ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Breakwater Construction in Hulhudhuffaru

Raa Atoll, Maldives

Proponent: Ministry of Housing and Infrastructure

Sandcays

February 2016

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Consultants Declaration

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

Ahmed Zahid (EIA 08/07)

بسم الله الرحمن الرحيم

Ministry of Housing and Infrastructure
Male', Republic of Maldives.

ހިދުމަތްތެރި ގެދޮރު ހަދާ ހިންގުމުގެ ތަރުތީބު ދާއިރާ
ގއ، ދިވެހިރާއްޖެ.

Date: 07th February 2016

No: 138-PIS2/203/2016/4

Mr. Ibrahim Naeem
Director General
Environmental Protection Agency
Ministry of Environment and Energy,
Ameenee Magu, Maafannu, Male', 20392,
Maldives.

Dear Sir,

Sub: EIA for the Proposed Harbour of R.Hulhudhuffaaru:

As the proponent of the project, we confirm our commitment to finance and implement all mitigation and the monitoring program as specified in the report.

Thanking you.

Sincerely,

MINISTRY OF HOUSING AND INFRASTRUCTURE
REPUBLIC OF MALDIVES

Aishath Bariyya
Engineer

Ameenee Magu, Maafannu, Male', 20392, Republic of Maldives.
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Proponent's Commitment and Declaration

This is in reference to the EIA report for the Proposed Breakwater construction in Hulhudhuffaru, Raa Atoll, Maldives.

As the Proponent of the project, we guarantee that we have read the report thoroughly and that to the best of our knowledge all information provided here is accurate and complete.

Aishath Bariyya
Engineer
Ministry of Housing and Infrastructure
07 February 2016

Executive Summary

The project is proposed by Ministry of Housing and Infrastructure. The project entails construction of breakwaters along the channel in the island of Hulhudhuffaru. A 130m long breakwater will be built on the northern side of the channel while 30 m structure will be built on the southern end. Additionally, the harbor basin will be dredged to obtain an even depth of 3m from MSL. Dredge material will be stockpiled north of the harbor. Proposed excavation and breakwater construction will be carried out using an excavator on barge, cranes and dump trucks. The project is expected to be completed within 250 days.

Under the Maldives Environmental Protection and Preservation Act (Law No. 4/93) and EIA Regulation 2012, such developments require an EIA to be carried out and the environmental clearance is given in the form of a Decision Statement by EPA. The project proponent commissioned Sandcays Pvt. Ltd to carry out the EIA. The scope of the EIA report is to assess, identify, predict and document potential environmental impacts from the proposed breakwater replacement and maintenance dredging by Ministry of Housing and Infrastructure in Raa. Hulhudhuffaru.

As the existing channel is rough and harbor basin has become shallow due to sediment deposition from surrounding areas, the key aim of the proposed project is to provide a safe access and mooring area for as many vessels as possible during both the monsoons.

Baseline environmental conditions of the site have been undertaken for which environmental impacts from the project has been identified and evaluated. Also, some alternatives, in terms of alternative materials, design and dredge material disposal to the project as well as no project development option have been stated. Preferred options have been stated over alternatives for the proposed project implementation.

The environmental impacts that are associated with the proposed breakwater construction are divided into construction phase and operation phase environmental impacts. Most of the construction phase environmental impacts are believed to occur from construction of breakwater and maintenance dredging. The main environmental impacts associated with the proposed project include changes in marine water quality and possible changes in oceanographic setting of the project area.

As part of the proposed development, a number of mitigation measures will be taken into consideration; such as careful planning of the project implementation, reusing and appropriately disposing of construction waste and undertaking regular environmental monitoring to asses any changes to the environment due to project activities and formulate mitigation measures to unexpected impacts.

The overall environmental performance will be monitored by an environmental monitoring framework that will be implemented as part of the proposed breakwater construction project on Raa. Hulhudhuffaru.

ސާރާ ހުލާސާ

މި ރިޕޯޓަކީ ރ. ހުޅުދުއްފާރު ހުޅަނގު ފަރާތު ބަނދަރުގައި ނެރުފައިކަރި ޖެހުމާއި ބަނދަރު ފުންކުރުމަށް ބަލައި ހުށަހަޅާފައިވާ މަޝްރޫޢުގެ ސަބަބުން ތިމާވެއްޓަށް އަސަރުކުރާނެ މިންވަރު ބަޔާންކޮށްދިނުމަށް ތައްޔާރުކޮށްފައިވާ ރިޕޯޓެކެވެ. މި މަޝްރޫޢުގެ އިދާރާއަކީ މިނިސްޓްރީ އޮފް ހައުސިންގ އެންޑް އިންފްރާސްޓްރަކްޗަރއެވެ.

ދިވެހި ރާއްޖޭގެ ތިމާވެށި ރައްކާތެރިކުރުމާއި ދެމެހެއްޓުމުގެ ޤާނޫނާއި އީ.އައި.އޭ ގަވާއިދު 2012 ގައި ވާ ގޮތުގެ މަތިން ހުށަހެޅިފައިވާ މަސައްކަތެއް ފެށުމުގެ ކުރިން ތިމާވެއްޓަށް އަސަރުކުރާނެ މިންވަރު ދިރާސާކުރުމަށް ފަހު ރިޕޯޓު ހުށަހަޅާ ރިޕޯޓަށް ބިނާކޮށް އީ.ޕީ.އޭ އިން ހުއްދަ ދޫކުރުމަށް އިދާރާގެ މައްޗަށް ލާޒިމުކުރެއެވެ. މިގޮތުން އިދާރާގެ ފަރާތުން ތައްޔާރުކުރި ރިޕޯޓު ބަލާ އީ.ޕީ.އޭ ގެ މަސައްކަތް ކުރުމަށް ހުށަހަޅައެވެ.

ހުޅުދުއްފާރުގެ ބަނދަރަށް ވަންނަ ނެރު ގަދަވުމާއި ބަނދަރު ތިރިވުމުގެ ސަބަބުން ބަނދަރުގެ ބޭނުން ކުރުމުން އަންނަ އޮޑިދޯނި ފަހަރަށް ނުރައްކާ ދަތިތަކާ ކުރިމަތިވެފައިވެއެވެ. މިކަމުން ހައްލުކުރުމަށް ބަލާ މަޝްރޫޢުގެ އިދާރާ މި ޕްރޮޖެކްޓް ހުށަހަޅާފައި ވަނީއެވެ. މިގޮތުން ނެރުގެ އުތުރުފަރާތުގައި 130މ ގެ ބްރޭކްވޯޓަރ ދިގު ފަރާތުގައި 30މ ގެ ބްރޭކްވޯޓަރ ޖެހުމަށް ވަނީ ހަމަޖެހިފައެވެ. މީގެ އިތުރުން ބަނދަރު ފުންކޮށްގެން ނަގާ ފަސް ބަނދަރުގެ އޮތް ފަރާތުން ސްޓޮކްޕައިލް ކުރުމަށް ވަނީ ހަމަޖެހިފައެވެ. މަޝްރޫޢު ނިމުމުން ދުރު މުސްތަޤްބަލުގައިވެސް އޮޑިދޯނިފަހަރަށް ބަނދަރު ބޭނުންކުރުމުގައި ރައްކާތެރިކަން ލިބިގެންދާނެކަމަށް ފެނެވެ.

މި މަޝްރޫޢުގެ ދަށުން ކުރުމަށް ހުށަހަޅާފައިވާ މަސައްކަތްތަކުގެ ބަދަލުގައި ކުރެވިދާނެ ބަދަލު ކަންކަމަށް މިރިޕޯޓުގައި އަލިއަޅުވާލާފައިވާނެވެ. އެގޮތުން ބޮޑުހިލަގެ ބަދަލުގައި ބޭނުންކުރެވިދާނެ ޖިއޯބޭގް ބޮކްސް އާއި ބޮލީގެ ޖެހުން އަދި ގުނޑީން ބަދަލުކުރުމާއި ބަނދަރުން ނަގާ ފަސް ސްޓޮކްޕައިލްކުރުމުގެ ބަދަލުގައި ކުރެވިދާނެ ބައެއްކަންކަމަށް އަލިއަޅުވާލާފައިވާނެވެ.

މަޝްރޫޢުގެ ސަބަބުން ތިމާވެއްޓަށް ކުރާނެ ކަމުން ހާނިއްކަމެއް ދެކެވޭ ނުރައްކާ އަސަރުތަކާއި ކުރާނެ އިތުރު އަދި އިޞްލާޙީ ފިޔަވަޅު ބޭނުންކުރަން ފާހަގަ ކުރެވިފައެވެ.

މި މަޝްރޫޢުގެ ސަބަބުން ތިމާވެއްޓަށް ކުރާނެ ނޭދެވޭ އަސަރުތަކުގެ ތެރޭގައި ވަގުތީގޮތުން މޫދު ކިލަނބުވާނެ ކަމަށް ފާހަގަ ކުރެވެ. މީގެ ސަބަބުން މުރަކަތަކުގެ މޫދުގެ ދިރުމަށް ގެއްލުންވާނެ ކަމަށްފެނުނު ނަމަވެސް މޫދު ކިލަނބު ވާނެ ކަމަށް ބެލެވޭ ސަރަހައްދުގައި ދިރޭމުރަކަ މަދު ކަމުން ތިމާވެއްޓަށް ލިބޭ ގެއްލުން ކުޑަކަމަށް ފާހަގަ ކުރެވިއްޖެ.

މަޝްރޫޢުގެ ސަބަބުން ވެށްޓަށް އަންނަމުންދާ ބަދަލުތައް ދެނެގަތުމުގެ ގޮތުން މިފަދަ މަޝްރޫޢުތަކުގައި މައިގަނޑު ގޮތެއްގައި ބަލާނީ ކޯރަލް ސަރަހައްދުން ފެނުގެ ކޮލިޓީ (ކިލަނބުގެ އަސަރު - ޓޯޓަލް ސަސްޕެންޑެޑް ސޮލިޑްސް އާއި ޓާބިޑިޓީ) އާއި އޮއިވަރު އަދި ރަށުގެ ގޮނޑުދޮށަށް އަންނަމުންދާ ބަދަލުތަކެވެ. މި މަޝްރޫޢުގެ ދަށުން ކުރާ މިފަދަ ދިރާސާތަކުގެ ބޭނުމަކީ މިފަދަ މަޝްރޫޢުތަކުގެ ސަބަބުން ކުރާ ނޭދެވޭ އަސަރު ދެނެގަތުމާއި މުސްތަޤްބަލުގައި މިފަދަ ކަންތަކުން އެންމެ އެކަށީގެންވާ ހައްލެއް ހޯދުމުގައި އެހީތެރިވާނެ މައުލޫމާތު ލިބިގަތުމެވެ.

މި ރިޕޯޓުގައި ހިމަނާފައިވާ ކަންކަމަކީ އޭގެ ސަބަބުން ތިމާވެށްޓަށް ކުރާ ނޭދެވޭ އަސަރު ކުޑަ ނުވަތަ ނޭދެވޭ އަސަރެއް ކަމަށް ކަނޑައެޅޭ ދުރާލާ ފިޔަވަޅުތައް ކަންކަމަށް ފެހިފައިވާ މަޝްރޫޢުގެ ސަބަބުން މައިގަނޑުގޮތެއްގައި ލިބޭ ފައިދާ ބޮޑުކަމަށް ފެންނާތީ، މި މަޝްރޫޢު ހުށަހަޅާފައިވާ ގޮތަށް ކުރިއަށް ގެންދިއުން އެންމެ ރަގަޅު ކަމަށް ފެނެއެވެ. ނަމަވެސް، މި ރިޕޯޓުގައި ފާހަގަ ކޮށްފައިވާ ބަދަލު އެޑްޖަސްޓްމަންޓްތަކަށް ރިޢާޔަތް ކުރުމަށްފަހު މަޝްރޫޢު ކުރިއަށް ގެންދިއުން މުހިއްމުކަމަށް ފެނެއެވެ.

1 Introduction

1.1 Background

The Environmental Impact Assessment (EIA) Report for the Proposed Coastal Modification Works in Raa. Hulhudhuffaru has been prepared in fulfillment of the requirement stipulated in the Environmental Protection and Preservation Act of Maldives (Law No. 4/93), where it states that an EIA is required to be carried out prior to implementing projects that have the potential for negatively impacting the environment and natural resources. A further confirmation is given in the Environmental Impact Assessment Regulation of 2012, which prescribes under the Schedule D of the Regulation that EIAs are required for any coastal modification, alteration and protection projects.

The report is based on information collected during site visit and based on experience of consultants from similar projects carried out in the past.

1.2 Project Overview

The proposed project for undertaking coastal protection measures involves;

A) Construction of a 140m rock boulder breakwater;

B). Maintenance dredging of the harbor basin to achieve a depth of 3m from MSL

1.3 Scope of the EIA and Approach

The scope of the EIA is based on the Scoping Meeting conducted by the Environmental Protection Agency (EPA) with key stakeholders on 25th October 2015. As discussed at the Scoping Meeting, the general scope of the EIA is to assess, identify, predict and document potential environmental impacts from the proposed breakwater construction and maintenance dredging at Raa. Hulhudhuffaru. Also, as part of the scope, existing environmental conditions of the site, measures to management and mitigate predicted environmental impacts, propose alternative project locations and methodologies, as well as an environment al monitoring plan in order to understand long-term environmental changes forms the comprehensive scope of the EIA.

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

- Review of available Project documentation;
- Discussions with key stakeholders;
- Site visits to the island;
- Baseline environmental assessments;
- Maldives Environmental Protection and Preservation Act No. 4/93;
- Regulation on Environmental Impact Assessment of 2012;
- Key government policies on environmental management;
- Sandcay's previous experience of undertaking EIAs for projects in the Maldives; and
- Other relevant EIAs for similar development projects that have been carried out in the Maldives.

1.4 Relevant Studies and Experiences

While preparing this EIA, the following reference EIAs on coastal protection projects carried out in the Maldives have been used. These reports are available on public domain on the EPA website.

- Environmental Impact Assessment Report for the Proposed Breakwater replacement Project at Naifaru, Lhaviyani Atoll, Maldives, prepared by Sandcays Pvt. Ltd. in July 2015
- Environmental Impact Assessment Report for the Proposed Coastal Modifications in Chaaya Lagoon Hakuraa Huraa, Meemu Atoll, Maldives, prepared by Sandcays Pvt. Ltd. in October 2013
- Environmental Impact Assessment Report for the Proposed Coastal Protection of Summer Island Resort, North Male' Atoll, Maldives , prepared by Water Solutions Pvt. Ltd. in January 2011

- Environmental Impact Assessment Study for Shoreline Rehabilitation and Protection Measures in Sun Island Resort and Spa, A.Dh. Atoll, Maldives, prepared by LaMer Group Pvt. Ltd. in February 2011

1.5 EIA Report Structure

This EIA Report and its contents have been produced in accordance with the general EIA guidelines and scope of work for preparation of EIA discussed at the EIA Scoping Meeting and stipulated in the EIA Regulation of 2012. A summary of the main contents of this EIA is presented below;

1. **Legal Framework:** An assessment of the existing policies, laws, regulations that the project has to comply with, and information on relevant agencies responsible for environment administration, management and protection;

2. **Description of the Project:** A description of the overall project including concepts and plans, aims, objectives and project justification, main project inputs and outputs, project schedule.

3. **Alternatives:** Assessment of alternatives to various project activities such as methods and locations;

4. **Existing Environment:** An assessment of the existing environmental status of the site in general and in particular existing coastal and marine environmental conditions;

5. **Stakeholder Consultation:** Presentation of key stakeholder concerns;

6. **Potential Environmental Impacts:** Prediction of potential environmental impacts and identification of the magnitudes of environmental implications that will be associated with the proposed project;

7. **Environmental Management and Mitigation:** Identification and assessment of the ways in which the environment of the project managed and mitigated; and

8. **Environmental Monitoring:** Development of a comprehensive environmental monitoring plan with regards to long-term monitoring of various environmental aspects related to the project development.

1.6 EIA Team

Following are the team members involved in the process of environmental assessment and preparation of the EIA Report.

9. **Ahmed Zahid,** Lead EIA Consultant (EIA 08/07): This EIA was reviewed by Zahid. He has many years of experience in the field of Environmental Impact Assessments in the Maldives. Mr. Zahid has largely involved in several small island coastal protection, harbour development, land reclamation, water/sewerage project and resort development project EIA's undertaken in the Maldives.

10. **Hussain Fizah,** EIA Consultant (EIA 01/14): This report was compiled by Fizah. He has been involved with all the EIAs carried out by Sandcays Pvt. Ltd. since late 2012. These include numerous harbour, land reclamation and coastal modification projects

2 Legislative and Regulatory Considerations

This section will identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. The proposed project is expected to conform to all of the policy and regulatory aspects outlined here. This section outlines and summarizes key policies, applicable laws and regulations and regulatory bodies regarding environmental protection in the Maldives.

2.1 Applicable Laws and Regulations

2.1.1 Environmental Protection and Preservation Act (Law No. 4/93)

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

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

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

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

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

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

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

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

2.1.2 Maldives EIA Regulation, 2012

The most important regulation concerning the proposed development is Environment Impact Regulations, 2007, which was amended in 2012 is enforced under Environment Protection and Preservation Act (Law No. 4/93) by the Environmental Protection Agency (EPA). The Clauses of Environment Protection and Preservation Act address the following that relate to the proposed project development and implementation.

- An impact assessment study shall be submitted to the relevant Government authority before implementing any development project that may have a potential impact on the environment

- The relevant Authority of Government shall formulate the guidelines for environmental impact assessment and shall determine the projects that need such assessment as mentioned in above.

- The Termination of projects. The relevant Government Agency has authority to terminate any project that has any undesirable impact on the environment. A project so terminated shall not receive any compensation

- Waste Disposal, Oil and Poisonous Substances. Any type of waste, oil, poisonous gases or any substance that may have a harmful effect on the environment shall not be disposed within the territory of the Maldives

- Government of Maldives reserves right to claim compensation for all the damages that area caused by the activities that are detrimental to the environment.

2.1.3 Environmental Damage Liabilities Regulation, 2011

Under the Environmental Protection and Preservation Act (No. 4/93), the Ministry of Environment and Energy formulated the Environmental Damage Liabilities Regulation in February 2011, which encompasses the basis to avoid environmental deterioration, extinction of biological resources, environmental degradation and avoid wastage of natural resources.

The main purpose of this regulation is to stop unlawful activities on environment and adequately implement a fining procedure for violations as well as implement a compensation mechanism on environmental damages. Its Schedules form the basis for levying fines on various environmental components and activities. Hence, the proposed project will be subject to this Regulation for any activity outside of the EIA scope and Environmental Decision Statement.

2.1.4 Dredging and Reclamation Regulation, 2013

The Dredging and Reclamation Regulations was gazetted on 2 April 2013 as Regulation No. 2013/R-15. This regulation is currently in Dhivehi and an English translation is awaited.

Clause 6 of the Regulation requires applying for approval under this Regulation by submitting the project details, land use plan, project justification and scaled maps of existing site plan and site plan with proposed project components. The EIA process can be commenced once EPA approves the application under this Regulation.

Clause 7 provides the conditions for dredging, clause 8 for reclamation and clause 9 for beach nourishment or beach enhancement. Clause 9 is of specific relevance to the project under consideration in this EIA. Clauses 13 and 14 are also of relevance. Clause 9(a) states that beach nourishment shall be done up to 10m from the registered shoreline. Clause 9(b) identifies that sand for beach nourishment shall be taken from an area (borrow area) that is not prohibited under clause 13 of the Dredging and Reclamation Regulation. Clause 13(c) states that borrowing material from the following areas are prohibited.

100m shore-wards from the reef line

500m seawards from the reef line

50m from the vegetation line

Protected Area or Environmentally Sensitive Areas (ESA) identified under Law No. 4/93 (Environmental Protection and Preservation Act of the Maldives).

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

2.2 Relevant Policies

2.2.1 National Framework for Development, 2009-2013

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

- Policy 1: Strengthen EIA process with an emphasis on EIA monitoring
- Policy 2: Conserve and sustainably use biological diversity and ensure maximum ecosystem benefits
- Policy 3: Develop resilient communities addressing impacts of climate change, disaster mitigation and coastal protection
- Policy 4: Strengthen adaptation and mitigation responses for beach erosion and develop a system to assist communities where livelihood and property are affected by beach erosion
- Policy 5: Ensure management of solid waste to prevent impact on human health and environment through approaches that are economically viable and locally appropriate
- Policy 6: Ensure protection of people and the environment from hazardous waste and chemicals
- Policy 7: Improve air quality to safeguard human health
- Policy 8: Enable a fully functional decentralized environmental governance system

- Policy 9: Develop a low carbon economy to achieve Carbon Neutrality by 2019
- Policy 10: Inculcate environmental values in the society and enable environmentally friendly lifestyle

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

2.2.2 3rd National Environmental Action Plan, 2009-2013

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

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

The key principles of the NEAP 3 are;

- Principle 1: Environmental protection is the responsibility of every individual
- Principle 2: Achieve results
- Principle 3: Promote and practice sustainable development
- Principle 4: Ensure local democracy
- Principle 5: Inter-sectoral co-ordination and co-operation
- Principle 6: Informed decision making
- Principle 7: Precaution first
- Principle 8: Continuous learning and improvement
- Principle 9: Right to information and participation
- Principle 10: Environmental protection complements development

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

2.2.3 Maldives national Strategy for Sustainable Development, 2009

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

The guiding principles outlined in the NSSD are;

- Principle 1: Promotion and protection of fundamental human rights
- Principle 2: Equity within and between generations
- Principle 3: Democratic and open society
- Principle 4: Full participation of businesses and civil society
- Principle 5: Policy coherence and coordination
- Principle 6: Use best available knowledge
- Principle 7: Precaution first
- Principle 8: Make polluters pay

While the country will be steered in accordance with the underlying principles of NSSD, the country aims to achieve very important environmental goals, including; adapting to climate change, protecting coral reefs, achieving carbon-neutrality in energy, ensuring food security, establishing a carbon neutral transport system, protecting public health and achieving full employment and ensuring social security.

2.3 Regulatory Bodies

2.3.1 Ministry of Environment and Energy, MEE

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

2.3.2 Environment Protection Agency, EPA

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

2.3.3 Atoll Councils and Island Councils

Under the Maldives Decentralization Law, elected Atoll Councils and Island Councils have been formed as regulatory bodies dealing directly with Atoll and Island issues. In this regard, some of the development projects are subject to approval of these councils through a public consultation process. For the proposed project, EPA requires that a copy of the final draft of the EIA Report be submitted to the Atoll Council and receipt provided to EPA or attached to the EIA report.

2.4 Environmental Permits Required

2.4.1 EIA Decision Statement

The most important environmental permit to initiate the proposed breakwater construction and maintenance dredging project would be a decision regarding this EIA from the EPA. The EIA Decision Statement, as it is referred to, shall govern the manner in which the project activities must be undertaken. It is the final environmental clearance granted by the EPA for the proposed project.

3 Project Description

3.1 Introduction

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

3.2 The Proponent

The project is proposed by Ministry of Housing and Infrastructure.

1.1 Project Location

Situated on the south eastern rim of Raa Atoll, approximately 185 km north of Male', the island of Hulhudhuffaru is located at 73°00'42" E (longitude) and 5°45'50" N (latitude). The island of Hulhudhuffaru sits on an individual reef system on which the island lies on the southern end.

The island is on the south eastern side of the reef system with large lagoon towards west with north western side more wide. .Eastern side is the oceanward side with strong wave action. However the northern part of Raa atoll is sheltered by the Shaviyani and Noonu atoll system found on the north east of Raa Atoll.

The island harbour is located towards mid of the island on the western side with a channel.The island is 1.6kmin length with a total land size of 14.27 hactares.

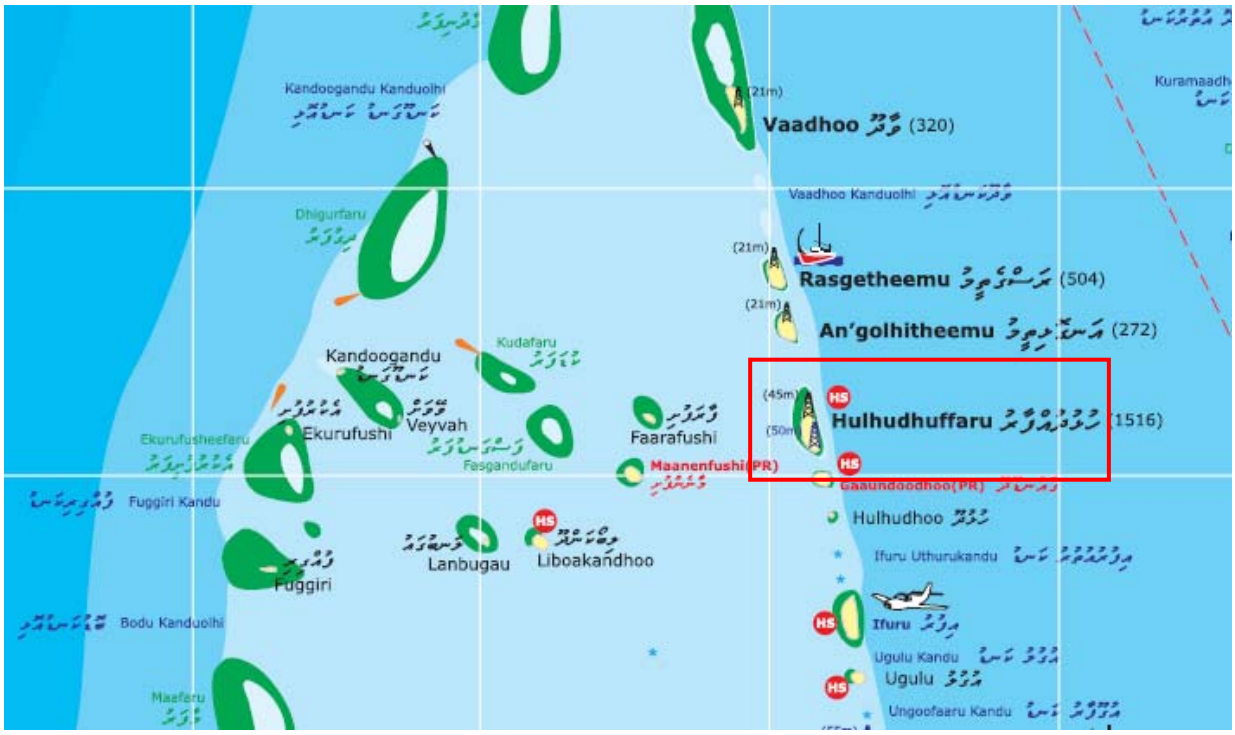


Figure 3-1: Location of Raa. Hulhudhuffaru

1.2 Project Boundary and Study Area

The proposed project entails construction of a 140 m breakwater structure along both sides of the entrance channel to the harbor and maintenance dredging of the harbor basin (Figure 3-2).

Northern side of the channel will be lined with a 110m long boulder rock breakwater structure and a 30 m structure will be place on the southern side.

Hence, the main study area for the purpose of collecting information on the existing environmental conditions is focused on the eastern coastal and marine area of the island (Figure 3-2).

Figure 3-2: Project Boundaries

3.3 The Project

The project aims at construction of a total of 140 m of breakwater along the islands harbor access channel. Currently the harbor is not protected by breakwater structures. This leads to frequent maintenance dredging and hindrances in navigating the channel during rough weather.

In addition maintenance dredging of harbor will be carried out. The harbor basin on average has a depth of 2m from MSL at present; ideal depth for a harbor basin for use by typical Maldivian vessels is 3m from MSL. As such, the basin will be deepened to obtain 3m from MSL. An estimated amount of 26 000m^3 will be obtained from this operation. The current proposal for material disposal is stockpiling at the northern end of the island; an area of 100m by 100m will be used for this (Figure 3-4).

3.3.1 Breakwater Design

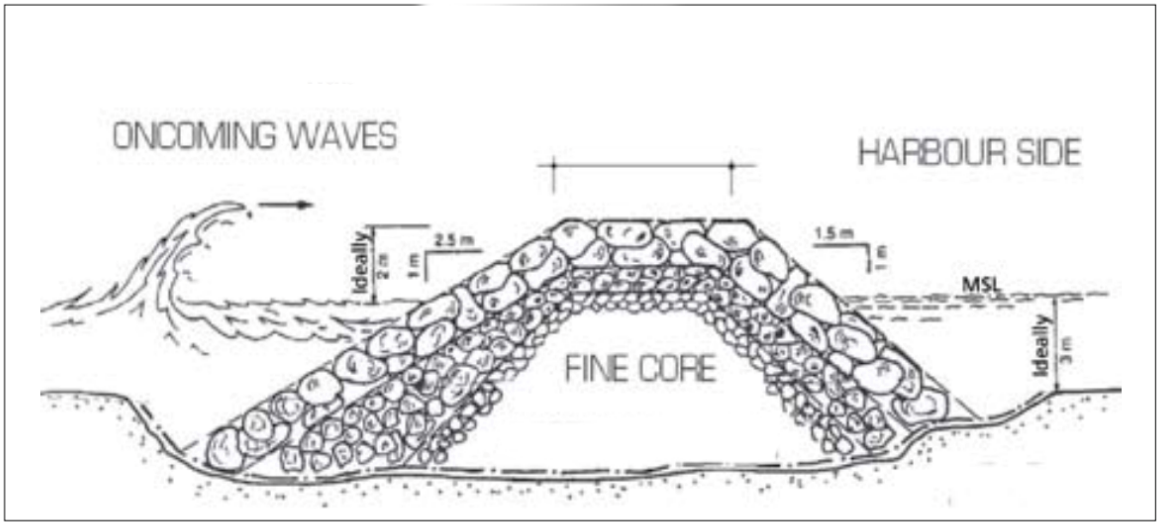


Figure 3-3: Cross section of a typical rubble-mound breakwater

The proposed breakwater is a rubble-mound construction with core built from smaller rocks weighing between 1 and 200kg. The core should be ideally three to four meters wide at the top and approximately half a meter above mean sea. When tipped into the water, the core rubble comes to rest at a slope of approximately 1 on 1, i.e. it drops down 1 meter in level for every 1 meter forward.

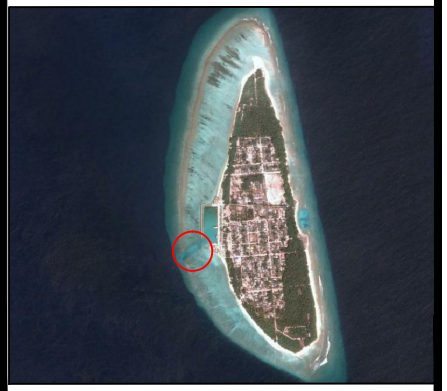
The under layer of stone that protects the core rubble from being washed away usually consists of single pieces of stone whose weight varies between a minimum of 200kg to a maximum of 500kg. These are usually laid in a minimum of two layers at a slope which is generally shallower than that of the core; 2/1 on the outer slope and 1.5/1 on the inner slope. A slope of 2/1 means that the level drops 1 meter for every 2 meters forward.

The main armor layer, as its name implies, is the primary defense of the breakwater against wave attack. The stone sizes for the cross-section in the shallow water example should be in the range of 500kg to 3000 kg. As with the first under layer, two layers of armor stones are required to complete the main armor layer.

Figure 3-4: Proposed Project Concept

HARBOUR LOCATION:

N



DRAWN BY: AHMED EVAN WASEEM

APPROVED BY:

PROJECT:

EXTENSION OF R. HULHUDHUFAARU BREAKWATER

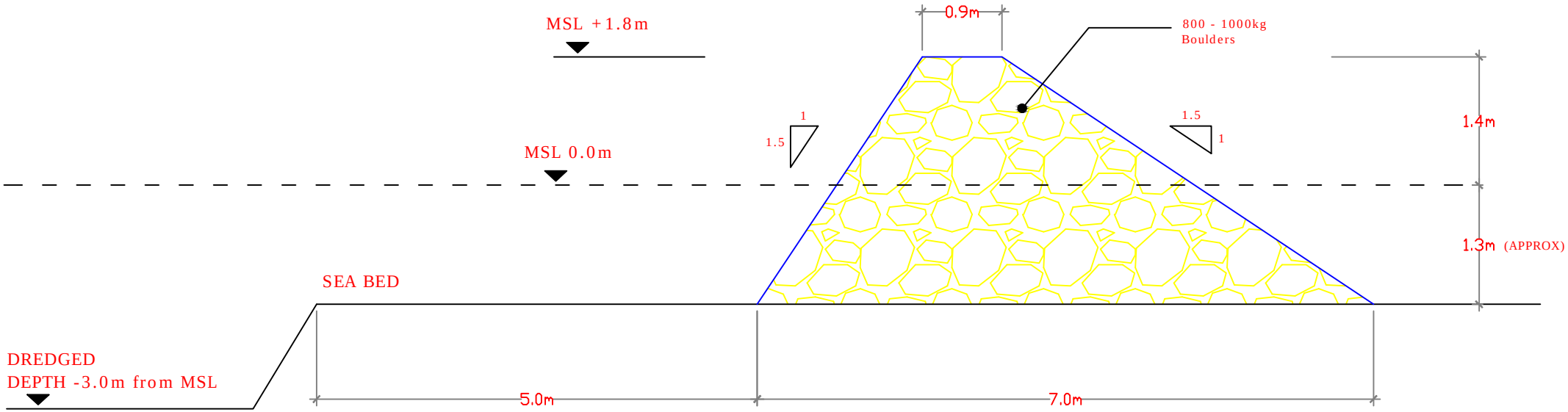
CONTENTS:

HARBOUR LAYOUT

DATE:

22 JUNE 2015

ENGINEERING DIVISION
MINISTRY OF HOUSING AND INFRASTRUCTURE
AMEENEE MAGU MALE' 20392
REPUBLIC OF MALDIVES
TEL: 300 4300, FAX: 300 4301



BREAKWATER PROFILE 1:75

ENGINEERING SECTION
MINISTRY OF HOUSING AND INFRASTRUCTURE
REPUBLIC OF MALDIVES

3.4 Work Method

The following sections describe work methods employed during project components.

3.4.1 Breakwater construction

Construction of breakwater will be mainly carried out by excavator and cranes. Dump trucks and barge will be used to facilitate the process. The first layer of stone may be placed by a hydraulic excavator on barge. The excavator should place the heavier stone as quickly as possible without leaving too much core rubble exposed to wave action. A wooden pole should be conveniently placed at the tip of the underlying core and cemented into place with mortar. At a distance equal to 2.5 x H, a heavy stone sinker with a marker buoy should be placed on the sea bed. A brightly colored nylon string should then be strung from the sinker to the required height on the pole. This procedure should be repeated every 5.0 meters to help the crane or excavator operator with the placing of the top-most layer. A swimmer wearing goggles should ensure that each separate rock is placed within the profile outlined by the nylon string (Figure 3-5).

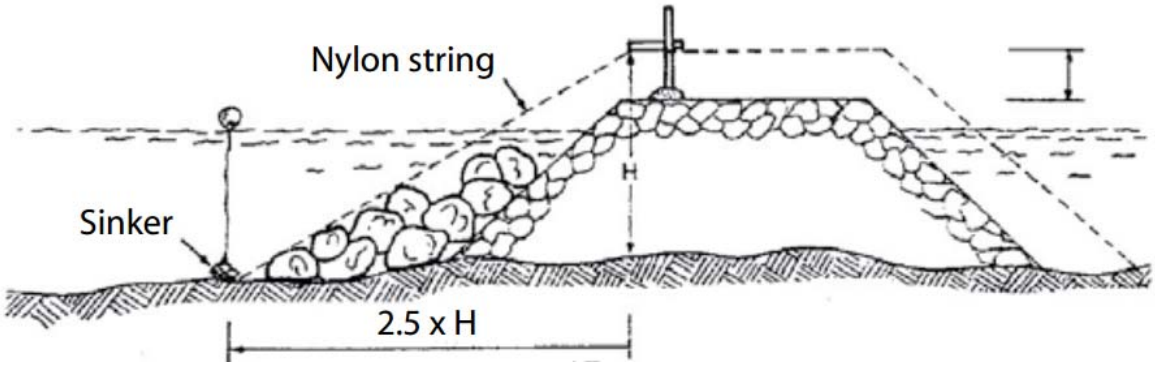


Figure 3-5: Constructing core and under layer

The large stones should be lifted singly using a sling or stone grapple and placed in the water with the aid of a diver swimming over the placing area. The armor layer should be placed stone by stone in a sequence which ensures interlocking; in Figure 3-6, for example, stone 2 is held in place by stones 1 and 3 whereas stone 4 is jammed between stones 3 and 5. This ensures that waves cannot pull one stone out and cause the upper stones to topple down the slope, breach the armor layer and expose the smaller rubble underneath. To ensure proper

placing, the swimmer or boat crew should direct the crane operator each time a stone is placed until the stone layer breaks the surface.

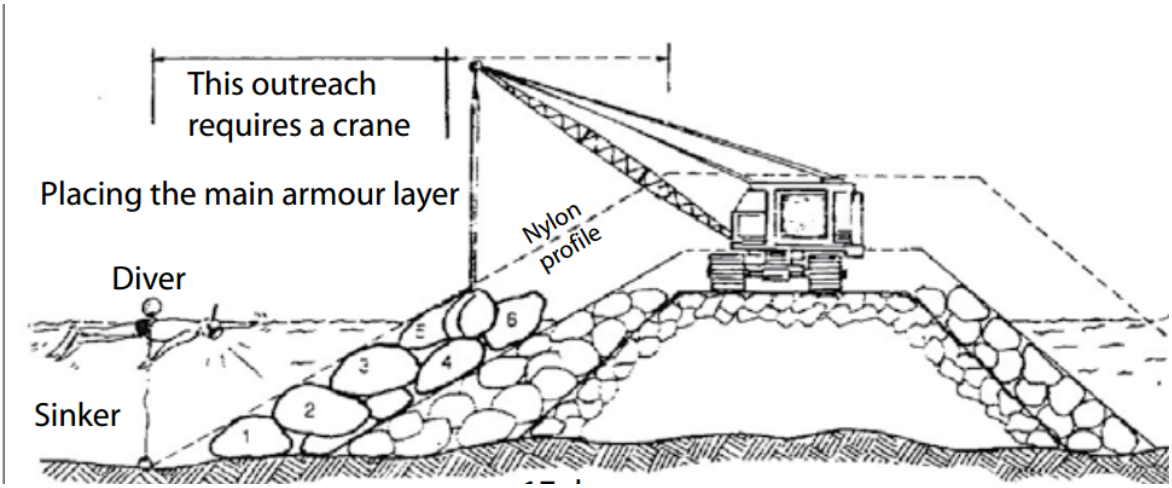


Figure 3-6: Constructing armor layer

3.4.2 Maintenance dredging

An excavator on barge will be used to dredge the harbor basin to obtain desired depths. Excavator will dump dredge material on the dump truck and be carried to stockpiling area. A detailed bathymetry of the basin will be compiled by contractor before construction begins. Areas that need to be excavated will be identified and marked with floating buoys.

3.5 Project Duration

The project is expected to be completed in a period of 250 days. The details of the project schedule are outlined in the following table.

Table 3-1: Project Schedule (Tentative)

Duration/ months	1	2	3	4	5	6	7	8
Preliminaries								
Survey and setting out								
Maintenance dredging								
Breakwater construction								
Supply of rocks								
Bed Preperation								
Construction of breakwater core								
Construction of armour layer								
Demobilisation								

3.6 Project Inputs and Outputs

The project has inputs in terms of human resources, natural resources and machinery. The main output of the project is developing the existing harbor on Hulhudhuffaru. The inputs and outputs are summarized in Table 3-2 and Table 3-3.

Table 3-2: Matrix of key inputs of the proposed project

Project Input/s	How to obtain resources
Labour requirements	Contractor
Management staff	Contractor
Machinery (excavator, concrete machine, etc)	Contractor and hired
Material (rock boulders, cement, aggregate, etc)	Contractor imported and purchased
Fuel	Contractor purchased
Food and accommodation	Contractor

Table 3-3: Matrix of major outputs

Project Output/s	Anticipated Quantities	Disposal Method
Waste oil from machinery	Small	Reused or taken to Thilafushi for final disposal
Construction waste	Small / Moderate	Reused or appropriately managed in the island
Noise and dust from machinery	Small	Localised in the project boundary
Solid waste from construction labours	Small	Island waste management
Sand from excavation	Est.440cbm	Stockpiled
Waste water from construction labours	Small	Island sewerage system

3.7 Need and Justification

R. Hulhudhuffaaru harbor is currently used by numerous vessels registered to the island as well as nearby islands. However, the access channel to the harbor is not protected at present; as such at times, especially during southwest monsoon, due to strong currents and high waves use of the access channel has become dangerous for all the vessels. In addition, the harbor basin has become shallow due to sediment deposition over time. For typical vessels to use the harbor during all tides, the basin should have a minimum depth of 3m from MSL. Harbour basin at Hulhudhuffaaru western harbor is shallower than 2.5m at present; making it unsuitable to use by large vessels during low tide. With possibility of beaching within the harbor basin as well as reef flat on either side of the access channel, the main means of access to the island is compromised. As such this project, to address these issues was proposed.

4 Project Alternatives

4.1 Introduction

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

4.2 No project option

It should be noted that the “no project” option cannot be excluded without proper evaluation. In this report this alternative was considered as the baseline against which to evaluate the other options. It is believed that a number of environmental impacts will be generated from the proposed coastal protection measures. Although no impacts on the environment will be associated if the proposed development does not go ahead, as well as there would be no financial implications in terms of implementing the project.

The proposed project to construct breakwaters on either side of the access channel as well as maintenance dredging of the harbor has long term and crucial benefits to large groups of the community. As has been described in the justification section of the report, harbor is the main route of access to the island; linked to supply of goods, people and other necessities of the island community. While the existing conditions of the harbor and access channel greatly hinder the access to the island, proposed project will significantly alleviate these problems. Compared to environmental cost, the benefits of the breakwater outweigh the negative impacts.

No option alternative takes into consideration that the existing depths within the harbor are sufficient and channel is usable. However, given the extent of sediment deposition and strong currents and waves in the channel this is a risky gamble that could lead to significant damage to harbor users and is not recommended.

4.3 Alternative Materials

There are a number of different artificial blocks used to construct breakwaters and revetments; Dolos, SHED and Tetrapod… etc. Armor units can be classified as compact, interlocking or hollow according to their shape and means of obtaining stability. Compact armor units which include rock and riprap use their weight, and to a lesser extent friction, to resist wave action. In comparison, interlocking armor units, such as the Dolos (Figure 4-1) rely principally on interlocking with adjacent units. A more porous armor layer is created enabling a higher proportion of wave energy to be dissipated within the voids between armor units. This however tends to force the armor units apart. The breakage of several adjacent interlocking units can lead to failure of the whole armor layer.

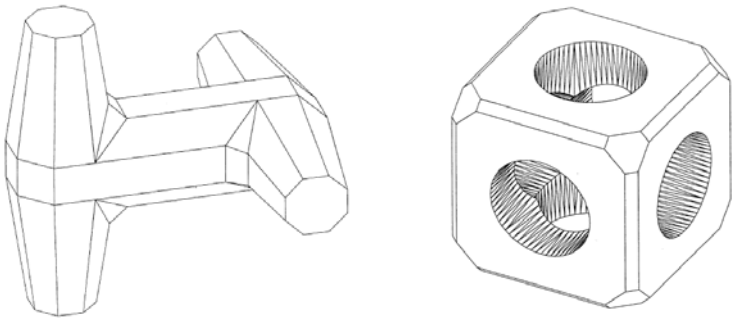


Figure 4-1: Dolos armor unit (left) SHED armor units (right)

Hollow armor units such as the SHED (Shephard Hill Energy Dissipator or tetrapod units such as Accropode are placed in a regular pattern forming a single layer. The internal void ensures that satisfactory space is always available for energy dissipation, unlike compact and interlocking armor units where porosity is dependent on their relative positions. Like interlocking units, hollow units are susceptible to differential settlement of the under layer.

Compared to proposed use of rock boulders for breakwater construction, these pre-cast blocks are expected to be more expensive and are relatively harder to construct. Hence rock-boulders are considered more suitable for this project. In addition Dolos armor and SHED armor blocks are not in use in the Maldives, thus casting of these blocks with moulds will increase the project costs.

4.4 Alternative Design

An alternative design to the proposed rubble mound breakwater would be vertical wall type breakwater (Figure 4-2). A vertical wall breakwater is usually constructed by placing two columns of concrete filled jute bags on a rubble core and pouring concrete between two columns.

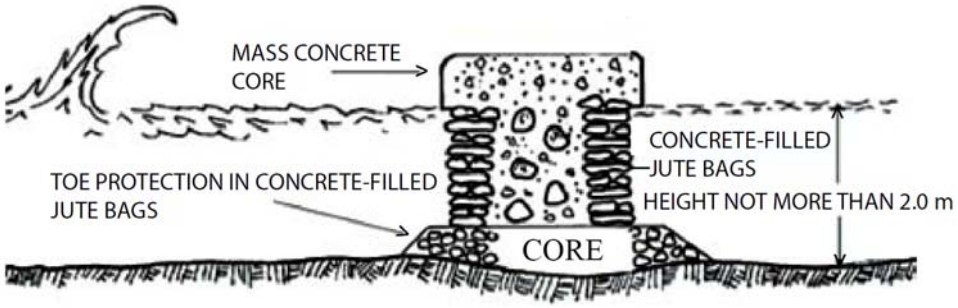


Figure 4-2: Cross section of a typical vertical wall breakwater

Compared to the proposed rubble-mound rock boulder breakwater, a vertical wall breakwater has significant disadvantages. Table 4-1 summarizes the advantages and disadvantages of the two designs.

Table 4-1: Advantages and disadvantages of rubble mound and vertical wall

Breakwater Type	Advantages	Disadvantages
Rubble Mound (Proposed)	Suitable for irregular bottom and weak soil	required material increases rapidly with increased water depth
	low toe scour	
	Progressive damage	large base cuts into basin area
	simpler construction and maintenance	high maintenance cost
	Higher potential for energy dissipation and small wave reflection	
	Small wave reflection	
Vertical	Less material	Requires firm soil
	Control water depth clearly defined	High construction requirements
		Repairing is difficult

As such, the proposed rubble mound breakwater is more preferable for this project.

4.5 Alternative Dredge Material Disposal

The proposed method of dredge material disposal is to the open space on the south of the harbour. One practical alternative option would use of dredge material for leveling main roads on the island. At present the roads on the island are uneven and prone to flooding during episodes of heavy rain. By using the material extracted from maintenance dredging a number of roads on the island could be leveled and hence the community will benefit greatly.

4.6 Preferred Alternative

Based on the above discussed points, the preferred alternative would use of dredge material for road leveling instead of stockpiling. This alternative does not have significant negative impacts. However temporary closure of roads would be required during the leveling work.

5 Existing Environment

This section outlines the key existing environmental conditions of the project site, especially areas where the proposed project components will be implemented and areas where the project is believed to impact the environment.

5.1 Methodologies

This EIA on proposed breakwater construction along the channel and maintenance dredging of harbor is based on both qualitative and quantitative data collected from field assessments undertaken on the island. Where site-specific data was unavailable, relevant data from published reports, relevant studies and assessments conducted recently in the Maldives as well as data available from online media have been used. Since the proposed project will be undertaken in the marine and coastal environment, most of the field data collected was from the marine and coastal environment of the island with particular attention to the project site.

Following are the key environmental components and the ways and methods used to gather relevant data for the project.

5.1.1 General Meteorological Condition

Secondary sources of information were used to describe meteorological conditions such as temperature, relative humidity, rainfall and wind data. The sources used include MHAHE, windfinder.com and MEE.

5.1.2 Currents

Purpose built drogue with a GPS (Trimble Juno) was made to create spaghetti diagrams of the ocean currents at the study site. On 3 selected locations around the project area, drogue tests were conducted to assess currents.

5.1.3 Coral Reef

Quantitative surveys were conducted to establish the status of the coral reef near the project site. Methodologies adopted for these surveys are internationally accepted and widely used to assess the status of coral reefs in the country as well. Photo Quadrates and visual observation of the reef were conducted at the coral reef system. Photo Quadrate technique has been used

for objectives ranging from large-scale special problems to morphological comparison of coral communities and studies assessing impacts natural and anthropogenic disturbances.

For the photo quadrates, a measuring tape of 40m was placed on the reef, a set of random numbers between 0 and 40 were selected using MS Excel prior to the set out. Ten photos were taken at random using these numbers and the measuring tape and later analyzed using Coral Point Count with excel extension (CPCe) created and maintained by National Coral Reef Institute, Nova Southeastern University Oceanographic Centre.

Photo Quadrates were conducted at 3 locations of the reef and lagoon as shown in Figure 5-15. These sites are representative areas within the reef system that can be monitored on long-term basis for assessing magnitude of possible impacts. Some of these areas may be most prone to any adverse impacts from the proposed work, therefore establishing permanent monitoring sites at these areas is important to assess the impacts.

5.1.4 Marine Water Quality

Marine water quality of the lagoon waters of the project site has been tested for temperature, pH, salinity, turbidity and total suspended solids to obtain baseline water quality conditions. The seawater was analyzed using handheld water quality meters.

5.2 Climatic Environment

5.2.1 General Conditions

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25^{o}C to 30^{o}C and relative humidity ranging from 73 per cent to 85 per cent. The country receives an annual average rainfall of 1,948.4mm. There is some variation of climate between northern and southern atolls. The Table below provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 5-1: Key meteorological information (Maldives)

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

5.2.2 Monsoons

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

stronger in the south west monsoon especially during June and July. During storms the impact is greater on the northern atolls than the southern atolls.

Table 5-2: Summary of Monsoons in Maldives

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

5.2.3 Temperature

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

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

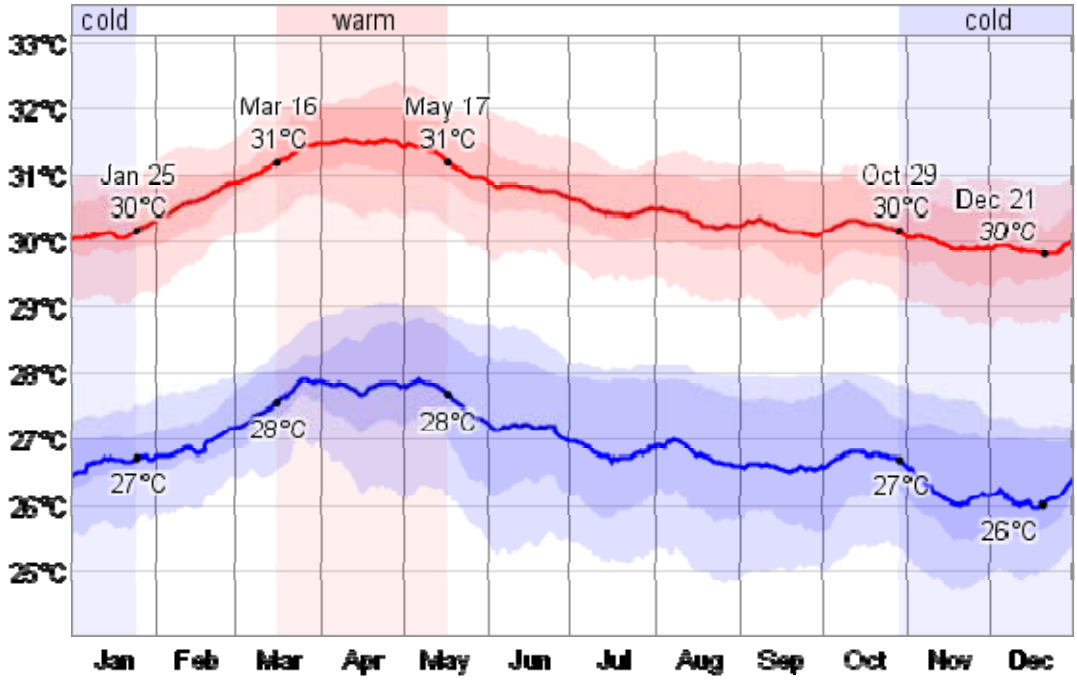


Figure 5-1: Daily average temperature for Central Maldives with percentile bands (*source: WeatherSpark***).**

5.2.4 Rainfall

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

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

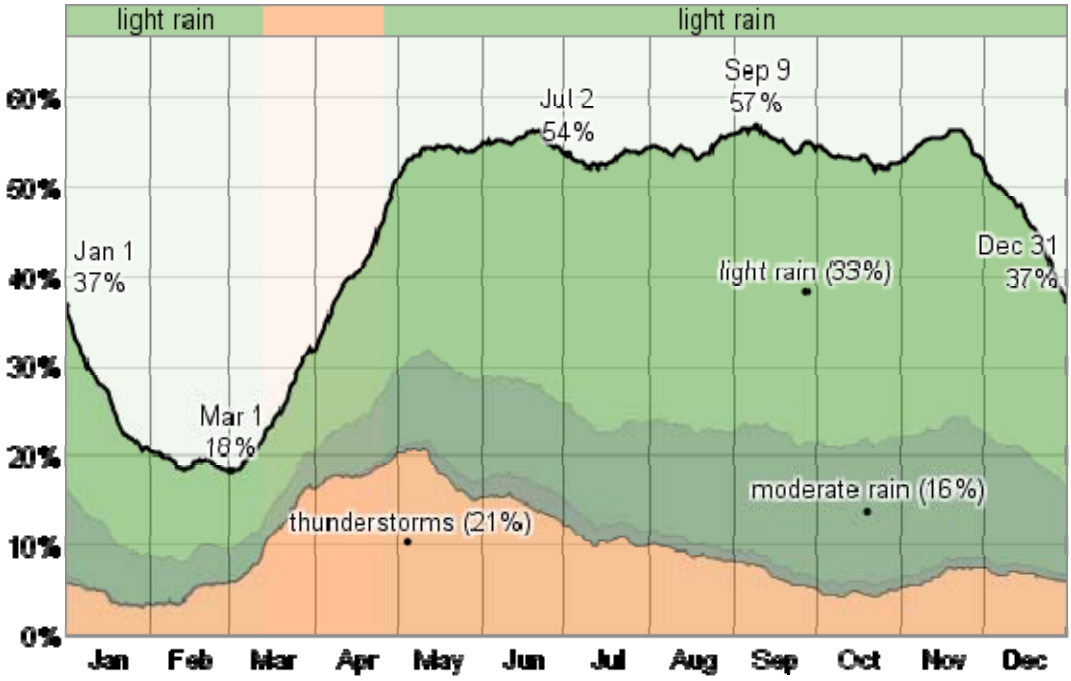


Figure 5-2: Probability of precipitation at some point in the day for Hulhulé, Maldives

5.2.5 Wind

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

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

Wind was uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer 2003). Wind speed is usually higher in central region of the Maldives

during both monsoons, with a maximum wind speed recorded at 18 m/s for the period 1975 to 2001. Maximum wind speed recorded in the south was 17.5 m/s during the period 1978 to 2001. Mean wind speed was highest during the months January and June in the central region, while wind speed was in general lower and more uniform throughout the year in the southern region. Wind analysis indicated that the monsoon was considerably weaker in the south (Naseer, 2003). During the peak months of the SW monsoon, southern regions have a weak wind blowing from the south and south-eastern sectors.

Table 5-3 summarizes the wind conditions around Malé region, applicable to the proposed location, throughout the year and Figure 5-3 provides the wind-rose diagram typical to the central region of the Maldives (adapted from windfinder.com). This analysis represents wind data from K. Hulhulé taken between 07/2002 and 03/2015.

Table 5-3: Summary of general wind conditions in project vicinity

Month of year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
	01	02	03	04	05	06	07	08	09	10	11	12	1-12
Dominant Wind dir.													
Wind probability >= 4 Beaufort (%)	55	40	15	18	48	45	32	32	33	40	24	40	**35**
Average Wind speed (kts)	11	10	8	7	11	10	9	9	9	10	8	10	**9**
Average air temp. (°C)	30	30	31	31	31	30	30	30	30	30	29	29	**30**

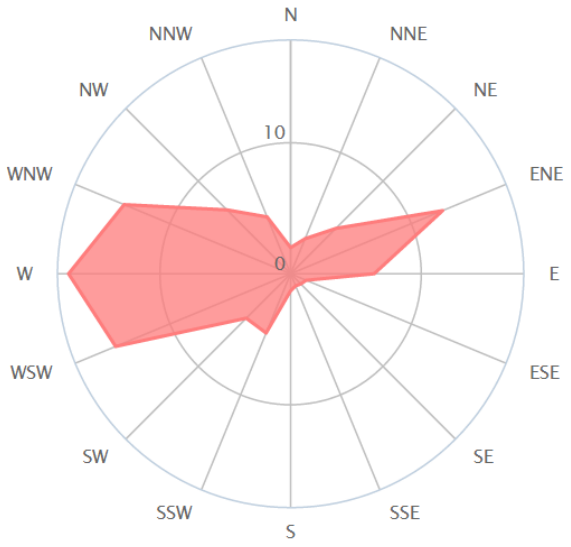


Figure 5-3: Windrose diagram based on data from Hulhule Airport

5.3 Oceanographic Environment

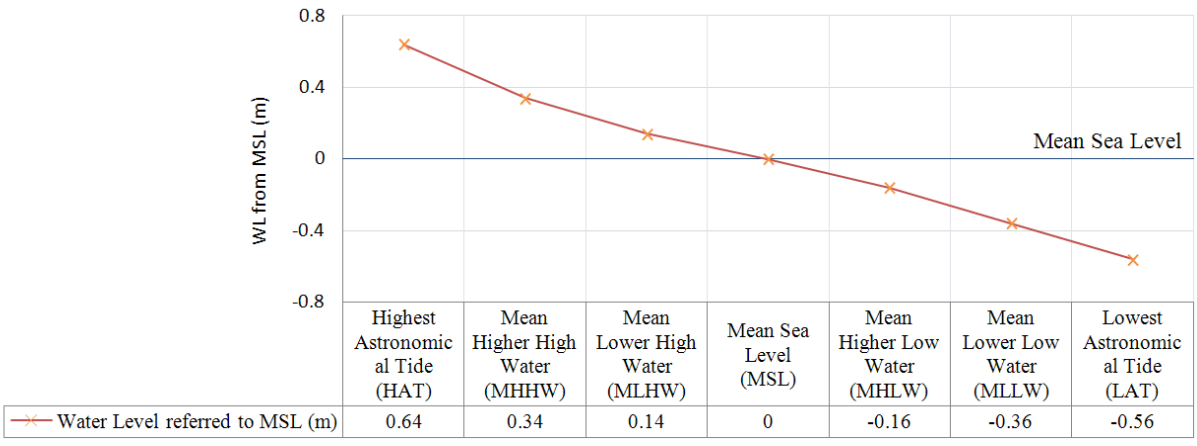
5.3.1 Currents, Tides and Swells

Tidal currents as well as oceanic currents are felt in the atoll. The exposure of the Atoll to the vast Ocean ensures that an immense body of water is constantly flowing across the atoll. The currents can be extremely strong in the channels between the reef systems around the atoll especially during ebb and flow into the atoll.

Current speeds of four knots or more have been recorded in the atoll channels in the country. Oceanic currents are largely influenced by the direction of trade winds and can be of great strengths. Tidal currents which flow according the height of the tide and the direction of prevailing wind are much weaker than oceanic currents.

Like most of the places semidiurnal tides are experienced in the atoll, that is two high tides and two low tides a day. The tide varies from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year.

The following figure shows the astronomical tidal variation recorded in the country with respect to the mean sea level. Astronomical tides are related to the motion of the earth-moon-sun system, and have a range of periodicities. The highest astronomical tide was recorded as 0.64 cm above the mean sea level and the lowest astronomical tide was recorded as 0.56 below the mean sea level. Tidal variation of 1.2m from lowest to the highest tide levels were recorded in the country.



	Highest Astronomical Tide (HAT)	Mean Higher High Water (MHHW)	Mean Lower High Water (MLHW)	Mean Sea Level (MSL)	Mean Higher Low Water (MHLW)	Mean Lower Low Water (MLLW)	Lowest Astronomical Tide (LAT)
Water Level referred to MSL (m)	0.64	0.34	0.14	0	-0.16	-0.36	-0.56

Figure 5-4: Astronomical tidal variation in the Maldives

5.4 Marine Environment

Coral reefs are very complex ecosystems and health or status of the coral reefs in terms of amount of live coral and other benthos is difficult to state as these attribute vary significantly depending on several causes of natural as well as anthropogenic factors. Some coral reef naturally has low percentage live coral cover and diversity of other reef benthos. In many cases human induced factors have resulted in decreased amount of live corals and other reef benthos.

Coral reefs are one of the most, if not the most important habitats attributed to the islands of Maldives, therefore an attempt to find out the goods and services offered by the habitat and to estimate an economical value is seen as an important effort to determine the potential loss of this natural resource.

According to the study carried out by the Ministry of Home Affairs Housing and Environment, USD9000 per linear meter of the shore line have to be paid for shore protection measures to be placed, as a replacement for the lost coral cover of the respective length. In this regard, one linear hector of the coral cover is worth USD9000. However, this is based only on the shore protective aspect of the Maldivian coral reefs, therefore the total economic value would be far greater.

House reef of Hulhudhuffaru shows relatively low coral growth on the reef edge especially on the western side. However towards the south western side in the reef flat zone live coral cover is relatively high.

Geomorphology of Hulhudhuffaru coral reef is mainly influenced by currents created by the two monsoon system experienced in the country i.e. easterly currents in southwest monsoon and westerly currents in northeast monsoon.

Error! Reference source not found. shows attributes of the housereef of Hulhudhuffaru island system, their extent, quantitative photo quadrate reef survey sites and status of the reef in terms of percentage of benthic cover at these sites. Photo quadrates were conducted in representative sections of the reef and following attributes were recorded.

- Live corals of different coral categories and genera
- Dead Coral with Algae

- Macro Algae
- Rubble
- Sand
- Fish and their relative abundance

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

5.4.1 Reef Condition

Two sites were asesed as part of this EIA study. Live coral cover at the site west of the harbour on the reef near the reef edge the coral cover is at 23% while at the channel its very low as showin in Figure 5-5. Rocky substrate and basement dominates all the surveyed sites.

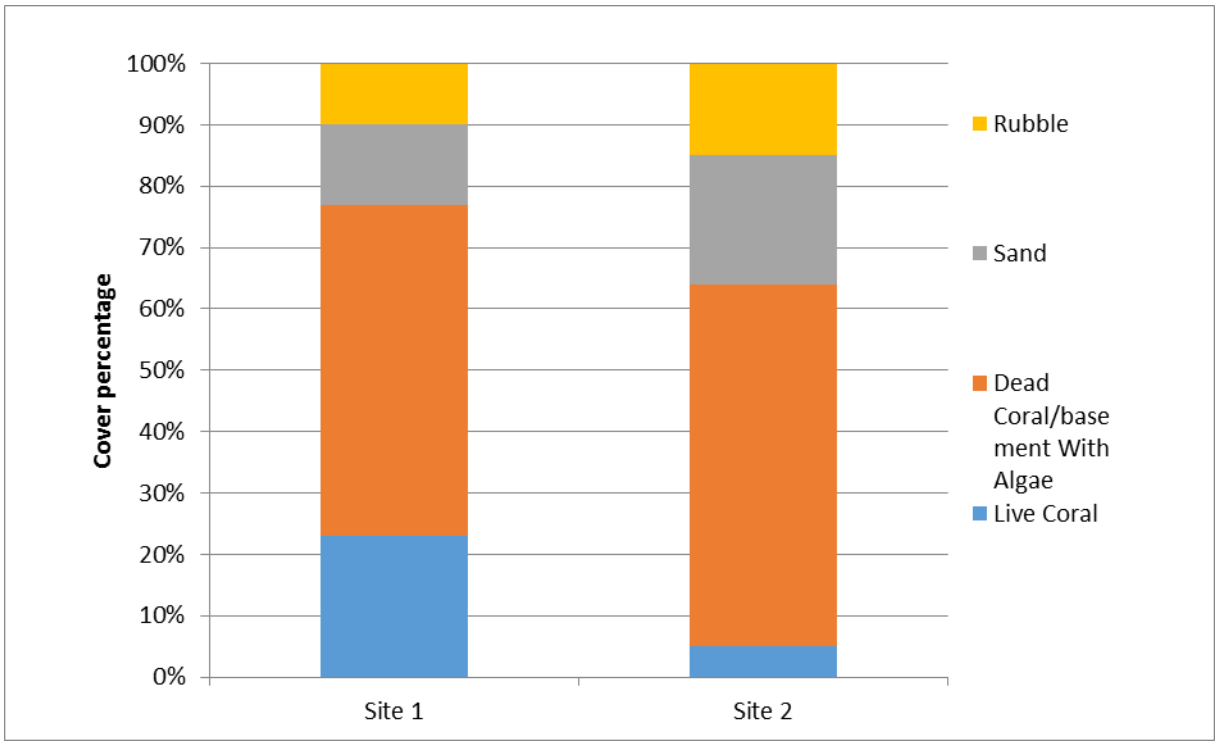


Figure 5-5: Overall benthic composition of marine survey sites

5.4.1.1 Site 1

This site was selected from west of the harbor on the housereef. Live coral cover was estimated to be 23% of the benthos while rubble made up 10% and dead coral with turf algae made up 54% of the benthos (Figure 5-6).

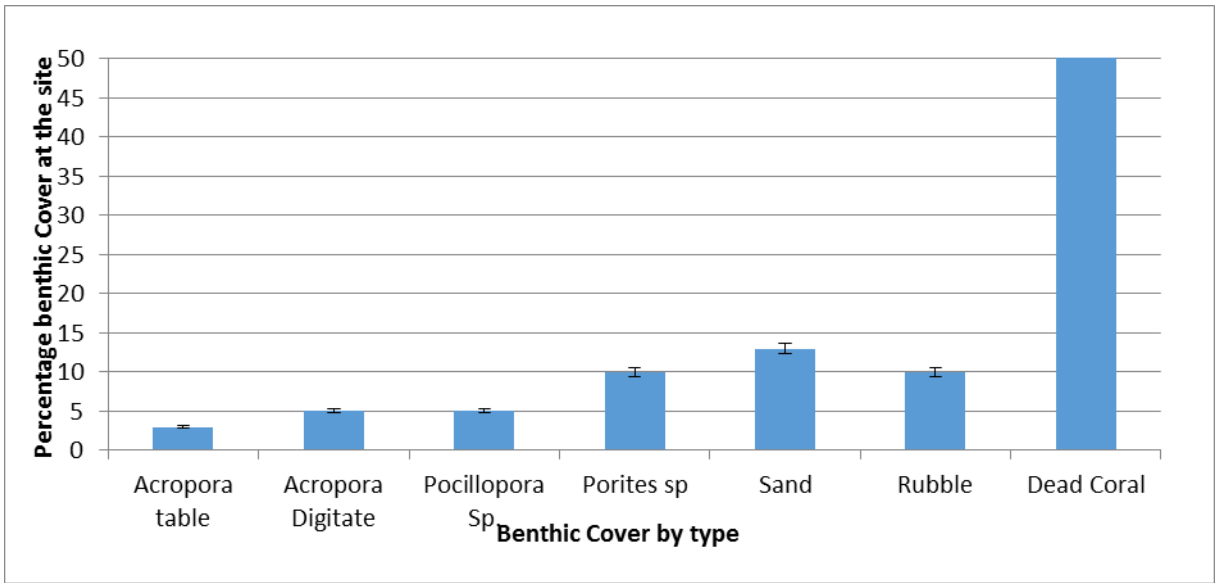


Figure 5-6: Benthic composition of Site 01

Despite lack of live coral, a fair amount of fish was seen at the site during the time of survey. A total of ten individual fish species were observed at the transect site one. The most common were red tooth trigger fish and surgeon fish species. (Table 5-4).

Table 5-4: Fish count; Site 01

Common Name	Scientific Name	Abundance
Powder-blue Surgeonfish	Acanthurus leucosternon	5
Blackaxil Chromis	*Chromis atripectoralis*	7
Six-barred Wrasse	*Thalassoma hardwicke*	10
Mimic Surgeonfish	*Acanthurus tristis*	12
Regal Angelfish	*Pygoplites diacanthus*	4
Twospot Damselfish	*Chrysiptera biocellata*	7
Red tooth trigger fish	*Odonus niger*	20+
Golden Chromis	*Chromis ternatensis*	15
Moorish Idol	*Zanclus cornutus*	3
Powder-blue Surgeonfish	*Acanthurus leucosternon*	9

5.4.1.2 Site 02

Site 02 was located near the access channel and is expected to feel the brunt of negative impacts from the proposed work. The site was found to have less than 5% live coral cover; dead coral with turf algae was found to make up 59% of the benthos while rubble made up 15% and sand made up 21% of the benthos (Figure 5-7).

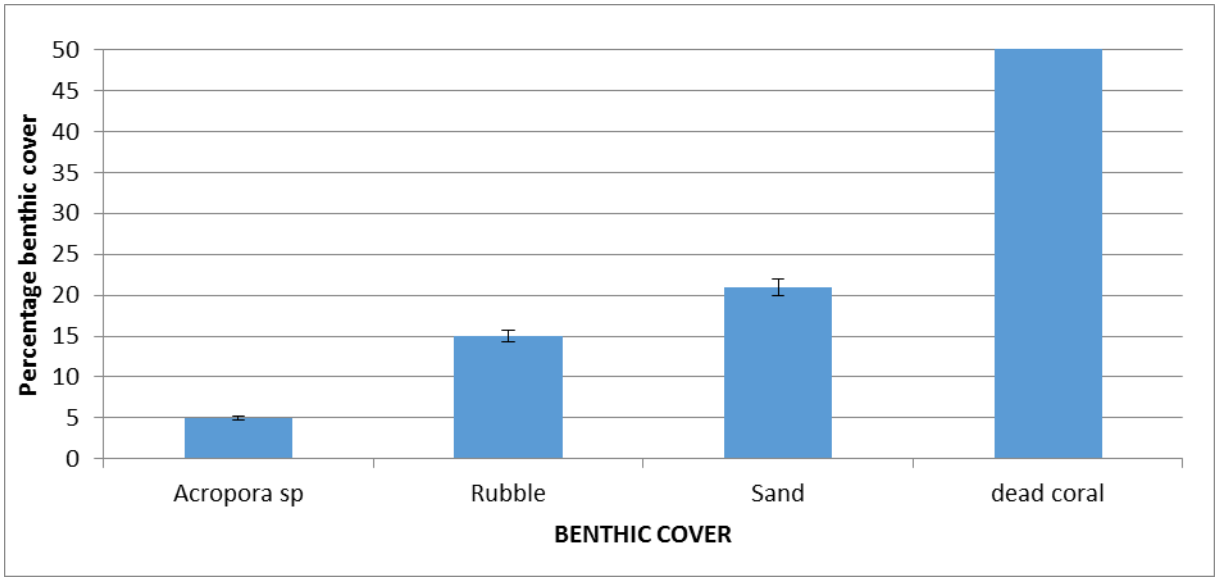


Figure 5-7: Benthic composition of Site 02

Fish count as significantly low given the site of the location. Eight individual species were observed with red tooth trigger fish being the most abundant.(Table 5-5).

Table 5-5: Fish Count; Site 02

Common name	Scientific name	Abundance
Powder-blue Surgeonfish	*Acanthurus leucosternon*	5
Mimic Surgeonfish	*Acanthurus tristis*	4
Lined Surgeonfish	*Acanthurus lineatus*	2
Orangespine Unicornfish	*Naso elegans*	3
Splendid Soldierfish	*Myripristis botche*	4
Red-toothed Triggerfish	*Odonus niger*	20+
Bigeye Bream	*Monotaxis grandoculis*	3
Golden Chromis	*Chromis ternatensis*	5

5.4.2 Seawater Quality

Water quality was tested at four locations shown in Figure 5-15. The water quality results indicate that the marine water quality is in pristine condition with good levels of dissolved oxygen.

Table 5-6: In-situ water quality results

Parameter	Unit	Site 01	Site 02	Site 03
Temperature	^{o}C	29.81	29.85	29.87
pH		8.48	8.04	8.03
E. Conductivity	uS/cm	53,487	53,524	54,614
Total Dissolved Solids	mg/l	35247	35981	35736
Salinity	ppt	35.91	35.96	35.74
Dissolved Oxygen	mg/l	5.12	4.68	4.97
Turbidity	NTU	0.03	0.03	0.06
Total suspended solids	mg/l	0.88	0.87	0.55

5.4.3 Marine Protected Areas and sensitive sites

As per the requirements of the TOR, Marine Protected Areas (MPAs) and ecologically important or sensitive sites such as breeding or nursery grounds for protected or endangered species have been considered.

The Environmental Protection Agency has identified Kandoogandu, Vandhoo and Gemanaa as environmentally sensitive sites. However, the closest of these, Kandoogandu is 14km away from the project site.

Some marine species currently protected, exploration, fishing and export banned under the Fisheries Law of Maldives (Law No. 5/87) have been observed to be occurring in small numbers from the reef close to the project site, and these include giant clams and parrot fish.

No endangered species have been observed during the field visit. However, it is recommended that future monitoring and observations will keep a record of all encounters with endangered or threatened species.

5.5 Social Environment

Raa Atoll (North Maalhosmadulu) has a total population of 15120 locals in 15 inhabited islands as per the 2014 preliminary census results. Hulhudhuffaru accounts for 7.20% of the atoll population with 15120 people. Sex ratio was found to be 86 males per 100 females in Hulhudhuffaru; lower than the atoll average of 94.

The island has an annual population of growth rate of -3.90 between 2006 census and 2014 census.

5.5.1 Population density

The island size being 14.27 hectares and population size 15120 the population density stands at 1059 per hectare. Economic setting

Main economic activities in Hulhudhuffaru are Boat building, fishing, fish processing, civil service, tourism related jobs and to some extent, boat building. Tis known for its handicraft work (lacquer work in particular) throughout the Maldives. However, an estimated number of less than 30 people are employed in this field at present.

As per the 2006 census data the major employing sector in the island is manufacturing, fishing and education sector.

Table 5-7:Occupation of Hulhudhuffaru community (Census 2006)

Locality, sex and occupation	Total	Industry																
	employed	Agriculture and forestry	Fishing	Quarrying	Manufacturing	Electricity, gas and water	Construction	Whole sale and retail trade	Hotels and restaurants	Transport, storage and communication	Financial intermediation	Real estate, renting and business activities	Public administration and defense	Education	Health and social work	community,services activities	Extra-territorial organizations and bodies	Not stated
Both Sexes	414	7	90	0	143	11	11	21	7	7	0	0	25	52	21	8	0	11
Legislators Senior Officials and managers	8	0	0	0	0	0	0	3	2	0	0	0	2	1	0	0	0	0
Professionals	44	0	0	0	0	0	0	0	0	0	0	0	0	34	7	3	0	0
Technicians and associate professionals	27	0	0	0	1	8	0	0	0	5	0	0	0	10	3	0	0	0
Clerks	10	0	0	0	0	0	0	0	0	0	0	0	6	2	2	0	0	0
Service workers and shop and market sales workers	22	0	0	0	0	0	0	17	4	0	0	0	0	0	1	0	0	0
Skilled agricultural and fishery workers	93	7	86	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Craft and related trades workers	159	0	4	0	142	0	11	1	0	1	0	0	0	0	0	0	0	0
Plant and machine operators and assemblers	4	0	0	0	0	2	0	0	0	0	0	0	1	0	1	0	0	0
Elementary Occupations	25	0	0	0	0	1	0	0	1	1	0	0	5	5	7	5	0	0
Armed forces	11	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0

5.5.2 Services available on the island

The Island has a harbor for the ease of access to the island.

Twenty four hour electricity is provided on the island by Fenaka Corporation. Sewerage or water system has not been provided to date.

5.6 Environmental Vulnerability

The following information on the vulnerability of the islands in the Maldives are taken from published literature such as Developing a Disaster Rick Profile for Maldives by UNDP (2006) as site – specific information on vulnerability of Hulhudhuffaru was not available. According to the UNDP (2006) the natural vulnerability of the islands and atolls of the country to potential hazards have been modelled to understand the risk factors of the country.

The disaster risk scenario for Maldives can be described as moderate in general. Despite this, Maldives is among the most severely affected countries hit by the Asian tsunami on December 26th, 2004. Maldives experiences moderate risk conditions due to a low probability of hazard occurrence and high vulnerability from exposure due to geographical, topographical and socio-economic factors.

Following are some of the risks that have been identified and potential areas that may be within the range of risks based on its sensitivity, location, exposure, historic events, etc.

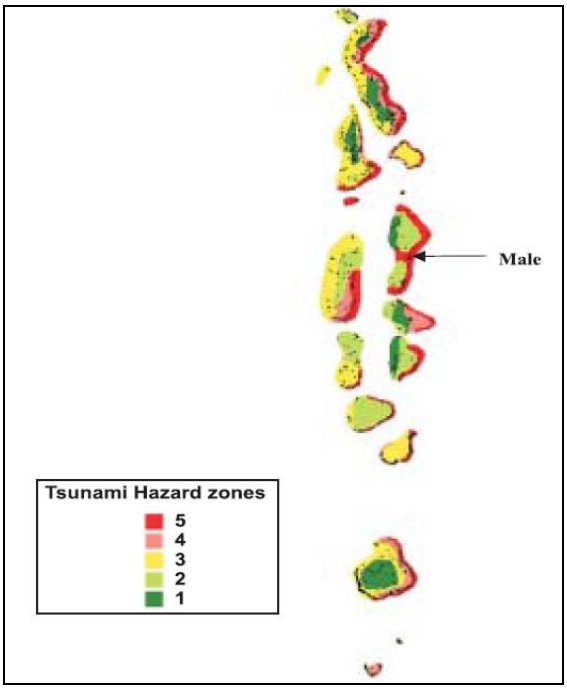


Figure 5-8: Tsunami hazard zones

Figure 5-8 show that Maldives faces tsunami threat largely from the east and relatively low threat from the north and south. So, islands along the eastern fringe are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe

experience a relatively low tsunami hazard. This map is produced based on the experience of the tsunami in 2004 and also occurrence of historic tsunami events in the greater region where most of the events have identified to have occurred from the Sumatra Region (UNDP 2006).

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

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

Maldives is also affected by severe local storms- thunder storms/ thunder squalls. Hazards associated with thunder storms are strong winds, often exceeding a speed of 100 kilometres per hour, heavy rainfall, lightning and hail; they also give rise to tornadoes in some regions. In general, thunderstorms are more frequent in the equatorial region than elsewhere, and land areas are more frequently hit by thunderstorms as compared to open oceans. However, thunder storms close to the equator are less violent when compared with those in the tropical regions and beyond. Maldives being close to the equator, thunder storms are quite frequent but less violent here. Strong winds generated by severe local storms generate large wind-driven waves which are hazardous for Maldives (UNDP 2006).

The islands of Maldives are less prone to tropical cyclones. The northern islands of the country were affected by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. Figure 5-9 shows the tracks of cyclones affecting Maldives during the period 1877-2004. The number of cyclones directly crossing Maldives is small. Only 11 cyclones crossed the islands over the entire span of 128 years. Most of the cyclones crossed Maldives north of 6.0^{o} N and none of them crossed south of 2.7^{o}N during the period (UNDP 2006).

Figure 5-9: Tracks of Cyclones affecting Maldives, 1877-2004

UNDP (2006) stated that there were 21 cyclonic disturbances within the 500km radius during 1877-2004, of which 15 were depressions with an average wind speed of about 28 knots. The highest wind speed due to cyclonic disturbances that affected the islands during that time was about 65 knots. Figure 5-9 shows the tracks of cyclonic disturbances that passed through the circle with 500km radius.

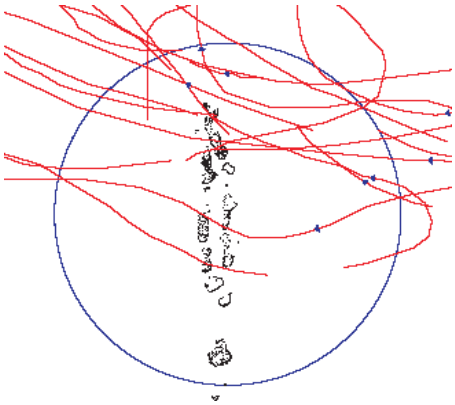


Figure 5-10: Tracks of Cyclones passed within the Scan Radius of 500 kilometres

Based on the above information, Maldives is divided into zones with varying scales of cyclone hazards based on based on a qualitative judgment based on the gradient of the storm tracks from north to south.

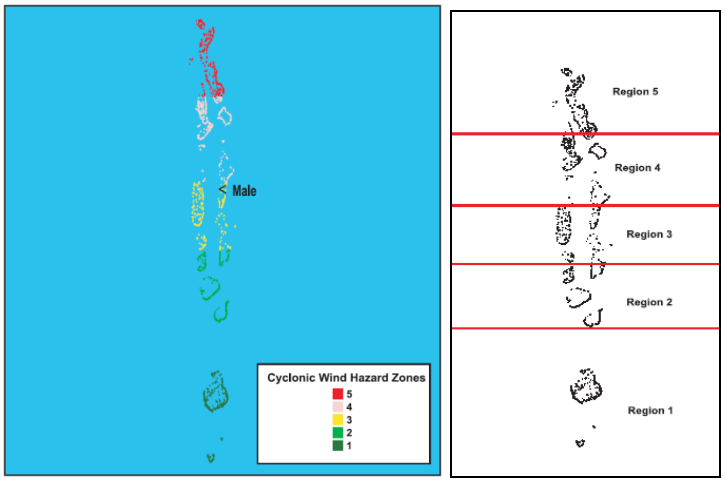


Figure 5-11: Regions to capture Cyclones passing through Maldives for Hazard Zoning

Figure 5-11 shows the regions used to compute the highest wind speed of each cyclone captured within the region. Majority of the cyclonic disturbances crossed the northern region. The frequency and wind speed decreases from northern region to southern region. Region 1 is not affected by any storm. Thus, Maldives can be divided into three cyclone hazard zones – the northern zone with high cyclone hazard, central zone with moderate cyclone hazard and the southern zone with very little cyclone hazard. Hulhudhuffaru falls within zone 4, the northern zone with high cyclone hazard.

With regards to the storm surge potential, the bathymetry around the Maldives shows that the ocean slope close to the east coast is steeper than the west coast, hence it can be generalized that the eastern islands of the Maldives are vulnerable to higher surge hazard compared to the western islands. Figure 5-13 shows the bathymetry around Maldives. Figure 5-14 shows storm surge hazard zones based on computed model with maximum pressure drops for 100 year return period and with historical data (UNDP 2006).

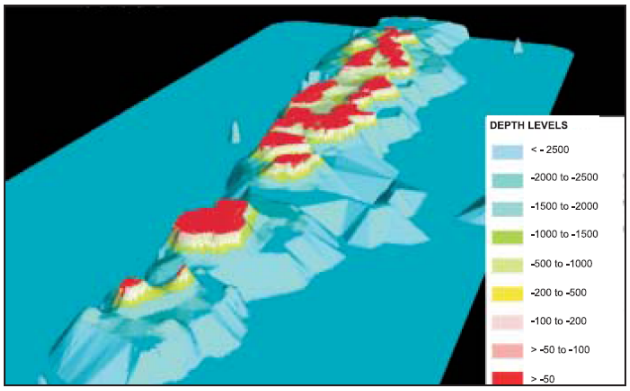


Figure 5-12: Three Dimensional View of Bathymetry of Maldives (depth in meters)

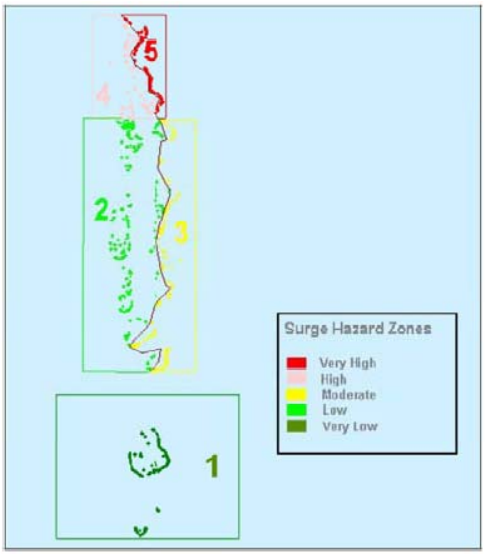


Figure 5-13: Storm Surge Hazard Zones with Cyclones Affected

Based on the above figure, it can be said that the north-eastern parts of the country are very vulnerable to storm surges.

Based on historical catalogues of earthquakes in the region, identifying seismic sources based on this historical information and based on numerical models, it was found that except for Seenu, Gnaviyani and Gaafu Atolls, earthquake hazard is low across the country. The probable maximum Modified Mercalli Intensity (MMI) is estimated between 7-8 in Zone 5 (Figure 5-13). This level of MMI can cause moderate to high damages (UNDP 2006). In accordance with the above analysis, Hulhudhuffaru falls within moderate risk surge hazard zone.

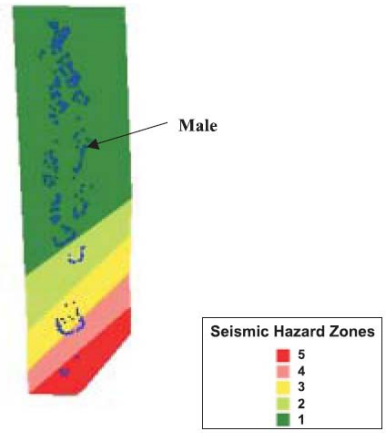


Figure 5-14: Maldives Seismic Hazard Zones

It can be summarized that the northern parts of the country are vulnerable to cyclones and storm surges while southern parts of the country are vulnerable to seismic activity. The eastern side of the country is more exposed to potential tsunamis and surges. Hulhudhuffaru also does not have high risks of potential seismic activity as these are more or less concentrated on the south of the country.

Figure 5-15: Survey locations and spot depths

Proponent: Ministry of Housing and Infrastructure
Consultant: Sandcays

Figure 5-16: Illustrated summary of conditions of the marine environment

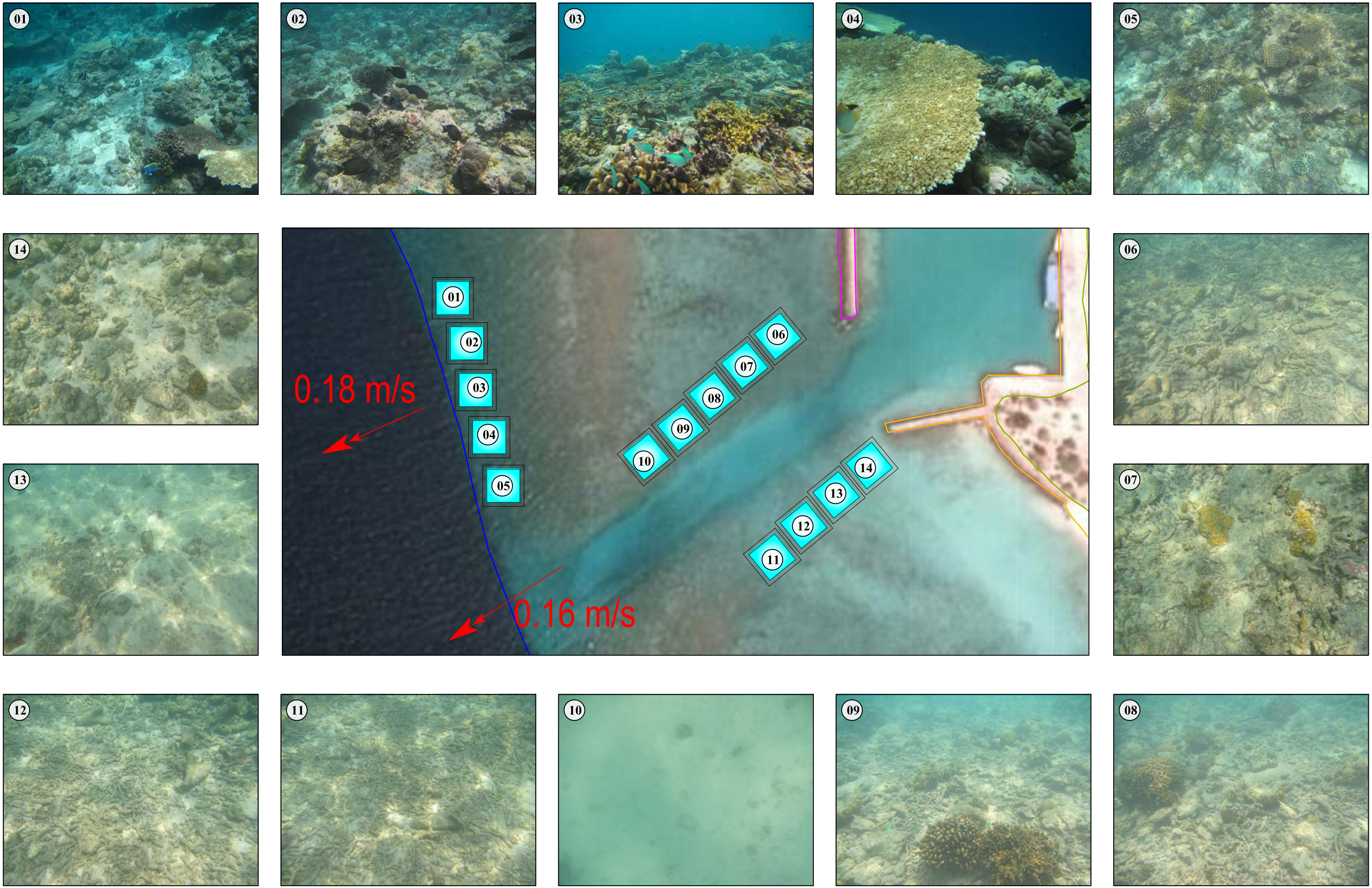


Figure 5-17: Illustrated summary of conditions of the harbor

6 Stakeholder Consultation

The key stakeholders of the project include the Atoll Council, Ministry of Environment and Energy, Environmental Protection Agency, Ministry of Housing and Infrastructure, Proponent Contractor and Project Engineers and Consultant. The stakeholders that participated in the Scoping Meeting have extensively discussed on the issues relating to the project. Public opinions have been gathered during the field visit.

6.1 Scoping Meeting

The Scoping Meeting was held on 14th of July 2015. The meeting was attended or represented by the following (A complete list of scope meeting participants is annexed to this report):

Environmental Protection Agency
Ministry of Housing and Infrastructure (Proponent)
Island Council
Consultant

A brief introduction of the project was given by the proponent. Numerous queries from EPA regarding the components of the proposed project were answered by the proponent. Due to nature of the project there were no major environmental concerns. The council members wish the project to be implemented as early as possible as the harbor depth is insufficient with strong currents at the channel area.

List of the participants of the scope meeting is annexed to this report.

7 Environmental Impacts and Mitigation Measures

7.1 Introduction

Development projects involving construction of coastal structures and dredging in island environments are believed to generate a series of environmental impacts, of which some can be felt immediately on the surrounding environment while others can be felt continually and can be far reaching. By far and large the most significant environmental impacts are those that are felt on the immediate environment. Marine environment is directly affected from high rates of sedimentation caused by dredging activities. Coral reefs environments are very sensitive and highly susceptible to immediate changes in physical environment such as changes in water quality. Therefore, all the development activities must take into consideration the understanding of the environment and changes as well as implications that it will bring about to the environment and surrounding.

The following account describes potential environmental impacts that will be associated with the proposed breakwater construction and maintenance dredging project during construction and operation phases of the project.

7.2 Methods and Limitations

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

7.3 Impact Identification

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

- A consultative process within the EIA team and the Proponent
- Purpose-built matrices
- Existing literature and reports on similar developments in the Maldives
- Baseline environmental conditions described in Chapter 4.
- Consultant's experience of projects of similar nature and similar settings

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

1. Magnitude (or severity): the amount or scale of change that will result from the impact
2. Significance: importance of the impact. Reversibility is considered part of its significance
3. Duration: the time over which the impact would be felt
4. Extent/spatial distribution: the spatial extent over which the impact would be felt

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

Table 7-1: Impact evaluation scale

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

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

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

7.4 Overall Impacts of the Proposed Project

The overall impact of the proposed project is slightly positive due to the socio-economic benefits of the proposed project. The value of property associated with the development of harbor is considered as positive socio-economic impacts of the project.

However, there are some minor negative impacts on some of the environmental components. The direct and project specific negative impacts of the proposed project are due to sedimentation and sediment re-suspension in the water column as a result of excavation (minor), and impact on lagoon and marine biodiversity (minor).

Table 7-2: Impact matrix for the proposed project

	KEY COMPONENTS								
	Environment				Socio-Economic				
PROJECT ACTIVITIES	Reefs incl. live bait	Lagoon/seawater	Hydrodynamics	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer
Construction									
Temporary facilities, machinery and workforce	0	-1 0 1 1	0	-1 1 1 1	-1 1 1 1	-1 1 1 1	1 2 1 3	-1 1 1 2	-1 1 2 3
Excavation and transport of materials	-1 1 1 1	-1 1 1 1	-1 0 1 2	-1 2 1 1	-1 1 1 1	-1 0 1 1	1 2 1 3	0 1 1 2	-1 2 2 3
Construction of breakwater	-1 1 1 1	-1 1 1 1	-1 0 1 2	-1 1 1 1	1 1 1 1	-1 1 1 1	1 2 1 3	-1 1 1 2	-1 1 2 3
Operation									
Existence of new coastal structures	1 0 3 1	0	1 2 3 1	0	1 1 3 2	0	0	1 2 3 1	1 1 3 1

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

	KEY COMPONENTS									
	Environment				Socio-economic					
PROJECT ACTIVITIES	Reefs incl. live bait	Lagoon/seawater	Hydrodynamics	Air/Noise/land or seascape	Services and Infrastructure	Health and Safety	Employment	Property Value	Costs to consumer/tax payer	**TOTAL API**
Construction										
Temporary facilities, machinery and workforce	0	0	0	-0.01	-0.01	-0.01	0.07	-0.02	-0.07	-0.05
Excavation and transport of materials	-0.01	-0.01	0	-0.02	-0.01	0	0.07	0	-0.15	-0.13
Construction of breakwater	-0.01	-0.01	0	-0.01	0.01	-0.01	0.07	-0.02	-0.07	-0.05
Operation										
Existence of new coastal structures	0	0	0.07	0	0.07	0	0	0.07	0.04	0.25
TOTAL CPVI	-0.02	-0.02	0.07	-0.04	0.06	-0.02	0.21	0.03	-0.25	0.02
API = Activity Potential Impact Index										
CPVI = Component Potential Vulnerability Index										

The table above indicates that the project has minor negative environmental impacts during construction which are short-lived and moderate positive social impacts during the operational phase. As such, the social and economic benefits of the project outweigh the negative environmental impacts, as a result of which the total potential impact index for the project is slightly positive. The higher cost of proposed project in relation to the social benefit of the overall project makes the total CPVI low.

7.5 Constructional impacts and mitigation measures

7.5.1 Temporary facilities, machinery and workforce

Based on the experience of several projects of this nature that has been undertaken in the region and elsewhere in the Maldives, this project is not expected to have adverse negative impacts of noise or pollution. However, during the time of dredging, vessels and people using this harbor will be slightly inconvenienced.

During the construction phase, there will be few temporary facilities used by contractor's workforce though existing infrastructure such as accommodation will also be used.

The use of diesel as well as petrol in vehicular engines and operation of machines such as the excavators cause emissions of carbon dioxide, sulphur dioxide and nitrogen oxides with fine particulate matter. For the proposed project, carbon emissions are considered to be negligible. However, carbon dioxide being the primary greenhouse gas and the main contributor to global warming, likely future carbon emissions would be a cause for concern, as the impact cumulatively adds to the global burden of carbon emissions.

The project will have noise levels of less importance but it may be of concern to the closest few households. It is not expected to interfere with their daily livelihood too much nevertheless. The construction period is expected to last few weeks at most; hence temporal and spatial extent of the impact is limited. However, in order to reduce any possible disturbance to the local community, the construction work will be carried out during day time only.

There is an unlikely risk of pollution given that the hazards are well controlled. Usually, in projects involving heavy machinery, fuelling of excavators and other machinery is undertaken manually and it carries the risk of spills. Such spills are a cause for concern in the case of using excavators and dredgers in the marine environmental as fuelling occurs on the water. However, small spills can be avoided from being disposed to sea using appropriate caution and care. Also, this impact is considered to be minor negative given the small scale of the project. Yet, all precautions shall be taken during fuelling of machinery to avoid spills.

Finally, some general impacts relating to such projects have to be identified. These involve the mobilisation of the excavator and barge as well as construction phase impacts. They are:

11. Accidental spillage of fuel, as discussed above
12. Accidental grounding of large vessels such as barges or landing craft.
13. Breakage of fragile corals while unloading of barge and excavator to site.
14. Damage to reef due to workers' negligence

To mitigate the above impacts, it is important to educate the staff, especially supervisory staff regarding proper environmental controls and the need for environmental protection in every little detail prior to mobilisation to site. The excavation area shall be marked using buoys to avoid excavating unnecessary areas. This shall also be done prior to mobilisation so work is started as soon as machinery is mobilized.

The project would not affect social values, norms and beliefs due to the workforce significantly as there are already a number of expatriates on the island. Besides, the construction phase being short, any such impacts would be negligible.

7.5.1.1 Health and Safety

This project will not have any major health and safety issues due to its small scale. However, in general, for coastal protection projects, key impacts predicted for the construction workforce is related to health and safety issues. Often in such construction environments, workers are prone to injuries. Also, if precautionary measures on health and safety are not taken into consideration, the entire operation may be affected as a result of incidents and injuries. Therefore, adequate safety measures are necessary.

7.5.2 Break Water Construction and Maintenance Dredging

The primary activity under the project is the construction of breakwater while maintenance dredging would be a minor activity if the project is undertaken as proposed. Excavation will be carried out to a small extent to achieve desired depth within the harbor basin. This would cause sedimentation and sediment re-suspension and consequential increase in turbidity of coastal marine water to a small degree. This will be a direct short-term negative impact of low significance. Rock boulders will be used for the construction of the breakwater; therefore, there would be very little in-situ concrete works for the proposed work. This impact is considered minor to negligible.

High amount of sedimentation will stress live corals and filter feeding marine organisms greatly if exposed to high rates for prolonged periods of time. Dredging/excavation could directly destroy benthic habitats in certain circumstances as well. As excavation under this project will be limited to harbor basin; majority of the sediment suspended during excavation activity will be naturally dispersed by the currents within a short period of time. As per the predominant currents in the project area, sediment movement is expected to be contained within the habor area. As there are very few live corals within close proximity of the project area, impact of sedimentation is considered as minor to negligible.

Since the impact from sedimentation are considered minor to negligible no additional mitigation measures other than general best practice guidelines employed by the contractor in similar case scenarios are proposed.

Figure 7-1: Predicted Sediment Plume (red)

7.6 Existence of Breakwater and Deeper Basin

With the proposed construction of the breakwater, the harbor will be able to provide safety to a number of vessels and as such will indirectly improve economic status of the community. Fuelling, food and similar service provides on the island will have an increased customer base and also overall access to the island, as in transport between Hulhudhuffaru and rest of the Maldivian islands (especially the capital) will be improved noticeably with increasing users of the harbor.

7.7 Limitations of Impact Prediction

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

7.8 Mitigation Measures

7.8.1 Mitigating impacts from Breakwater removal

The major output of this activity will be slight sedimentation and debris from existing harbor. To reduce waste, debris could be used to form core of the new breakwater and any remaining waste could be sent to the island waste management site or transported to Thilafushi for proper disposal.

7.8.2 Mitigating Impacts from Breakwater Construction

In order to reduce environmental impacts associated with the proposed breakwater construction,

- Carefully plan all activities related to construction
- All positions will be georeferenced in order to ensure exact position on ground during development
- Adequate timing will be allowed in between removal of units to allow monitoring of immediate changes
- Undertake removal of breakwater units towards the end of the project implementation to allow adequate timing for adaptation

- Setting out prior to all construction activities
- Major parts of the construction and placing of desired structures will be undertaken during low tide to ensure stable environmental conditions during construction

Transport removed rock boulders to land immediately to reduce prolonged working time to reduce sedimentation and other impacts

7.8.3 Mitigating Impacts from Construction Machinery and Waste

In order to reduce environmental impacts from operation of construction machinery as well as disposal of construction waste during construction period, the following measures will be undertaken;

- Define boundaries and pathways for machinery operation to minimize impact areas
- Develop machinery operation schedule and implement strictly to reduce impact duration, especially to reduce noise and dust implications
- Efforts must be made to avoid accidental spillages from machinery including overtopping leading to severe spillages.
- Machines will be operated by experienced operators.
- Avoid throwing of cleaning materials and changed oils into the environment. They must be properly handled, stored and disposed
- No construction material will be disposed on land or marine environment
- Usable items and material will be reused rest, appropriately disposed within the island or stored on site for final disposal in Thilafushi
- Use signboards to restrict disposal of construction waste on site

8 Environmental Monitoring

8.1 Introduction

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

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

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

- The parameters that are most relevant for monitoring the impacts that may arise from the proposed project activities and operation are included in the monitoring plan. These include currents, tides, and turbidity and seawater quality, sedimentation, live coral cover and coral recruitment. Monitoring will be carried out as part of the environmental impact assessment and mitigation of possible negative impacts from the proposed project .

8.2 Aims and Objectives

The primary aim of the monitoring is to provide information on marine environment that will aid impact management, and secondarily to achieve a better understanding of cause-effect relationship and to improve impact prediction and mitigation methods.

The following monitoring plan is used to measure impacts that occur during the proposed project activities and determine the accuracy of impacts that are predicted and the effectiveness of mitigation measures.

8.3 Monitoring Report

A detailed environmental monitoring report is required to be compiled and submitted to the Environment Protection Agency yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this report. In addition, a post construction monitoring report will be prepared. The following monitoring requirements covered in the approved Terms of Reference will also be considered in the post construction report.

- Environmentally sound site preparation
- Environmentally sound removal of construction machinery and equipment

The reports will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. The report will also include fuel and water consumption data and greenhouse gas emission calculations.

Table 8-1: Proposed annual monitoring schedule with costs

No.	Indicator/locations	Parameters to be monitored	Frequency and duration	M1	M4	M7	M10	M12	Total	Rate (USD)	Total (USD)
1	Marine water quality (EIA baseline locations)	Water quality: temperature, conductivity/salinity, DO, pH, Turbidity, TSS	Every six months	3		3			6	50.00	**300.00**
2	Marine life/biodiversity (2 baseline locations)	Live coral cover and fish survey - Photo quadrates/LIT and fish survey	Annual	2					2	30.00	**60.00**
3	Currents/hydrodynamics	Drogue tracks	Every three months for one year	4	4	4	4		16	30.00	**480.00**
4	Water quality during construction within 50m radius of dredging and material disposal area	Water quality: total suspended solids (TSS) and turbidity	Daily during construction	5					5	50.00	**250.00**
6	End of construction stage monitoring report		Construction phase only	1					1	200.00	**200.00**
7	Annual Monitoring Report							1	1	500.00	**500.00**
TOTAL				**580.00**	**120.00**	**270.00**	**120.00**	**500.00**			**1,790.00**

Note:

M indicates Month

After the initial end of construction monitoring report, the proponent will submit a monitoring report annually for 2 years

9 Conclusions

The main environmental impacts from the proposed project are believed to occur within the harbor basin and immediate reef area.

An important mitigation measure identified in the EIA is careful planning and scheduling of project activities to ensure that environmental damages are minimized at the very initial stages of the project development.

Environmental monitoring frequently during construction is highly important to understand how changes in the environment are occurring as well as to understand whether the predicted impacts are accurate.

If there are unforeseen environmental impacts that are quite serious in nature, the project activity should be stopped and the environmental impacts should be either remediated or further mitigation measures should be placed.

Even if the project is completed, a 2 year environmental monitoring programme in order to understand the environmental components adapting to the new conditions have been highly advised. Such monitoring will provide vital information to take necessary actions immediately.

10 Acknowledgements

The author wishes to acknowledge the work of several people who have contributed to this report. Thanks are also due to those who participated in the different meetings, interviews, discussions although their names have not been specifically mentioned here.

The Technical Team of Sandcays who gathered field data, analyzed the data and presented some of the data in this report as well as the previous report are worthy of credit for the important work they did. Thanks to Mohamed Riyaz for undertaking field work and assisting in the data processing and field data representation.

The field team wishes to express their appreciation for the assistance provided by the Proponent.

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12 Appendices

Appendix 1: Terms of Reference

Appendix 2: DnR approval/application

Appendix 3: Document receipt from Atoll Council

Appendix 4: Scope meeting participants

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Environmental Protection Agency EPA

"Dhivehin" – Always Maldivian, Forever Independent

ނަންބަރު: 203-EIARES/138/2015/241

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ރ. ހުޅުދުއްފާރުގައި ނަރުދަމާއި ފެނު

ރ. ހުޅުދުއްފާރުގައި ނަރުދަމާގެ މަޝްރޫޢާއި ބެހޭ ގޮތުން ތައްޔާރުކުރައްވާފައިވާ އީ.އައި.އޭ ޓާރމްސް އޮފް ރެފަރެންސް (ޓީ.އޯ.އާރު) ފާސްކުރުމަށްފަހު މިސިޓީއާއެކު ފޮނުވީމެވެ. އަދި ދަންނަވަމެވެ. ޓީ.އޯ.އާރު ފާސްކުރުމަށްފަހު ރިޕޯޓް ތައްޔާރުކުރުމުގެ ކަންތައްތައް ކޮންސަލްޓަންޓާއި މަޝްވަރާކޮށްގެން ކުރިއަށް ގެންދިޔުމާއި އީ.އައި.އޭ ރިޕޯޓް އީ.ޕީ.އޭއަށް ހުށަހެޅުމަކީ ޕްރޮޕޯނަންޓްގެ ޒިންމާއެއް ކަމުގައި ދަންނަވަމެވެ.

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EPA/ToR/2015/162

Terms of Reference for Environmental Impact Assessment for Harbor Rehabilitation Project in R. Hulhudhuffaru

This is the Terms of Reference (ToR) for undertaking the EIA of the proposed harbor rehabilitation project R. Hulhudhuffaru. While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration of matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction and rationale** – Describe the purpose of the project and, if applicable, the background information of the project/activity and the tasks already completed. Objectives of the development activities should be specific and if possible quantified. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked to other activities that are carried out or that is being carried out within the project boundary.

2. **Study area** – Submit a minimumA3 size scaled plan with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent or remote areas, such as relevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – The report should be categorised into the following components:

Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the coastal protection works, using maps at appropriate scales where necessary. The following should be provided:

- Coastal defence structures and justification for their selection;
- Details and justification of location and materials of coastal protection;
- Construction methods, materials, equipment and scheduling.
- Excavation methods, if required
- Emergency plan during spillages;
- Environmental monitoring during construction activities;
- Measures to protect environmental values during construction and operation phase i.e. sedimentation control;
- Project management (include scheduling and duration of the project)

Task 2. Description of the environment – Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the project (e.g. monsoon season). Identify baseline data gaps and identify studies and the level of detail to be carried out by consultant. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that data collected is suitable for use as a baseline. As such all baseline data must be presented in such a way that they will be usefully applied to future monitoring. The report should outline detailed methodology of data collection utilized.

The baseline data will be collected before construction. All survey locations shall be referenced with Geographic Positioning System (GPS) including water sampling points, reef transects and manta tows sites for posterior data comparison. Information should be divided into the categories shown below:

** There is a description of the specific data collection requirements given in the appendix of this TOR.*

Climate

- Temperature, rainfall, wind and waves
- Risk of flooding and storm surges;

Geology and geomorphology

- Offshore/coastal geology and geomorphology (use maps);
- Bathymetry (bottom morphology) (use maps);
- (Seasonal) patterns of coastal erosion and accretion (shoreline and vegetation line); and
- Beach profiles.

Hydrography/hydrodynamics (use maps)

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Sea water quality measuring temperature, pH, salinity, turbidity and total suspended solids.

  Sea water quality should be tested from at least one control location.

Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector.

Socio-economic environment

- Demography: total population, sex ratio, density, growth
- General land use patterns on the island,
- Community needs;

Hazard vulnerability:

- Vulnerability of area to flooding and storm surge.

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. Include permits and approvals in the EIA document. The report should clearly identify the different articles and clauses that apply to the said project and should state how the project meets these requirements.

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology;
- Sediment dispersal in water column (related to shore protection activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish etc.;
- Impacts of noise, vibration and disturbance;
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment

- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Level of protection against hazards like sea level rise, storm surges, etc.

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternative designs and alternative materials. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures with particular attention paid to future changes in coastal processes. Measures for both construction and operation phase shall be identified. Cost the mitigation measures. The confirmation of commitment of the Proponent to implement the proposed mitigation measures shall also be included. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan (see appendix)– Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for coastal modification, beach morphology, sediment movement around the island. Environmental monitoring reports will be submitted to the EPA to evaluate the damages during construction and as per a monitoring schedule outlined in the EIA report. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

Task 8. Stakeholder consultation – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders. Consultation shall be undertaken with R.Hulhudhufaaru Council and the general public of Hulhudhuhfaaru. The EIA report should include evidence of consultation, including names of those consulted and their contact details. The EIA report should include the methodology of consultation with justification, details of the date, time and place of the consultation and the summary outcomes. The report should include evidence that EIA report has been submitted to atoll council prior to submission to EPA.

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Presentation- The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations f or any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations 2012 and related ammendments.

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 6 months from the date of this Term of Reference.

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25 October 2015

Atoll Council Reciept

Raa Atoll Council

Please acknowledge receipt of the following document(s)/item(s) by signing below:

- EIA report for R.Hulhudhuhfaaru breakwater.

Signature: .....

Name: Ibrahim Abdul Kareem

Designation: R. Atoll Council Vice President

Date: 11th February 2016

Environmental Protection Agency

Male', Rep of Maldives

Meeting: channel protection project at R. Thilhedhuffaaru
Date: 28/10/2015 (wed)
Time: 9:00

ATTENDANCE FORM

	Name	Designation	Office	Email	Phone No.	Signature
01	Al-Aakhir Yoosuf	Council President	Thilhedhuffaaru Council	akhir.usf@gmail.com	7548483	
02	Ibrahim Shifaz	Council member	"		7477554	
03	Hassan Ahmed Saleem	Assistent Director	~	~~hassan~~ hassan7742125@gmail.com	7742125	
04	Abdulla Shiham	R. Atoll council member	R. Atoll council ra	Shiham.hassa@gmil.com	7731257	
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07	Mohamed Hamdhan	Asst. Director	EPA		7668606	
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