

The study found no evidence that the proposed construction will result in:

- loss of unique habitat or wilderness areas;
- loss of protected area;
- loss of protected flora or fauna;
- removing or destroying cultural properties;
- resettling of local communities;
- contravening with national laws, regulations, policies or multinational environmental agreements to which the Maldives is a Party to or customs or aspirations concerning environment, economy, employment, cultural traditions or life styles.

In order to enhance the positive impacts of proposed construction, the consultant recommends to conduct regular monitoring of the south western coastal region of Feydhoo as part of the project’s monitoring program.

The study found that through the implementation of the proposed practical and cost effective mitigation measures in this addendum report in conjunction with the EIA all significant impacts can be brought to an acceptable level.

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11. REFERENCES

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12. ANNEX 1: DECLARATION AND COMMITMENT LETTER (PROPONENT)

13. ANNEX 2: TERMS OF REFERENCE

14. ANNEX 3: A3 SITE LOCATION & SITE DETAIL SURVEY DRAWINGS

15. ANNEX 4: STAKEHOLDER ATTENDANCE

16. ANNEX 5: APPROVED CONCEPT PLAN

17. ANNEX 6: SUBMISSION TO CITY COUNCIL

18. ANNEX 7: EPA DECISION STATEMENT