ENVIRONMENTAL IMPACT ASSESSMENT
For the Harbour Development at Omadhoo, Thaa Atoll, Maldives

March 2016

Proposed by
Ministry of Housing and Infrastructure

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For Water Solutions Pvt. Ltd
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146 रुपये जीतने के लिए रिसर्च खर्च किए जाने वाले ज्ञात: 28,462 रुपये।
EIA for Harbour Development Project at Th. Omadhoo
Non-Technical Summary

This report discusses the findings of environmental impact study undertaken by Water Solutions Pvt. Ltd. upon request from Ministry of Housing and Infrastructure for the proposed harbour development project in Th. Omadhoo.

Th. Omadhoo is located on the southern rim of Thaa atoll and has a population of 456. Majority of the island community depend on fishing as their main economic activity. Until now, the island has no harbour facility and is one of the most crucial issues faced by the island community. This project is initiated by the government as part of its national programme to provide safe harbour to each and every inhabited island of Maldives. Presently, lack of a harbour is an obstacle for the economic expansion and diversification of the island.

Lack of a harbour in Omadhoo has many developmental obstacles for the island. At present the only way to access the island is by means of a damaged jetty on the north side of the island. For mooring the vessels, fisherman and other vessel owners use deep lagoons within the island reef system. In rough weather, getting in out of the island is almost impossible. Some of the vessels have to go to a nearby harbour for mooring in unfavourable weathers. This is the dilemma the islanders have faced until now.

The construction of the harbour at Th. Omadhoo includes construction of a quay wall on inner side and both ends of the harbour using T-shaped concrete blocks, deepening the harbour basin to 3 meters at mean sea level, dredging of the harbour basin which is 500 feet long and 250 feet wide, construction of 563 feet long breakwater with rock boulders, reclamation of the area between the harbour and shoreline by using dredged material from the harbour basin, reclamation of area east of harbour, dredging of an access channel to a depth of 3 meters at Mean Sea Level (MSL).

The dredging work for the project is expected to generate around 28,462 m³ of dredged material. The dredged material will be used for reclamation purpose. A 563 ft long seawall would be constructed on western side of the area which would be reclaimed between harbour and the island to protect the reclaimed area from erosion. The project also include construction of 146 ft seawall at the area which is presently used to access the island.

The proposed project is therefore geared towards developing a third generation harbour on the north side of the island with an entrance channel and breakwaters to protect the harbour basin. Since, the harbour is proposed to be constructed on the lagoon, the area between the harbour and island shoreline will be reclaimed using the dredged material from harbour basin.

The harbour is expected to ease many of the challenges faced by the islanders, especially for the vessel owners, as safe mooring will be guaranteed. A detail environmental assessment was undertaken for this project and the findings are reported in this EIA. This EIA has been prepared to assess the social and environmental impacts of this proposed project.

As this is a completely new development, significant negative impacts on the island marine environment will be felt through permanent habitat modification and direct destruction of the marine environment. Similarly, the coral reef will be directly and indirectly impacted for this project. As the same time, the socio-economic impacts of this project will be significantly felt on a very large scale and not necessarily for the islanders only.

In such projects, environmental damage cannot be avoided and hence the goal should be to undertake the works in a least damaging manner. As a large area of the marine and coastal environment will be affected, careful implementation of the mitigation measures and adopting methods which minimizes the damage will be the key for this project. Most of these measures are the best practice guidelines and protocols that does not require sting financially to implement.

Stakeholder consultations were held with various groups including island council, island community, Ministry of Housing and Infrastructure and Ministry of Environment and Energy in order to incorporate the socio-economic components in the project. Stakeholders, most importantly the island community representatives were most significant as they have the maximum knowledge and experience from the daily difficulties faced due to lack of a harbour. Alternative locations and alternative designs have been investigated for the harbour development.

The development of the harbour in Omadhoo will have significant environmental impacts to the island, most of which will be felt on the coastal and the marine environment. The project takes place in an environment that has not been modified or damaged previously. However, natural erosion of the island has been affected to the southern area of the island. The biggest threat to the islands when a harbour is developed is the disruption it causes to natural movement of the beach. Social impacts of this project will be significant and will benefit the community as well as the region. The development of a harbour in Omadhoo is expected to bring many beneficiaries to island community.
Although the project involves inevitable negative impacts, the project is justifiable in light of the socio-economic conditions and anticipated benefits resulting from this project. Therefore, it is justifiable to undertake the project.
1 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2015, issued by the Ministry of Environment and Energy. We certify that the statements in this EIA study are true, complete and correct, to our knowledge and ability.

Name: Ahmed Jameel (EIA 07/07)
Signature:

Name: Ibrahimm Faiz (T06/15)
Signature:
Proponents Declaration

Re: EIA for Th. Omadhoo Harbor

As the proponent of the proposed project we guarantee that we have read the report and to the best of our knowledge, all information relevant to this project in terms of project description, project construction works and operational aspects provided here are accurate and complete.

Signature: [Signature]
Name: Fathimath Shaana Farooq
Designation: Director General
On behalf of: Ministry of Housing and Infrastructure
Date: 17 April 2016
3 Commitment from proponent
Date: 17 April 2016

Mr. Ibrahim Naeem,
Director General,
Environmental Protection Agency,
Ministry of Environment and
Energy, Green Building, Male’,
Maldives.

Dear Sir,

This is in reference to the EIA report for the proposed Harbor at Th.Omadhoo. As the Proponent of the project, we assure you our commitment to undertake the proposed mitigation measures and monitoring programme given in the report.

Thanking you

Sincerely,

Fathimath Shaana Farooq
Director General
4 Introduction

This report is an Environmental Impact Assessment which was developed for the proposed harbour development project at Th. Omadhoo. The aim of this EIA study is to assess the potential environmental impacts due to the harbour development project and identify mitigation measures for minimizing the adverse impacts, while undertaking the project. The EIA takes into consideration issues and concerns that will be considered as critical with respect to environment and aspects covered in the approved TOR for this project.

This Environmental Impact Assessment report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts from harbour development project at the island.

Figure 1: Aerial view of the project site at Th. Omadhoo

4.1 Extent of the EIA

This report addresses the environmental concerns of the proposed harbour development project at Th. Omadhoo. The report would facilitate the planning of the proposed harbour development project, assist in mitigating impacts caused due to the harbour development to the island’s environment. This report demonstrates the commitment by the proponent on the importance of environmental protection and preservation. The content of the report will address issues which might be a concerns to physical and biological environment of the island due to harbour development project that have been considered in the ToR provided by EPA for this project.

4.2 Structure of the EIA

The report has been structured to meet the requirements of the EIA regulations 2015 issued by the Ministry of Environment and Energy. This report has an executive summary at the beginning. Sections that will follow include a description of harbour development project, existing environment of site which has an impact due to the project, justifications and alternatives considered for the harbour development at the island.

4.3 EIA Implementation

The major findings of this report are based on qualitative and quantitative assessments undertaken during site visit to the island on 8 to 9th February 2016. The team visited Omadhoo included Ahmed Jameel (Registration number: EIA 07 / 07) (Lead consultant), Abdul Aleem (Registration number: EIA 09 / 07) and Ibrahim Faiz (Junior Environment Consultant) (Registration number: EIA T06/15)
The impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment and available long term data. However, due to unavailability of long term site-specific data, the impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment. Available long term data were collected from available sources, such as long term data on meteorology and climate from global databases.

4.4 Terms of Reference

The terms of reference for this EIA have been attached as an appendix 1. This EIA has been prepared based on this term of reference.
5 Applicable Policies, Laws and Regulation

5.1 Overview

This section outlines the relevant environmental legislation pertaining to this project as the project takes place in the context of the Maldivian law and regulations. Hence, this section will outline the relevant laws and regulations that are relevant for this project and how the project components address these concerns.

5.2 Environmental Protection and Preservation Act

Article 5 (a) of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the submission of an EIA (Majilis, 1993). It states that an EIA shall be submitted to Ministry of Environment before implementing any developing project that may have a potential impact on the environment. This project complies with this act.

5.3 Protected Areas and Sensitive Areas

Under Article 4 of the Environment Protection and Preservation Act, the Ministry of Environment is vested with the responsibility of identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation. At present there are no rules and regulations made available to the public on designation and protection of habitats and heritage areas. This project does not fall to a boundary of a protected area.

5.4 Environmental Impact Assessment Regulation 2012

The Ministry of Environment has issued EIA regulation on May 2012, which guides the process of undertaking the Environmental Impact Assessment in the Maldives – This guideline also provides a comprehensive outline of the EIA process, including the roles and responsibilities of the consultants and the proponents. This regulation outlines every step of the IEE/EIA process beginning from application to undertake an EIA, details on the contents, minimum requirements for consultants undertaking the EIA, format of the EIA/IEE report and many more.

The guidance provided in this Regulation was followed in the preparation of this EIA report. The EIA has also been prepared by registered consultants.

5.5 Regulation on Coral, Sand and Aggregate Mining

This regulation addresses sand mining from uninhabited islands that have been leased; sand mining from the coastal zone of other uninhabited islands; and aggregate mining from uninhabited islands that have been leased and from the coastal zone of other uninhabited islands. Coral mining from the house reef and the atoll rim has been banned through a directive from the President’s Office dated 56th September 1990. Under Article 7 (c) of the Regulation on Sand and Coral Mining issued by the Ministry of Fisheries, Agriculture and Marine Resources (MOFAMR) on the 13th of March 2000, it is an offence to mine sand or coral from the beach, lagoon or reef of any inhabited island. No new corals would be mined for the implementation of this project.

5.6 National Biodiversity Strategy and Action Plan

The goals of the National Biodiversity Strategy and Action Plan are conserve biological diversity and sustainably utilize biological resources, build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding, foster community participation, ownership and support for biodiversity conservation (Ministry of Housing and Environment, 2003). In implementing the proposed project activities due care would be given to ensure that the national biodiversity strategies are adhered to. The proponent has committed on conservation and protection of the environment while undertaking this proposed project. More specifically, the coral reef and generally the marine environment have been assessed in order to assess baseline values. Quantitative and qualitative surveys were undertaken to assess the biological diversity of the marine environment, especially in close proximity to the proposed project area. Practical mitigation measures and solutions have been identified to conserve and protect the biodiversity.

5.7 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was issued by the Ministry of Environment. Clause 5 (a) of the regulations states that prior to the commencement of any project(s) that would require the indiscriminate removal and export of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the regulation to prepare and Environmental Impact Assessment Report stating clearly the details of the Project(s) with all necessary information.
and submit the same through the relevant Ministry to Ministry of Environment, and the project(s) can only commence upon the grant of written approval from the Ministry of Environment and Energy. The regulations requires permission be obtained from Ministry of Environment, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted. Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (Ministry of Environment, 2008).

Neither the proposed harbour nor any of the alternatives proposed in this report involve clearing land.

5.8 Maritime and Port Legislation

There is no maritime or port legislation of relevance. The only regulations that exist in the transport sector are Law No. 65/78 (Law on the lighting requirements for vessels parked in Maldivian ports) and Law No. 66/78 (Law on port tariff or tariff levied on vessels parked in Maldivian waters).

5.9 Third National Environment Action Plan

The Third National Environment Action Plan is divided into principles, results and goals to achieve the results. Some of the fundamental principles prescribed in NEAP 3, which have been incorporated into this environmental impact assessment exercise include local democracy, informed decision making, continuous learning and improvement, right to information and participation and most importantly the complementing role of environmental protection in socio-economic development. The proposed project is expected to provide a learning experience in terms of effectiveness of the use of EIA as a planning instrument and appropriate monitoring for which specific focus is laid in Objective 24.1 of NEAP 3 (Ministry of Housing, Transport and Environment, 2009).

5.10 Waste management policy

The ministry of Environment has developed the framework for a national waste management policy. The key elements of the policy include;

- Ensure safe disposal of solid waste and encourage recycling and reduction in waste generated.
- Develop guidelines on waste management and disposal and advocate enforcing these guidelines through inter-sectorial calibration.
- Ensure the safe disposal of chemical, industrial and hazardous waste.

The key objective of the waste management policy would be the formulation and implementation of guidelines and means for solid waste management to maintain a healthy environment. Waste management for the proposed project will be in line with this policy.

5.11 Regulation on Dredging and Reclamation of Island and Lagoon Areas

Following are the clause of this regulation that are applicable to this project.

Clause 6, a, and c outlines the situation or cases to which dredging and permit can be given.

Clause 7 discusses the types of situations in which dredging and reclamation can be undertaken.

Clause 11 outlines the criteria’s to be utilized during dredging and reclamation.

Clause 13 outlines the details conditions to be met in a borrow area. This includes minimum buffer zone between the reef line, shore lines and also buffer zones around reef.

Clause 14 outlines the dredge spoil disposal methods and its use.

Clause 15 outlines the maximum area for dredging.

Clause 16 outlines the maximum area for reclamation.

This project will be in line with this regulation.
6 Project Descriptions

6.1 Project Proponent

This project is proposed by the government of Maldives with Ministry of Housing and Infrastructure as the Implementing Agency. Ministry of Housing and Infrastructure is the government ministry responsible for the development and regulation of the construction sector of the country. It is also the agency which oversees the development of public infrastructure of the country. All harbour development projects therefore fall under the responsibility of Ministry of Housing and Infrastructure. Ministry of Housing and Infrastructure has undertaken several harbour design and implementation projects throughout the Maldives and have also developed standards and criteria’s for developing harbours.

The project would be executed by contractor who would be selected through the government tendering process. Tendering would be done after the EIA approval has been approved.

6.2 Project Location and Study Area

This project takes place at the island of Omadhoo at Thaa Atoll, Maldives. This island is formed at the southern edge of the Thaa atoll (see Figure 2). The island is located at the geographic coordinates of 2°10'00"N and 73°02'01"E. The island is situated on a large reef system with large reef flat areas and deep lagoons (vilu). The closest inhabited island is Hirilandhoo and Kinbidhoo. At present there is no harbour in Omadhoo. However there is a small jetty on north side of the island which is used to access the islands. The following figure shows the locations of Omadhoo.

Figure 2: Project location, Th. Omadhoo

6.3 Need and Justification

The primary reason to undertake this project is to find a permanent solution for the community of Omadhoo faced by lack of a harbour. The existing access to the island is by means of jetties on the north side of the island (see Figure 2) and the natural lagoon on north side of the island is used for mooring vessels. This does not provide sufficient access to the island and safe anchorage for the vessels. Due this difficulty, very few vessels uses the island lagoon for mooring. This project will directly benefit the local population by providing a suitable harbour and increasing the standard of living through provision of safe and easy access to the island. This project will also help to establish further facilities and opportunities to develop the fishing industry and other economic activities in the island.
6.3.1 Why a new harbour?

The proposed harbour will provide easy and safe access for the vessels providing opportunity for developing and improving economic activities on the island. This would be a huge improvement over the current condition as the island does not have a harbour. Like all such projects, harbour construction in Omadhoo is also expected to interrupt the sediment movement around the island resulting in changes to the near shore environment. However, the economic and social benefits of constructing the harbour outweigh the changes that are expected to bring to the island physical environment.

6.3.2 Why Proposed Design?

The proposed concrete quay walls and rock boulder breakwater are the new third generation harbours tested in Maldives. Compared to previous two generations, third generation harbour provide more protection and are more durable. The proposed design has also been considered based on the following.

- The concrete quay wall are considered more durable
- The breakwater that would be made using rock boulders
- The harbour would be 250 ft. wide and 500 ft. long
- Entrance channel and harbour basin would deepen up to -3 m at main sea level
- 563 ft. rock boulder breakwater would be constructed on northern side of the harbor basin
- This design is proven in Maldives
- 146ft sand cement bag seawall will be built at the exiting T jetty at the island
- A 563 ft long seawall would be constructed on western side of the area which would be reclaimed between harbour for coastal protection
6.4 Project Duration and Scheduling

The implementation of the project would start after the completion of the EIA approval and a contractor is finalised and awarded the contract to develop the harbour at the island. Development of a harbour at Omadhoo is a priority as this is one of the few islands which do not have a harbour for safe accessibility to the island. The project is expected to complete in 350 days.

6.5 The Project

The proposed project involves the development of new harbour on the north side of the island. Based on the findings during the field visit and discussion with community, a concept incorporating the requirements of the community has been presented in the recommendation section of the report. A description of the project components in the project are discussed below.

6.5.1 Description of the project components

To provide modern harbouring facilities to Omadhoo community, a harbour which is 214 ft wide and 506 ft long will be constructed under this project. The harbour construction project of Omadhoo will have the following main components.

- Dredging of the harbour basin. The proposed harbour basin would be dredged to a depth of 3 m at MSL. The harbor basin would be 50 ft. long and 250 ft. wide. The area of the proposed harbour basin 10,944 m2. The harbor basin to be excavated to a depth of -3m at MSL
- Widening the existing entrance channel to the island to have width of 23 m and 126 m long and -3 m deep at MSL.
- Construction of 563 ft long rock boulder breakwater on the outer side of the harbor.
- Construction of quay wall on the inner side of the harbor, western and east side using T-shaped blocks whose top will be finished with a concrete capping beam.
- On northern side, inside the harbor, 437 ft sand cement bag quay wall would be constructed
- Disposal of dredged material. The excavation of harbor, entrance channel and beaching area is expected to generate approximately 28,462 cbm of dredged material. This material will be used to reclaim the area between the harbour and island shoreline and the area east of the proposed harbor.
- Sand cement bags would be used to construct a 563 ft long seawall on western side of the area which would be reclaimed as a coastal protection measure.

6.5.2 Process and Materials

6.5.2.1 The Dredging Process

The dredging of harbour basin would be undertaken by using excavators. It is recommended to use larger excavator to minimize the impact on environment. Using large excavators will save time and the impact of dredging on the marine environment would not be prolonged. Excavators will be working on
December 2014

HARBOUR LAYOUT

CONCRETE QUAY WALL

SAND-CEMENT BAG SEA WALL

RECLAIMATION AREA

TH.OMADHOO HARBOUR

CONSTRUCTION OF BREAKWATER (TYPE 1)

CONCRETE SLAB BREAKWATER (TYPE 2)
sand bed. The dredged material would be disposed in the area proposed for reclamation using dump trucks.

The entrance channel would be excavated using excavator on a barge. The excavated material would be transported on the barge to the island where it would be disposed at the location where it would be used for reclamation as part of the project.

6.5.2.2 Reclamation process

The dredged material would be disposed in the areas proposed for reclamation. An area of approximately 17,776 m² will be reclaimed under this project. This is the size of the area that can be reclaimed using the dredged material from harbour basin.

6.5.2.3 Construction Materials

The quay wall would be constructed with concrete T-shaped blocks. Concrete caps placed on these blocks will be placed using concrete. The quay wall on northern side of the harbour would be constructed using sand cement bags. The breakwater outside the harbour, on the northern side will be build using rock boulders. Sand cement bags would be used to construct a sea wall as coastal protection on western side of the area which would be reclaimed as part of the project.

6.5.3 Labour and equipment

Heavy machineries like excavators and dump trucks will be used for dredging harbour basin and construction of quay wall and breakwater. Moreover, total 27 workers will be utilized for this project.

6.6 Project Implementation

The implementation of the project would start after the completion of the EIA approval and a contractor is finalised and awarded the contract to develop the harbour at the island. Development of a harbour at Omadhoo is a priority as this is one of the few islands which does not have a harbour for safe accessibility to the island. The project is expected to complete in 350 days.

6.7 Operation and Maintenance

Harbour management in the Maldives is a responsibility of the government. The Ministry of Housing and Infrastructure has a budget line allocated to investment and maintenance of the harbour. Harbour inspections are undertaken by the Ministry at regular intervals and condition of the harbours assessed regularly. Harbours requiring maintenance are then taken into consideration for public funding. In many islands, day-to-day management of harbours are undertaken by the island councils.

6.8 Project Inputs and Outputs

The project has inputs in terms of human resources, and natural resources and machinery. The main output of the project is a modern harbour that would bring direct and indirect benefits to the local communities in terms of social and economic development. The inputs and outputs are summarised in Table 1 and Table 2.

Table 1: Main inputs of the proposed project

<table>
<thead>
<tr>
<th>Input resource(s)</th>
<th>How to obtain resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction workers (27)</td>
<td>Contractor’s responsibility</td>
</tr>
<tr>
<td>Management and maintenance staff</td>
<td>Island Council</td>
</tr>
<tr>
<td>Construction materials. Concrete blocks,</td>
<td>Import and purchase where locally available at</td>
</tr>
<tr>
<td>reinforcement steel bars, sand, cement,</td>
<td>competitive prices – Contractor’s responsibility.</td>
</tr>
<tr>
<td>aggregates, etc.</td>
<td></td>
</tr>
<tr>
<td>Breakwater using rock boulders</td>
<td>Imported from India or any other country</td>
</tr>
<tr>
<td>Water supply (during construction)</td>
<td>Ground or rainwater</td>
</tr>
<tr>
<td>Electricity/Energy (during construction)</td>
<td>Diesel-based electricity from island mains</td>
</tr>
<tr>
<td>Machinery such as excavators, crane lorries and dump trucks</td>
<td>Contractor’s responsibility</td>
</tr>
</tbody>
</table>

Table 2: Matrix of major outputs

<table>
<thead>
<tr>
<th>Products and waste materials</th>
<th>Anticipated quantities</th>
<th>Method of disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fill material or dredge spoil</td>
<td>28,462 cbm</td>
<td>Disposed to areas requiring reclamation</td>
</tr>
<tr>
<td>Constructional waste (concrete and cement debris)</td>
<td>1,000 cbm</td>
<td>Used as landfill in fill area behind quay wall</td>
</tr>
<tr>
<td>Accidental oil leakage</td>
<td>Trace amounts</td>
<td>Take precautionary measure to avoid</td>
</tr>
</tbody>
</table>
### 6.9 Risks Associated with the Project

There are few risk factors associated with this project that could possibly have both financial and environmental implications. The most significant risk associated is not completing the work on time and causing delay in demobilizing from the island.

There is also the risk of project delays caused by bad weather. This risk can be minimized if the works are scheduled as such that major work is planned to north east monsoon. The mobilisation to the project could be planned as such heavy machineries are transported at the end of the north east monsoon.

### 6.10 Project Schedule

Following is a tentative schedule for undertaking the proposed harbour development project at Omadhoo after project is awarded to a contractor. Total project duration is expected to be 351 days.

Table 3: Project Schedule

<table>
<thead>
<tr>
<th>Description</th>
<th>Months</th>
<th>Duration / Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Preliminary works</td>
<td>1 2 3 4 5 6 7 8 9 10 11 12</td>
<td>7</td>
</tr>
<tr>
<td>2 Mobilization</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>3 Site setup</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>4 Survey and setting out</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>5 Dredging and excavation</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td>6 Breakwater construction</td>
<td></td>
<td>85</td>
</tr>
<tr>
<td>7 Quaywall construction</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>8 Revetment construction</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>9 Out survey</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>10 Site clearance</td>
<td></td>
<td>14</td>
</tr>
<tr>
<td>11 Demobilization</td>
<td></td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Unavoidable during the construction stage but will be minimized</th>
<th>Dust emission during construction work and exhaust gases from machineries. Unavoidable but will be minimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>Only localized to the island environment</td>
<td></td>
</tr>
<tr>
<td>Air pollution</td>
<td>Limited quantities of dust and exhaust gas</td>
<td></td>
</tr>
</tbody>
</table>
7 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental and socio-economic components of the project that were considered are physical environment, social and economic environment and coral reef areas as the marine environment. Data collection was undertaken for the above components. In order to study the existing environment of the island, the following data collection methodologies were used during the field visit undertaken in February 2016 to the island.

7.1 General Methodologies of data collection

Conditions of the existing environment were analyzed by using appropriate scientific methods. The environmental components of the study area were divided into marine and coastal zone. The marine environment of the island covered the house reef, especially eastern side of the island, around the area of the proposed project. The coastal environment covered the coastline within the project boundary.

7.2 Mapping and Location identification

The entire island, shore line, vegetation line and marine survey locations (in the project boundary) and existing coastal structure were mapped. Mapping was undertaken using hand held differential GPS. The location of data collection sites were marked using handheld GPS. These data collection points include water sampling locations, marine survey areas and proposed borrow areas.

7.3 Marine Survey

To assess the benthic composition of the survey site, an LIT transect of 20 meters were undertaken. The benthic categorization was focused on categorizing life forms followed under the Reef Check protocol, which emphasises on benthic composition categorizing such as hard corals, sand, rock and others. This method is universally used throughout the world by Reef Check surveyors and hence it has been used. The 20 meter segment was divided in to 2 segments, each 10 m long.

This LIT method was also complimented by qualitative methods, such as visual observations and through the use of photos. Fish counts were also undertaken to get a snapshot of the fish population. Details of these methodologies are discussed in the methodology section.

The following are definition of benthic categories used in this survey.

- HC: All living coral including bleached coral; includes fire, blue and organ pipe corals
- SC: Include zoanthids but not anemones (OT)
- RKC: Coral that has died within the past year; appears fresh and white or with corallite structures still recognizable
- NIA: All macro-algae except coralline, calcareous and turf (record the substrate beneath for these); Halimeda is recorded as OT; turf is shorter than 3cm.
- SP: All erect and encrusting sponges (but no tunicates).
- RC: Any hard substrate; includes dead coral more than 1 yr old and may be covered by turf or encrusting coralline algae, barnacles, etc.
- RB: Reef rocks between 0.5 and 15cm in diameter
- SD: Sediment less than 0.5cm in diameter; in water, falls quickly to the bottom when dropped.
- SI: Sediment that remains in suspension if disturbed; recorded if color of the underlying surface is obscured by silt.
- OT: Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrate. Seagrass is also recorded under this category.

General impression and quantitative results of the sites surveyed are described in the following pages. The diagrams in the following pages illustrates the marine survey locations as well as reef status, their GPS coordinates.

7.4 Bathymetric survey

A rapid bathymetric survey was undertaken to assess the baseline condition of the proposed the harbour basin, entrance channels and the disposal site. Bathymetric surveys were used to determine the volume of sand that could be excavated from harbour basin and entrance channel and sand required to undertake the proposed areas for reclamation.
7.5 Marine water quality

The quality of marine water in the proposed area harbour was assessed by testing water samples at the site. Using a GeoXT GPS, the positions of the locations were identified. Turbidity was the main parameter that was tested.

7.6 Socio-economic condition and stakeholder consultation

The baseline socio-economic condition of the island and the possible impacts of the project to be caused to the island community were studied by using various methods. The EIA team met the island community representatives and island council. In this meeting detailed discussions were held with the committees regarding the proposed harbour development project and gathered views and perceptions of community and the island council. A site inspection was also carried and gathered information about the socio-economic condition of the island.
8 Existing Marine Environment

8.1 Marine Environment

The marine environment of Omadhoo Island consists a very extensive shallow lagoon area, sea grass beds, extensive reef flat on south side and deep lagoons on northern side of the island. Omadhoo Island is situated within the southern edge Thaa atoll in a very large reef system. The reef system has a length of approximately 25 km. The reef system has 12 islands out of which 3 area inhabited island. Nearest islands to Omadhoo are Kinbidhoo, Veymandoo and Hirilandhoo.

8.1.1 Abiotic Marine Environment

Omadhoo is an island lies on the southern edge of the Thaa atoll. The island is protected by shallow extensive shallow lagoon area and few deep lagoons within the reef system of Omadhoo. Two major geomorphic components of marine environment of the island comprise the coral reef system and the lagoon system. Various features and habitats are contained within these two components of the marine environment. The lagoon system on the north side of the island covers a large area of sea grass beds.

8.1.2 The Lagoon System

Omadhoo Island is covered by an extensive lagoon system. Most of the lagoon area that surrounds the island is shallow and covered with sea grass. The area further out is deeper lagoon. Bottom substrate of deep lagoon consists of mainly fine sand and unconsolidated rubble, coral patches and individual coral colonies.

8.2 The Coral Reef System

Island is located within a large reef system which is approximately 25 square kilometres. The coral reef system consists of reef slope, reef flat and patch reefs. The reef flat on northern side of the island is more than 150m wide. The harbour is proposed to be developed on north side of the island where the area is covered by shallow lagoon.

8.3 Marine Survey

The marine environmental survey at Omadhoo was eight sites as indicated in the following diagramme. Site selection for the marine survey was based on representative points that will ensure that the reef system near the island is well represented, that includes dredging and filling areas as well as other areas of the reef further away from the proposed harbour.

Figure 5: Marine survey locations
The following table outlines the GPS locations of the marine survey locations.

Table 4: GPS locations of the marine survey locations

<table>
<thead>
<tr>
<th>Survey location</th>
<th>M</th>
<th>GPS coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey location 1</td>
<td>M1</td>
<td>2°10'12.73&quot;N / 73° 1'29.85&quot;E</td>
</tr>
<tr>
<td>Survey location 2</td>
<td>M2</td>
<td>2°10'16.27&quot;N / 73° 1'28.01&quot;E</td>
</tr>
<tr>
<td>Survey location 3</td>
<td>M3</td>
<td>2°10'16.73&quot;N / 73° 1'31.92&quot;E</td>
</tr>
<tr>
<td>Survey location 4</td>
<td>M4</td>
<td>2°10'13.85&quot;N / 73° 1'36.56&quot;E</td>
</tr>
<tr>
<td>Survey location 5</td>
<td>M5</td>
<td>2°10'25.24&quot;N / 73° 1'35.72&quot;E</td>
</tr>
<tr>
<td>Survey location 6</td>
<td>M6</td>
<td>2°10'33.74&quot;N / 73° 1'33.21&quot;E</td>
</tr>
<tr>
<td>Survey location 7</td>
<td>M7</td>
<td>2°10'44.03&quot;N / 73° 1'40.23&quot;E</td>
</tr>
<tr>
<td>Survey location 8</td>
<td>M8</td>
<td>2°10'44.96&quot;N / 73° 1'34.84&quot;E</td>
</tr>
</tbody>
</table>

### 8.4 Coral reef

Eight sites were surveyed to assess the marine environment as baseline for reef benthic community. The coral formation in Omadhoo reef varies from site to site. Some areas of the reef do not have live corals or any type of corals for that matter while other areas have high coral cover. Geologically, the reef structure and formation is not very complex in terms of its composition. As the project involves reclamation, a representative site was chosen from the lagoon as well.

#### 8.4.1 Status of coral reef at site 1

Site 1 was chosen from where the harbour basin is proposed. The entire area is considered as sea grass beds and as a result, the depths in this location were approximately 0.5 to 1 meters at mean sea level. There is heavy growth of sea grass in site 1 and hardly any fish species were encountered except for some juvenile herbivores. During low tide seagrass bed is exposed.

![Figure 6: Photos from site 1](image)

#### 8.4.2 Status of coral reef at site 2

Site 2 was chosen from where breakwater is proposed. Similar to site 1, site 2 also has seagrass and sand as benthic cover. No live corals or fishes were observed during the survey. Attached below are underwater photos from site 2.

![Figure 7: Photos from site 2](image)
8.4.3 Status of coral reef at site 3

Site 3 was chosen from where harbour channel is proposed. Similar to site 1 and 2, site 3 also has seagrass and sand as benthic cover. No live corals were observed during the survey. Attached below are underwater photos from site 3.

Figure 8: Photos from site 3

8.4.4 Status of coral reef at site 4

Site 4 was chosen from the existing beaching area lagoon. This area is proposed for dredging under the harbour development project. Some part of this area is covered with sea grass. However, since the area is dredged in the past the deep areas in this location are covered with fine sand with no or very few live corals. Photos are attached below.

Figure 9: Photos from site 4

8.4.5 Status of coral reef at site 5

Site 5 was selected in one of the shallow areas inside the deep lagoon area. There are several such shallow areas within the reef system. These areas may need to be removed as they make it very challenging to navigate through the deep lagoon, especially during night time. Benthic composition of the site 5 is dominantly covered with rubble and sand. Few acropora coral species were observed in this location. It is noticeable that most of the live coral in this area is relatively small in size. Underwater photos from this location are attached below.

Figure 10: Photos from site 5
8.4.6 Status of coral reef at site 6

Site 6 also was selected in one of the shallow areas inside the deep lagoon area. Site 5 and 6 has similar benthic environment, however live coral percentage is higher in site 6 compared to site 5. Benthic composition of the site 6 is dominantly covered with rubble and sand. Acropora coral species were observed in this location. It is noticeable that most of the live coral in this area is relatively small in size. Underwater photos from this location are attached below.

Figure 12: Photos from site 6

Figure 13: Benthic substrate cover at Site 6
8.4.7 Status of coral reef at site 7

Site 7 was selected on reef area east to the deep lagoon entrance channel. This area of the reef is very healthy with high live coral percentage and fish population. Coral massives and acropora species dominate the live coral in this site. Few table corals were also observed. Attached below is photos from site 7.

Figure 14: Photos from site 7

![Figure 14: Photos from site 7](image)

![Figure 15: Benthic substrate cover at Site 7](image)

8.4.8 Status of coral reef at site 8

Site 8 was selected on reef area west to the deep lagoon entrance channel. This area of the reef is also very healthy with high live coral percentage and fish population. Coral massives and acropora species dominate the live coral in this site. Attached below are photos from site 8.

Figure 16: Photos from site 8
8.5 Assessment Fish Communities in the Surveyed Area

The result of 20 minutes swim for fish count along transects at sites reveals that the abundance and diversity of fish as moderately good on the reef area but very low on the lagoon proposed for harbour development. This may be due to the presence of a number of live coral colonies in the outer reef. Since most of the lagoon area was covered with seagrass, sand and rubble, few fishes associated with this type of environment were encountered. The dominant fish taxa observed in the surveyed area included grazers like surgeon fishes, wrasses, parrotfishes and damsselfishes (see table below).

Table 5: Results of the fish encounter survey (Sites 1 to 4)

<table>
<thead>
<tr>
<th>Family</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
<th>Site 5</th>
<th>Site 6</th>
<th>Site 7</th>
<th>Site 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angelfishes (Pomacanthidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>-</td>
<td>-</td>
<td>R  R</td>
</tr>
<tr>
<td>Anthias</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Batfish</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Bigeyes (Priacanthidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butterflyfishes (Chaetodontidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td>A  C</td>
<td></td>
</tr>
<tr>
<td>Damsselfishes (Pomacentridae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C  C</td>
<td>A  A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emperors</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusiliers (Caesionidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goatfishes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Groupers</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  R</td>
<td>C  C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hawkfishes</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C  C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jacks</td>
<td>-</td>
<td>R</td>
<td>-</td>
<td>R</td>
<td>-</td>
<td>R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lethrinidae (Emperors)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Moorish idol (Zanclidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C  C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parrotfishes (Scaridae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  R</td>
<td>C  C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rudderfishes (Kyphosidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snappers (Lutjanidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C  C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soldier fish</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squirrelfishes (Holocentridae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgeonfishes (Acanthuridae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>C  C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweetlips</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triggerfishes (Balistidae)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>R  C</td>
<td>C  C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrasses (Labridae)</td>
<td>R  R</td>
<td>-</td>
<td>R  R</td>
<td>R  C</td>
<td>C  C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8.5.1 Marine water quality and bathymetry

Qualitative and quantitative assessments were made on seawater from one location. The following table illustrates the result of the marine water quality test. SW1 is the same location as M1. Refer to the marine environment survey location.

Table 6: Results of the marine water quality tests undertaken in Omadhoo Island

<table>
<thead>
<tr>
<th>Water Quality</th>
<th>Site</th>
<th>M1</th>
<th>M2</th>
<th>M4</th>
<th>Optimal range</th>
<th>Ref</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical appearance</td>
<td></td>
<td>Clear</td>
<td>Cloudy</td>
<td>Clear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Conductivity (us/cm)</td>
<td></td>
<td>55,500</td>
<td>53,500</td>
<td>55,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature C</td>
<td></td>
<td>28.3</td>
<td>29.0</td>
<td>28.5</td>
<td>18 - 32 Degree Celsius</td>
<td>GBRMPA 2009</td>
</tr>
<tr>
<td>Total Dissolved Solids mg/L</td>
<td></td>
<td>37,401</td>
<td>38,444</td>
<td>37,400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salinity (mg/l) or PPT</td>
<td></td>
<td>33,800</td>
<td>33,900</td>
<td>33,800</td>
<td>3.2% - 4.2%</td>
<td>GBRMPA 2010</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8 to 8.3. Levels below 7.4 cause stress</td>
<td></td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td></td>
<td>1.0</td>
<td>2.0</td>
<td>1.0</td>
<td>3 to 5 NTU. &gt; 5 NTU causes stress</td>
<td>Cooper et al 2008</td>
</tr>
</tbody>
</table>

The marine water quality results do not indicate any sign of pollution. These ranges reflect the current status of the water quality. However, it is anticipated that the turbidity levels would increase temporarily during the construction period due to dredging.

8.5.2 Bathymetry

A rapid bathymetric survey was undertaken in the lagoon at proposed harbour development location and the entrance channel. Bathymetric map is attached as an annex. The average depth of the proposed harbour location is around 1.0 m at MSL. The average depth of the existing entrance channels is around -2.0 to 2.5 m. The bathymetric survey was carried out by the contractor.

8.5.3 Environmental Condition of the Reclamation Site (Dredged Material Disposal Sites)

The dredged material from the harbour basin would be disposed to area between the harbour and shoreline. This area is mainly covered by sea grass. The average depth is 0.5 m at MSL. No significant benthic life other than sea grass was encountered during the visual observation.
8.6 Existing Coastal Environment

There are few coastal modifications and structures on the island. The only coastal structure is the jetty and the beach area that had been developed on northern side of the island. The following points were noted regarding the existing harbour.

8.6.1 Climatic setting

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°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 considerable variation of climate between northern and southern atolls. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are unavailable for longer periods.

8.6.1.1 Monsoons

Monsoons of Indian Ocean govern the climatology of the Maldives. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. Monsoons can be best characterized by wind and rainfall patterns. The southwest monsoon is the rainy season which lasts from May to September and the northeast monsoon is the dry season that occurs from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November.

8.6.1.2 Wind

The two monsoon seasons have a dominant influence on winds experienced across 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 kts have been recorded at Male’ during such storms.

Medium term meteorological data from Met Office at Kadhdhoo Airport weather station was used in this analysis. The south-west monsoon brings winds predominantly between SW and NW. During May and June winds are mainly from WSW to WNW, and in July to October winds between W and NW predominate. The north-east monsoon brings winds between N to E quadrant. During March and April, winds are variable and during November winds are predominantly from west, becoming variable.

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 during both monsoons, with a maximum wind speed recorded at 18 m.s-1 for the period 1975 to 2001.

Maximum wind speed recorded in the south was 17.5 m.s-1 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.

8.6.1.3 Waves

It was not possible to obtain site specific data on wave conditions due to lack of time. Studies conducted elsewhere in the Maldives have been considered as a general guide to wave conditions at Omadhoo.

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

Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives.

In addition, Maldives have been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP, 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than 1 occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Krakatoa (Choi and others, 2003).
8.6.1.4 Currents

In general, currents tend to be monsoonal in origin, generally setting W during the NE Monsoon (January to March) and E during the SW monsoon (May to October). During the transition months, the currents are variable. Ocean currents flowing through channels between the atolls are driven by the monsoon winds. Current speeds of 1 to 1.5 knots are reported in the Admiralty pilot. However, the current in the E/W channels of the Maldives may attain 5 knots.

Currents which affect around Omadhoo reef system and within reef flat can be the result of one or more of tidal currents, wind-induced currents, wave-induced currents and ocean currents.

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

Studies in other coral atolls show that wind and waves as the primary driving mechanism of lagoon flushing and circulation on coral atolls (Kench, 1994). Within the lagoon, the surface water is moved primarily by wind, whereas deeper water is moved by tide. Currents within a reef flat are modified by reef and island morphology. In general terms, the tidal component of current is eastward during flood tide and westward during ebb tide.

Tides experienced in Maldive islands are mixed and semi-diurnal/diurnal. Typical spring and neap tidal ranges are approximately 1.0m and 0.3m, respectively (MEC, 2005). Maximum spring tidal range in the central and southern atolls is approximately 1.1m. There is also a 0.2m seasonal fluctuation in regional mean sea level, with an increase of about 0.1m during February to April and a decrease of 0.1m during September to November.

The predicted astronomical tides provided above may vary at any given time and location based on a number of meteorological and other factors including: wind set-up or set-down, due to onshore or offshore winds, atmospheric pressure deficiency or excess, due to areas of low or high pressure, leading to a positive or negative surge component respectively, wave set-up or set-down due to ‘groupiness’ of waves reaching the shore, due to ‘surf beats’, or due to ponding of broken waves, seasonal variation in Mean Sea Level and tsunamis.

8.6.1.5 Natural hazard risk

The primary sources of natural hazard risks in Maldives are strong winds during monsoons or freak storms, earthquakes, island interior flooding caused by heavy rain, coastal flooding caused by high surf, storm surge, prolonged strong monsoonal wind, high astronomical tides or tsunamis, and sea level rise. Coastal flooding related flooding and wind damage can be considered as the most frequent natural hazards that occur in Maldives (Maniku, 1990). Most of these risk factors (apart from earthquake, wind damage and rainfall flooding), stems from the extremely low elevation of all Maldivian islands: the average elevation is 1.5 meters above sea level. In spite of the occasional natural hazards, Maldives in general is relatively from high risk natural disasters.

Spatial variations in hazards are evident across Maldives (Maniku, 1990). Northern atolls are more exposed to intense storm systems, increasing the risk of wind damage in these atolls. In comparison, southern atolls experience less storms systems, but are more exposed to flooding events, probably as a result of exposure to intense South Indian Ocean storm surges and wind-waves during south west monsoons. Southern atolls are also more likely to experience earthquakes.

Historical records suggest that Omadhoo is prone to natural disasters compared to other islands of Maldives. Tsunami of 2004 was biggest natural disaster that affected Omadhoo. Project site could be considered as being in a relatively safe zone, in terms of natural hazards. Impacts from wind damage and flooding due to a combination of high astronomical tide and strong wind generated waves during southwest monsoon are the most probable sources. Risk of tsunami damage exists, although its probability is low and could be managed with proper code of construction. The harbour is located on northern side as the risk of Tsunami is on eastern side.

8.6.1.6 Cyclones in the Maldives

The islands of the Maldives are less prone to tropical cyclones. The northern islands of the country have been affected by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. The number of cyclones directly crossing the Maldives is small. Only 11 cyclones crossed the islands over the entire span of 128 years between 1877 and 2004.
Most of the cyclones crossed the Maldives north of 6.0°N and none of them crossed south of 2.7°N during the period. All the cyclones that affected the Maldives were formed during the months of October to January except one, which formed in April.

In the northern islands, the probable maximum storm tide due to cyclones has been estimated to be around 1.82m (storm surge of 0.84 m) for a return period of 100 years. This storm surge was computed taking into account probable maximum winds and probable maximum pressure drops.

8.6.1.7 Rainfall

Annual average rainfall in 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.

8.6.1.8 Temperature

Daily temperatures of Maldives vary little throughout the year with a mean annual temperature of 28°C. The annual mean maximum temperature recorded for Male’ during the period was 30.4°C and the annual mean minimum temperature was 25.7°C. Average daily temperatures for Omadhoo area varies between 27°C and 30°C.
9 Stakeholder Consultations

Extensive stakeholder consultation had been carried out by Ministry of Housing and Infrastructure regarding the proposed harbour development project at Omadhoo. Omadhoo Island Council had undertaken several consultation meeting with the community of Omadhoo regarding the harbour development project.

9.1 Omadhoo Island Council

Consultations were held with the island council of Omadhoo on 8th February 2016 through a formal discussion held at the council office at 1400hrs. This discussion was held with council members. The following are the major issues discussed with the council members. The consultations were led by Water Solutions, with the help of two consultants who were mediating the discussions. Below are the outcomes of the consultation meeting with the island council.

- According to the council, the present jetties are not sufficient for the fishing vessels and other commercial use. The deep lagoon used for mooring vessels gets very rough during the north east monsoon.
- The council members briefed to the EIA Team that the existing jetty and the entrance channel was created during 1990s through the access programme which the government implemented. Before that the island was very isolated as the access to the island was very difficult.
- The existing entrance channel is shallow and there are many shallow areas between the entrance channels to T jetty. This makes very difficult for cargo vessels which travels from Male’ atoll to visit Omadhoo. Due to lack of a routine cargo vessel service between Male’ and Omadhoo creates difficulty for the business to provide basic goods un-interrupt to the community.
- With the present condition, industrial activities cannot be expanded and developed.
- The council noted that the harbor development project should place marker lights at the entrance channel and shallow areas on the way from entrance channel to the harbor entrance.
- The council expressed their interest to create a path for the small vessel to travel to southern side of the island around the island to load and unload fish. The council is planning to allocate land on southern side of the island for industrial use.
- The council members noted that the harbor is an urgently needed infrastructure to the island and they agree with the current concept that Ministry of Housing and Infrastructure had developed based on communication between the Ministry and Council.

9.2 Omadhoo Island Community

Consultations were held with Omadhoo Community on 8th February 2016 through a stakeholder meeting held at Omadhoo Preschool. The meeting was held at 2045. This discussion was held in presence with the council members. The following are the issues discussed with island community at the stakeholder meeting.

- According to the community members at the stakeholder meeting, Omadhoo has been neglected by all governments. Some of the community members expressed their skepticism about the project. They are in the opinion that the proposed harbor development project would not become a reality.
- The community members noted that the existing T jetty at the island has been badly damaged and it is not safe for the people to use the jetty. The harbor development project is urgently needed.
- The community members noted that the proposed harbor at the island is small but they do not have an issue as they want the project to start as soon as possible. They expressed their happiness as the existing T jetty has been integrated into the harbor development of the project.
- The community members noted that the island needs a vessel beaching area and the proposal to improve the existing beaching area at the island is welcomed by the community.
- The community noted that the area proposed for reclamation as part of the harbor development project would help to create infrastructure which is related to the development of the island.

9.3 Consultation with Ministry of Housing and Infrastructure

Discussions were also held with the project Engineer from Ministry Housing and Infrastructure to obtain their views and understand the policy implications. Following are the key points discussed.
• The project is a contractor design and built project. Hence, the final design of the harbour will be designed by the contractor based on the proposed concept and design guidelines.
• The Ministry will accommodate minor adjustments to the proposed concepts as long as it does not have huge financial implications and is found to benefit the community. Hence, even works that have not been included in the project concept will be accommodated if environmental permits and the budget allow to do so.
• The recommendations and findings from this EIA report will be utilized in finalizing the detail components. Such details include the size of the harbour, the length of the entrance channel, disposal sites and issues like coastal protection and revetments.

9.4 Consultation with EPA
EPA was consulted on 22<sup>nd</sup> March 2016 regarding the harbour development project at Omadhoo. EPA noted that harbour development projects should undertake Environmental Impact Assessment as this kind of projects is classified as EIA projects in the EIA Regulations. EPA noted that stakeholder consultation with relevant stakeholders needs to be undertaken as part of the EIA process and the outcomes of the stakeholder consultation should be reported in the EIA report. When such consultations are being carried out it is important to include Island Council and Island Community. EPA further noted that Ministry of Housing and Infrastructure should obtain Dredging and Reclamation Permit for the harbour development project. The application for the dredging and reclamation permit could be applied when EIA Report is submitted to EPA for approval.

9.5 Consultation with a Contractor
Since the project has been not been awarded to a contractor, consultation was carried out with a contractor who have done harbour development projects in island. This consultation was carried out at Water Solutions on 22<sup>nd</sup> February 2016. The following are the main points that the contractor highlighted regarding a harbour development project.

• The contractor highlighted that it is important the community is in agreement with the proposed design of the harbour at the island. If not, the contractor would be the people who would be on the ground to face the unhappy community.
• Harbour development project usually will take one year to complete, if no changes are brought to the design.
• After the contractor is mobilised to the island, the contractor would get a number of request from the island council and communities ranging from uprooting a coconut tree in a house to clearing roads at the island. The contractor would not be able to do all the request as some of the request will need some kind of approval from a government authority.
• The contractor highlighted the proposed harbour development project at Omadhoo would not be difficult to implement.

9.6 People Consulted
Following are the list of people who were consulted during the EIA Addendum work. The consultations were held at Omadhoo Island Council, Ministry of Housing and Infrastructure and Environmental Protection Agency.

<table>
<thead>
<tr>
<th>Person</th>
<th>Title</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fathimath Shaana Faroq</td>
<td>Director General</td>
<td>Ministry of Housing and Infrastructure</td>
</tr>
<tr>
<td>Amir Mustapha</td>
<td>Engineer</td>
<td>Ministry of Housing and Infrastructure</td>
</tr>
<tr>
<td>Suhaida Ibrahim</td>
<td>Assistant Engineer</td>
<td>Ministry of Housing and Infrastructure</td>
</tr>
<tr>
<td>Nafha Aujaz</td>
<td>Environment Analyst</td>
<td>Ministry of Housing and Infrastructure</td>
</tr>
<tr>
<td>Hussain Shiyam</td>
<td>Engineer</td>
<td>With Contractor experience</td>
</tr>
<tr>
<td>Abdulla Riyaz</td>
<td>MP</td>
<td>Kinbidhoo Dhairaa</td>
</tr>
<tr>
<td>Azmeel</td>
<td>President</td>
<td>Omadhoo Island Council</td>
</tr>
<tr>
<td>Abdulla Shakir</td>
<td>Member</td>
<td>Omadhoo Island Council</td>
</tr>
<tr>
<td>Mohamed Shabiu</td>
<td>Member</td>
<td>Omadhoo Island Council</td>
</tr>
<tr>
<td>Ahmedbe</td>
<td></td>
<td>Omadhoo Resident</td>
</tr>
<tr>
<td>Ahmed Mohamed</td>
<td>Member, Harbour Committee</td>
<td>Omadhoo Resident</td>
</tr>
<tr>
<td>Mohamed Ibrahim</td>
<td>Member, Harbour Committee</td>
<td>Omadhoo Resident</td>
</tr>
<tr>
<td>Ibrahim Naeem</td>
<td>Director General</td>
<td>EPA</td>
</tr>
<tr>
<td>Fathimath Reem</td>
<td>Assistant Director</td>
<td>EPA</td>
</tr>
<tr>
<td>Abdul Aleem</td>
<td>Environment Consultant</td>
<td>Water Solutions Pvt Ltd</td>
</tr>
</tbody>
</table>
10 Alternatives

In this project, there are alternatives that have been suggested and considered. Since the EIA Regulations require two alternatives to be analysed and assessed, two alternatives have been suggested in addition to the no project alternative. These alternatives are discussed below:

10.1 No Project Option

The no project option takes the following into account.

- No harbour will be developed.
- Jetty will be not be repaired and redeveloped.

The main advantages and disadvantages of these are given below.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow islanders to use the existing method of getting in and out of the island.</td>
<td>Environmental problems related to developing a new harbour can be avoided. No costs to the proponent and hence there is a short term benefit.</td>
<td>Economic burden will increase. Long term socio-political problems may arise. Higher long term costs. Damage and loss to property and people. Health and wellbeing will severely be affected, especially children, women and the elderly. Economic expansion would be limited.</td>
</tr>
<tr>
<td>Allow public frustration and anger to continue</td>
<td>Short term costs of dealing with the problem can be avoided.</td>
<td>Political unrest. Stability and peace in the island affected. Economic activities and social fabric weakened. Lives and livelihoods will be affected.</td>
</tr>
</tbody>
</table>

Table 7: Advantages and disadvantages of the no project option

10.2 Alternative analysis matrix

For this project, an alternative analysis was carried out on the basis of various biophysical and socioeconomic parameters including:

- Technical feasibility,
- Economic viability and
- Environmental acceptability of the project and
- Social benefits

Based on the above four factors, an alternative analysis matrix was developed with scores given for each factor from 1 to 5. This analysis provides information about the advantages and disadvantages of each alternative considered with regard to its technical, economic, environmental and social factors. The purpose of this matrix is to obtain a favourable implementation of alternatives proposed by considering alternatives in terms of site selection, design and operational methods, the project scale and timing of project. The total for all factors gives an overall score for a given alternative. The highest total score provides the most desirable and preferred alternatives and vice versa.

The following table outlines the various alternatives proposed for this project, their economic, technical, environmental as well as social factors taken into consideration.
10.2.1 Alternative A1

In these options, the harbour is proposed to be created at the shoreline of the island. This option would create a 152 m long and 76 m wide harbour basin and 23 m wide and 126 m long entrance channel. Dredging to a depth of -3m at MSL would generate 29,000 cbm of sand. Out of which 21,000 cbm of sand would be used for the reclamation work and remaining 8,000 cbm sand would be piled on western side on the area which would be reclaimed as part of the project. This sand would be made available to the community to use for their construction work.

Figure 18: Alternative option 1 – creation harbor close to the island

In this option, since the harbour basin is located inside the existing T jetty, harbour basin would be exposed during north east monsoon. In this layout, it is difficult to construct a protection on the eastern side of the entrance channel as the area near the existing jetty is proposed to be used a quay wall area. Hence this option would not create moorable condition inside the harbour during north east monsoon.

10.2.2 Alternative A2

The island council proposed an alternative design to the harbour development which was provided to the EIA Team.

Figure 19: Alternative option 2 – creation a path for bakkuras to move to the eastern side of the island
During the stakeholder consultation with the Island Council and Island community, the Island Council provided the design which has been included in Figure 19. This design alternative has an additional component to create a path for small vessels to travel to eastern side of the island. The Island Council stated that they want to create an industrial area on eastern side of the island. The key activity undertaken on a large industrial scale is fish processing. Creation of a 265 m long and 10 m wide narrow channel and 20 m by 20 m area would create additional material which need to managed. This option would also create more issue on near shore coastal environment on eastern side of the island. This option could enhance the loss of beach on eastern side of the island. This council may consider create a road inside the island to access the industrial area from the harbour area. In this matter, the harbour basin would create safe moorable condition of the small vessel and easy loading and unloading of fish during both seasons.

**Figure 20:** Alternative option 3 - repairing of the existing T Jetty. This option would help to improve the condition of the quay wall. The T Jetty would be exposed during north east monsoon and also in south west monsoon when the direction of wind is from North West. The Island requires a breakwater to protection for the vessel which would not be achieved only repairing and dredging the area to a depth of -3m.
### Table 8: Alternative analysis matrix for the project

<table>
<thead>
<tr>
<th>SN</th>
<th>Alternatives proposed</th>
<th>Technical feasibility</th>
<th>Economic viability</th>
<th>Environmentally acceptable</th>
<th>Social benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Carry out the harbour development close to the shoreline on northern side of the island</td>
<td>The harbour basin and the location for the breakwater is at a shallow area of the island. However the access channel to the harbour basin would expose the harbour during north east monsoon. This option has been considered but again rejected considering the technical aspect.</td>
<td>Feasible.</td>
<td>This option is environmentally not damaging if properly executed. The sea grass beds at the harbour location would be destroyed.</td>
<td>Community not be able to use the harbour effectively during north east monsoon.</td>
</tr>
<tr>
<td>A2</td>
<td>Carry out the expansion of the harbour basin as proposed with an additional component to create a channel for the small vessel to move to the east of the island.</td>
<td>This additional component would create additional near shoreline movement and could enhance the loss of beach on east of the island.</td>
<td>In this option, the additional component will add additional cost to the project.</td>
<td>This option is environmentally damaging.</td>
<td>The community would be able to access the industrial area of the island without using the land.</td>
</tr>
<tr>
<td>A3</td>
<td>Repairing the T-jetty and excavating the area to a depth of – 3m.</td>
<td>This technically acceptable. But the quaywall at the T-jetty would not be able to use during north east and days when winds is from north west during south west monsoon.</td>
<td>This option would be financially acceptable.</td>
<td>In this option, the existing development footprint would be utilised.</td>
<td>The community would not be happy as they didn’t get a harbour.</td>
</tr>
<tr>
<td>A4</td>
<td>Rubble – mound breakwater</td>
<td>Rubble-mound breakwaters are ineffective for harbours because they collapse during storm conditions.</td>
<td>Economically cheap, but sourcing is not possible now.</td>
<td>Very unacceptable as it damages and encourages coral reef destruction.</td>
<td>Low cost may be attractive for low income societies, but ongoing maintenance cost will be a cumulative burden for the society.</td>
</tr>
</tbody>
</table>

### 10.3 Alternative analysis scores

The following table outlines the results of the alternative analysis scores calculated for this project as well as graphical representation of the scores.
Table 9: Alternative evaluation scores

<table>
<thead>
<tr>
<th>Alternatives proposed</th>
<th>Technical feasibility</th>
<th>Economic viability</th>
<th>Environmentally acceptable</th>
<th>Social benefits</th>
<th>Total scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Developing harbor close to the island</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>A2 Including additional component for the smaller vessel</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>A3 Repairing T Jetty</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>A4 Rubble-mound breakwater</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 10: Total scores for alternatives considered

Based on the analysis, Alternative A3 ranks the highest in terms of score and thus, it is considered as the preferred alternative for this project.

10.4 Preferred Alternative

The preferred alternative for this project is to repair the existing T Jetty. For mitigation, refer to the impacts and mitigation section as this section outlines the details of the measures proposed.
11 Environmental Impacts

11.1 Prediction of impacts on the coastal environment

Impacts on the marine environment from the proposed coastal modification have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analysed to predict the extent and significance of the impacts that may arise from the proposed harbour rehabilitation project’s activities. The assessment was also based on area calculations of the coastline that fall within the project boundary and anticipated to be impacted.

11.2 Prediction of impacts on the marine environment

Impacts on the marine environment from the proposed project have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Quantitative and qualitative data collected from filed work were analyzed to predict the extent and significance of the impacts that may arise from the proposed harbour rehabilitation project’s activities.

Quantitative assessment of potential direct and indirect impacts due to the proposed project was based on area calculation of the sea grass beds. Impacts from the proposed activities will be due to disturbance to the sea grass beds in harbour and release of fine sediment to the water column from dredging and filling works.

Indirect impacts will be felt to the pelagic organisms inhabiting the reef-flat, lagoon and coral reef areas close to the development locality. Indirect and long term impacts on the marine environment will be more accurately assessed by long term monitoring and assessment as part of this environmental assessment.

11.3 Uncertainties in Impacts Identification

Environmental impact prediction involves a certain degree of uncertainty as the natural and anthropogenic impacts can vary from place to place due to even slight differences in ecological, geomorphological or social conditions in a particular place.

Although measures will be taken to mitigate known impacts, there is always the probability that an unforeseen impact will occur. It is also important to note that some of the impacts predicted may turn out to be far greater than predicted. This will make mitigation measures ineffective. To avoid or reduce the chances of such events, it is vital to monitor key important parameters at the vicinity of the project.

11.4 Magnitude of impacts

Environmental impacts of the harbour development have been examined through the above mentioned processes and the results are outlined. By using the impact assessment matrix as a tool, the magnitude of the impacts can be assessed as outlined in the following table.

This EIA identifies and quantifies the significance of impacts on the environment from the proposed project. Impacts on the environment were identified and described according to their location/attribute, extent (magnitude) and characteristics (such as short-term or long term, direct or indirect, reversible or irreversible) and assessed in terms of their significance according to the following categories:

- Negligible – the impact is too small to be of any significance;
- Minor– the impact is minor;
- Minor adverse – the impact is undesirable but accepted;
- Moderate adverse – the impact give rise to some concern but is likely to be tolerable in short-term (e.g. construction phase) or will require a value judgment as to its acceptability;
- Major adverse – the impact is large scale giving rise to great concern; it should be considered unacceptable and requires significant change or halting of the project.
- Positive – the impact is likely to bring a positive change in the sense that it is aimed at further minimizing the impacts as a result of the proposed actions.
Construction phase impacts

Construction phase will have the major, direct short-term impacts and some secondary long-term impacts on the environment. Excavation work generally lead to major impacts on lagoon and coastal hydrodynamics. However, the impacts are short-lived. For this particular work for dredging of entrance channel and harbour basin, the impact would be considerably significant.

Impacts of excavation may range from removal of sea grass beds, lagoon bottom, other flora and fauna on the sea bed. Coastal modification involved in the creation of the temporary bund can have short to long term impacts on the on the coastal processes and beach profiles of the island. Significant impact on the coastal environment would be the reclamation of area using excavated material from entrance channel and harbour basin. Specific impacts on the marine environment arising from the proposed project will be mainly an alteration of the bottom of lagoon where dredging is done and a minor impact on the sediment movement along the shoreline. Main impact from the proposed activities will be due to release of fine sediment to the water column. There is also an impact on the benthic and nektonic communities that inhabit in the possible impact zone.

11.5.1 Mobilization Impacts

The transport and use of excavators and other heavy duty equipment may have an impact as a result of increased traffic with barges and other large vessels. The impacts may arise from:

- Accidental spillage of construction materials (cement bags, timber, iron bars).
- Accidental oils and other chemical spills.
- Accidental grounding of large vessels such as barges.
- Propellers’ wake can break fragile corals.
- Anchor damage from the vessels.
- Hazards of transport of material to site including overtopping of barges.

11.5.2 Impacts of dredging and reclamation

When dredging and disposing of non-contaminated fine materials in shallow waters, the main environmental effects are associated with suspended sediments and increases in turbidity. All methods of dredging release suspended sediments into the water column, during the excavation itself. In many cases, the locally increased suspended sediments and turbidity associated with dredging and disposal is obvious from the turbidity ‘plumes’ which may be seen trailing behind excavators or disposal sites.

11.5.3 Construction of Breakwater

The breakwater will be built on northern of the harbour. The breakwater would be constructed using rock boulders. The rock boulders would be used for the core and the crest of the breakwater. The harbour needs a breakwater for protection.

During construction, sedimentation would be an issue when core materials are placed at the breakwater water locations. Sedimentation impact would be short term.

11.5.4 Construction of the quay wall

The quay wall placed on the eastern, southern, northern and western side eastern side of the harbour. This would be made using precasted concrete blocks. Sedimentation would be created during the time when precasted concrete blocks are placed at the location of the quay walls.
11.5.5 **Seawall for the coastal protection of the reclaimed area**

A sea wall would be constructed on western side of the reclaimed area for coastal protection. This would be carried out using sand cement bags. During this process sedimentation and turbidity level would increase at the harbour basin.

11.6 **Impacts due to Harbour Operation**

Impacts associated with the harbour operation can be considered as minor to moderate and short to long term. These impacts include (but are not limited to):

- Poor water quality due to siltation and stagnation of water.
- Impacts due to accidental spillage of oils, other chemicals and waste.
- Hydrodynamic changes forming dead zones in the inner harbour where litter may accumulate
- Erosion and its associated impacts like loss of coastal vegetation.

11.7 **Significance of the Impacts**

Impacts that may arise from activities of the proposed harbour development project were categorized into the characteristics mentioned in the following table.

The significance of impacts was determined based on these characteristics and analysis of the impacts from this project and other analogous projects. These impacts correspond in the worst case scenario and after mitigation measures were taken. The main impacts that will arise from the proposed project activities and their significance based on impact characteristics.

Magnitude of impact is calculated in relation to the total area of the lagoon and the coral reef. Direct geographic range of impact felt will be the immediate proposed development area and indirect impacts will be felt on a larger area due spreading of fine sediment. Duration of the impact is predicted in terms of severity of impacts. The impacts are likely to be felt on an estimated 20% of the sea grass. Estimated error of these predictions may vary ±10 percent.

Reversibility of impacts was predicted based on natural recovery of the habitats affected. The coral reef naturally takes longer to recover than the lagoon habitats. Significance of the impacts is predicted based on the nature, geographic range where impacts are felt, magnitude, duration and reversibility of the impacts.

Table 12: Significant impacts of the proposed harbour development project

<table>
<thead>
<tr>
<th>Impact characteristics</th>
<th>Harbour basin dredging and re-dredging of entrance channels</th>
<th>Dredged spoil discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of impacts</td>
<td>Cumulative, long term</td>
<td>Significant impact</td>
</tr>
<tr>
<td>Magnitude of impacts</td>
<td>Minor- negative</td>
<td>Major - positive on coastal ecosystems from erosion prevention. Major +ve on socioeconomic aspects – additional protection and extension of land.</td>
</tr>
<tr>
<td>Geographical range and environmental attributes</td>
<td>Direct impact on 11,500 m² of sea grass beds and lagoon</td>
<td>Destruction of the lagoon bottom and the coral reef areas. NA</td>
</tr>
<tr>
<td></td>
<td>Direct impact on coral reef on 550m²</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Indirect impact on 10,000m² of lagoon system around the island</td>
<td>NA</td>
</tr>
<tr>
<td>Duration of impacts</td>
<td>Short term on coral reef and long term on sea grass and beach</td>
<td>Short term</td>
</tr>
<tr>
<td>Reversibility of impacts</td>
<td>Permanent alteration of physical and biological system of the harbour basin area, short term reversible impacts on coral reefs, and sea grass beds adjacent to the harbour basin</td>
<td>Irreversible</td>
</tr>
<tr>
<td>Significance of the impacts</td>
<td>Minor impacts on the harbour basin, shore-line and beach. Minor impacts on the adjacent areas of reef-flat and other environmental attributes</td>
<td>Medium</td>
</tr>
</tbody>
</table>
12 Mitigation Measures

Several actions can be taken to minimize the above mentioned impacts. Expert consultations, past experience and local knowledge are essential in reducing the impacts. Mitigation measures are employed to eliminate or reduce the severity of any predicted impacts. This will ultimately improve the environmental outcomes of the project. The predicted impacts on the coastal environment of Omadhoo can be mitigated by joint cooperation and careful environmental planning. All parties, the Island council and the contractor must work carefully to eliminate or reduce the identified risks. Given the magnitude of impacts for this project, the adverse effects can be mitigated at virtually no cost if best environmental practice and precautionary principles are used.

12.1 Identifying Mitigation Measures

Where an impact identified can be mitigated, mitigation measures are identified and discussed along with the identification of the impact. The mitigation measures proposed will help to alleviate environmental problems before they occur. Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project.

12.2 General mitigation measures to minimise the impacts

Supervision and inspection of the project activities are imperative to minimize adverse impacts. Therefore, competent environmental consultants with experience in same or similar work in the local environment will be consulted and allowed to inspect and monitor the work activities of the project life-cycle.

Supervision of work will be carried out by a competent and independent party with experience of similar work and its possible impacts to the environment. Supervising party will not be in anyway related to the contracted party to ensure that mitigation measures were taken even at extra project costs. Supervising party will carry out compliance monitoring and reporting to ensure that the predicted impacts are not exceeded. If predicted impacts were exceeded, the work will be halted and impacts re-assessed and reported.

Proposed project’s work will be carried out to coincide with low tide and easterly current so as to minimize effects of sediment on the reef. The work will be carried out in calm weather and sea condition.

Machinery, equipment and vessels used in the project activities will be maintained in good condition and operated in a manner that they do not pose a risk of the environmental degradation.

All work activities will be kept to the minimum period of time to reduce impacts on the environment.

The monitoring programme specified in this report will be followed and reported in both work phase and operation phase. Table 13 provides more information on potential impacts during construction and operation of the harbour rehabilitation project and mitigation measures.

12.3 Mitigating construction phase impacts

This section outlines mitigation measures that will be undertaken to minimize environmental impacts from the dredging, breakwater construction, and reclamation and revetment construction activity at Omadhoo for the harbour development project.

12.3.1 Monitoring turbidity levels

Given that the water quality in marine environment of the islands is very good, the turbidity levels behind zone of mixing in dredging operations shall be less than 10 NTUs.

The compliance locations given in the monitoring section of this report shall be considered the limits of the temporary mixing zone for turbidity allowed during construction. If monitoring reveals turbidity levels at the compliance location indicated above is greater than 10 NTUs (or 10%) above the associated background turbidity levels, whichever is greater, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels.

12.3.2 Using Appropriate Dredging Methods

There are a number of dredging methods whereby dredging operations are undertaken, namely, conventional dredging, cutter-suction and excavation to name a few. For the purpose of excavation of harbour basin and entrance channel, excavator shall be used. It is recommended to use large excavators for dredging activity to excavate the harbour basin. The entrance channel would be excavated using a small excavator on a pin barge. The material excavated would be transported back to the island where it will be disposed to the area where it would be used for reclamation.
12.4 Socio economic impacts of the proposed project

The following positive impacts may result from the harbour development project.

12.4.1 Easy accesses to the island

The proposed harbour will make it easier for the island fishermen, visitors and local traders and public to have easy access to the island. The existing quaywall jetty has limitations in terms of access to the island due to lack of proper facilities including proper anchoring facilities. The existing mooring area cannot be accessed by bigger vessels due to shallowness and lack of space within the inner area. This causes the local fisher men and traders to load and unload the fish catches and goods by using smaller vessels.

12.4.2 Protection for fishing and other vessels

The local fishermen have started to build bigger fishing vessels to meet the demand of more fish catch. The existing access area cannot be accessed by bigger fishing vessels, since it has limited area. This has become the major concern of the local fishermen. The existing area has no proper breakwater to protect the inner harbour and which causes damages to local fishing and other sea vessels due to high waves especially during monsoon period. The proposed harbour will address these issues and provide better facilities for protection of the harbour and vessels.

12.4.3 Decrease accidents during access

The lack of anchoring facilities, proper landing jetty and size of the mooring causes the vessels to use smaller boats to access the harbour. This method is used to load and unload the goods. This very often causes accidents whereby causing greater losses to the goods and sometimes to the workers. Although proper data is not available on the number of accidents and losses caused to the goods and workers, it is believed that this can be very much reduced after completion of the new harbour.

12.4.4 Other impacts

There are other positive impacts which can be summarized but not limited as described below.

- Create a service market after providing water and fuel for vessels;
- Increase visitors for the island;
- Increase fishing catch by using larger fishing vessels;
- Increase income of local community

12.4.5 Other issues

The main negative impact would be dissatisfaction of the community due slow progress of the project and lack of proper harbour management procedures. These issues need to be addressed to avoid any community unrest and future operation and maintenance of the harbour and its facilities.
## Table 13: Information on potential impacts during construction of the harbour project and mitigation measures

<table>
<thead>
<tr>
<th>Potential impacts</th>
<th>Mitigation measures</th>
<th>Impact locality</th>
<th>Development phase</th>
<th>Intensity and reversibility</th>
<th>Responsible authority</th>
<th>Estimated cost (MVR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Damage to reef by Loading/unloading works</td>
<td>Raising awareness and utilizing environmental best practice, careful planning</td>
<td>Reef-flat and reef-slope and lagoon</td>
<td>During construction</td>
<td>Minor, short term –ve impact. Reversible over long run</td>
<td>Contractor, Island Council</td>
<td>Included in the contract</td>
</tr>
<tr>
<td>Loss of habitat at the spoil disposal site.</td>
<td>Clearly marking the areas to be filled</td>
<td>Lagoon</td>
<td>During construction and Operational phase</td>
<td>Minor, long term –ve impact. Most likely irreversible.</td>
<td>Contractor</td>
<td>Included in the contract</td>
</tr>
<tr>
<td>Sedimentation and siltation on the sea grass and lagoon due to Excavation works</td>
<td>Creation of a sand bund to reduce the sedimentation impact, carried out in low tides</td>
<td>Lagoon, reef-flat and reef slope</td>
<td>During construction</td>
<td>Moderate, short term –ve impact. Reversible over long run</td>
<td>Contractor, Island Council</td>
<td>Included in the contract</td>
</tr>
<tr>
<td>Loss of habitat, damage or loss of sea grass beds, death of coral at the entrance channel area, harbour basin and quay wall areas</td>
<td>Clearly marking the areas to be excavated.</td>
<td>Lagoon, reef-flat and reef slope</td>
<td>During construction</td>
<td>Moderate, short term –ve impact since these are new dredging sites</td>
<td>Contractor, Island Council</td>
<td>Included in the contract</td>
</tr>
<tr>
<td>Habitat modification at the spoil disposal site.</td>
<td>The material will be disposed at the eroded areas with strictly marking the areas to be filled.</td>
<td>Beach and lagoon</td>
<td>During construction and Operational phase</td>
<td>Moderate, long term –ve impact. Most likely irreversible. Positive impacts</td>
<td>Contractor, Island Council</td>
<td>25,000</td>
</tr>
<tr>
<td>Possible erosion due to obstruction of littoral sediment movement</td>
<td>Filling the eroded areas from dredge spoil from the dredging works. In addition, constructing revetments on either side of the harbour.</td>
<td>Beach</td>
<td>Operational phase</td>
<td>Minor and unpredictable impact. Most likely no change</td>
<td>Island Council</td>
<td>Cost is difficult to estimate since the timing of impact unpredictable</td>
</tr>
<tr>
<td>Impact of dredging works on the existing operations of the lagoon and beach activities.</td>
<td>Dredging will be carried in a manner that will not interfere with the operation of the lagoon (this area is not used for any recreational activity at present).</td>
<td>Lagoon and coastal areas</td>
<td>During construction</td>
<td>Minor, –ve impacts on the operation of the harbor</td>
<td>Contractor, Island Council</td>
<td>N/A</td>
</tr>
<tr>
<td>Impacts of storm-water drainage and coastal flooding.</td>
<td>The spoil will be disposed at the western and eastern side and levelling should be maintained same as the island and sloped</td>
<td>Coastal area</td>
<td>During construction and Operational phase</td>
<td>Minor, Most likely no change.</td>
<td>Contractor, Island authorities</td>
<td>N/A</td>
</tr>
<tr>
<td>Category</td>
<td>Action</td>
<td>Time Period</td>
<td>Impact</td>
<td>Responsible Party</td>
<td>Cost</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>------------------</td>
<td>-----------------------------</td>
<td>-------------------</td>
<td>--------------------------------</td>
<td></td>
</tr>
<tr>
<td>Air pollution</td>
<td>Completing the excavation works as soon as possible.</td>
<td>Air</td>
<td>Minor, short term –ve impact. Reversible</td>
<td>Contractor</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Noise pollution</td>
<td>Completing the excavation works as soon as possible, avoid working at night</td>
<td>Land</td>
<td>Minor, short term –ve term impact. Reversible</td>
<td>Contractor</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Solid waste</td>
<td>Employ a staff for monitoring and cleaning the harbour</td>
<td>Harbour</td>
<td>Minor, long term –ve impact Reversible</td>
<td>Contractor</td>
<td>monthly salary equivalent to 2,000</td>
<td></td>
</tr>
<tr>
<td>Accidental spillage</td>
<td>Put up sign boards</td>
<td>Harbour</td>
<td>Minor, short term –ve impact Reversible</td>
<td>Island authorities</td>
<td>1000 -1500</td>
<td></td>
</tr>
<tr>
<td>Construction waste</td>
<td>Debris will be used as backfill material for the construction of the existing T jetty</td>
<td>Coastline and beach</td>
<td>Minor, short term –ve impact Most likely Reversible</td>
<td>Contractor, Island authorities</td>
<td>No cost. A clause will be included in the contract document for the contractors to utilize the construction waste</td>
<td></td>
</tr>
<tr>
<td>Construction of new L-shaped quay wall using reinforced concrete prefab walls.</td>
<td>Construction works other than dredging will be mainly quay wall construction using pre-fabricated L-shaped concrete walls. Impacts of these works on the marine environment will be negligible as they will be executed on dry land. Proper construction methods to ensure that only work is confined within the designated areas.</td>
<td>Harbour area, mainly along the quay wall</td>
<td>Minor, short term –ve impact Most likely Reversible</td>
<td>Contractor</td>
<td>No cost. A clause will be included in the contract document for the contractors to use debris.</td>
<td></td>
</tr>
<tr>
<td>Coastal stability.</td>
<td>Western side of the harbour will be affected and prevent coastal erosion in the short term.</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No cost.</td>
<td></td>
</tr>
</tbody>
</table>
13 Environmental Management and Monitoring

13.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. The parameters that are relevant for monitoring the impacts that may arise from the proposed activity are included in the monitoring plan. These include aerial photography, turbidity, sedimentation, and live coral cover and nektonic fauna. Monitoring will be carried out as part of the environmental impact assessment and mitigation of possible negative impacts from the proposed project.

13.2 Cost of Monitoring

The proponent has committed fully for the monitoring programme outlined in this report. The cost indicated below is for monitoring the project during the construction stage and operational stage. Monitoring will be undertaken by subcontracting the work to an independent consultant or a consulting firm. The amounts indicated is the total cost of monitoring during the construction and operational phase (2 years after the construction). Monitoring will include, marine and coastal environmental monitoring plans identified in the report. Summary monitoring reports will be provided every two months and final report will be provided at the end of the construction stage and will adhere to the EIA Regulations, 2015.

13.3 Methods of monitoring

Environmental monitoring will be undertaken using standard methods described in the methodology section. As socioeconomic changes take more time to materialize, socio-economic monitoring will be undertaken using qualitative and quantitative surveys done after 18 months of project completion. One survey will be sufficient to assess the impacts. Quantitative monitoring will mainly focus on the indicators outlined in the baseline socio-economic assessment outlined in this report, which can be obtained from household surveys, the island council office, health facility and published reports, surveys, and studies.

Table 15 outlines the indicators for monitoring. These indicators in the table are not limited but have been considered as the important aspects of monitoring.

Table 14: Aspects of the social and environmental monitoring program with cost breakdown

<table>
<thead>
<tr>
<th>Monitoring Attribute</th>
<th>Indicator</th>
<th>Methodology</th>
<th>Monitoring Frequency</th>
<th>Estimated Cost (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coral and other benthic cover.</td>
<td>Percent cover</td>
<td>LIT</td>
<td>Upon completion of the project and once a year there after.</td>
<td>500 per survey</td>
</tr>
<tr>
<td>Diversity and abundance of fish communities</td>
<td>Number / percentage of fish present</td>
<td>Visual fish census</td>
<td>Upon completion of the project and once a year there after.</td>
<td>250 per survey</td>
</tr>
<tr>
<td>Siltation/ Sedimentation</td>
<td>Quantity of sediment</td>
<td>Quantitative assessment of sediment loading using Sediment traps</td>
<td>Prior and during the project works; and after 2 months, there after once a year</td>
<td>150 per survey</td>
</tr>
<tr>
<td>Seawater quality</td>
<td>DO, nutrients and turbidity</td>
<td>Lab analysis</td>
<td>Twice during the project, 2 months after the completion, there after once a year</td>
<td>100 per test performed</td>
</tr>
<tr>
<td>Hydrodynamic</td>
<td>Changes in the current movements</td>
<td>Drouge tracks at a recording interval of 60s</td>
<td>Once during the project, 2 months after the completion, there after once a year</td>
<td>100 per survey</td>
</tr>
<tr>
<td>Aerial photography</td>
<td>Vegetation cover and shoreline of the island</td>
<td>Drone</td>
<td>Upon completion of the project and once a year there after.</td>
<td>500 per survey</td>
</tr>
<tr>
<td>Socio-economic survey</td>
<td>Outlined in Table 15</td>
<td>User survey</td>
<td>Once, preferably after 18 months from the completion of the project.</td>
<td>750</td>
</tr>
</tbody>
</table>
Table 15: Indicators for socioeconomic impact monitoring.

<table>
<thead>
<tr>
<th>Category</th>
<th>Indicator</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service quality</td>
<td>Efficiency of operation and maintenance of harbour.</td>
<td>User survey</td>
</tr>
<tr>
<td></td>
<td>Services available to vessels</td>
<td>User survey, island and atoll administration data</td>
</tr>
<tr>
<td></td>
<td>Five main operation and maintenance problems.</td>
<td>User survey</td>
</tr>
<tr>
<td></td>
<td>Care and use of harbour facilities.</td>
<td>User survey evidence of facilities</td>
</tr>
<tr>
<td>Financial sustainability</td>
<td>Income generated from the harbour and related activities.</td>
<td>Financial statements/audit reports, user surveys</td>
</tr>
<tr>
<td></td>
<td>Safety of harbour.</td>
<td>Safety standards enforced by the government.</td>
</tr>
<tr>
<td>Safety</td>
<td>Records of accidents or injuries.</td>
<td>Health record and island office records</td>
</tr>
<tr>
<td></td>
<td>Advocacy of users.</td>
<td>User interviews</td>
</tr>
<tr>
<td>Institutional arrangements</td>
<td>Functioning of Harbour management committee</td>
<td>Island and Atoll Council /line Ministry</td>
</tr>
<tr>
<td></td>
<td>Participation of public.</td>
<td>Minutes of Island Council meetings.</td>
</tr>
<tr>
<td></td>
<td>Regulatory / management regime</td>
<td>Island Council</td>
</tr>
<tr>
<td></td>
<td>Complaints dealt</td>
<td>Correspondences/records</td>
</tr>
<tr>
<td>Mobility of vessels /traffic analysis</td>
<td>Development plans</td>
<td>Island and atoll Council.</td>
</tr>
<tr>
<td></td>
<td>Vessel types, size and numbers</td>
<td>Island Council</td>
</tr>
<tr>
<td></td>
<td>Frequency of use</td>
<td>Island Council</td>
</tr>
<tr>
<td>Employment</td>
<td>New employment created as a result of the harbour rehabilitation</td>
<td>Island Council, interviews, published reports.</td>
</tr>
<tr>
<td>Demography</td>
<td>Population</td>
<td>Island Council, census data</td>
</tr>
<tr>
<td></td>
<td>Population migration</td>
<td>Island Council, census data</td>
</tr>
</tbody>
</table>

13.4 Cost of monitoring

The following table outlines a tentative cost of monitoring programme. The following table gives the cost of annual monitoring based on three-monthly monitoring and based on consultants visiting the site at three-monthly interval. This would be for two years. The frequency may be reduced to every six months in the subsequent years, if monitoring for additional years may be required. Unit cost is given as the cost per monitoring trip.

Table 16: Cost of two-year monitoring programme
A detailed environmental monitoring report is required to be compiled and submitted to the EPA yearly based on the data collected for the monitoring the parameters included in the monitoring plan given in the EIA.

The report will include details of the site, strategy of data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed. In addition to this, more frequent reporting of environmental monitoring will be communicated among the environmental consultant, project proponent, the contractor and client.
14 Conclusion

This report discusses the findings of an environmental impact study undertaken by Water Solutions Pvt. Ltd. at the request of Ministry of Housing and Infrastructure for the proposed harbour development project at Th. Omadhoo. Environmental impacts does not appear to be major and of significance, as this project takes place in a modified environment. Most of the environmental impacts will be felt during the construction stage, whereas, the beneficial effects will be evident after the project is complete. These beneficial impacts will be mainly socioeconomic in nature as it is clearly proved in this report.

The major impacts have been identified as resulting from the dredging works. However, as this project involves creation of a harbour basin and filling the dredge materials (reclamation), environmental impacts from the dredging works will be significant. Omadhoo is located in a very large reef system and island is surrounded by a very extensive sea grass beds. In considering the impact on the marine environment, sea grass beds has to be emphasized that the impact zone is only within the project boundary. If the whole reef system of Omadhoo is considered, it will only be a very small percentage. The bottom of the reef-flat was dominated by sand, rubble, dead coral remnants and rock. Disposal of the dredged material will not impacts on the marine environment, as the western side of the harbour will be reclaimed. The impacts on coastal dynamics also seem to be significant, as the area which has thick sea grass would be reclaimed. The existing T jetty build has already disrupted the sediment movement on northern side of the island, which is seen during both seasons.

During the construction stage, especially while undertaking dredging, good care has to be taken to allow only a pre-determined minimum of suspended sediments to escape from the working areas. Mitigation measures, such as bunds should be employed as outlined in the report. Although several alternatives to the proposed project were considered, these alternatives cannot be implemented for various reasons. Alternative locations cannot be considered for this project, as the harbour is already located in the most suitable location and environmental consequences of creating a new harbour in a new location cannot be justified. Other alternatives proposed mainly include design and technological alternatives such as the use of sheet piles and constructing a new jetty on pile.

Because the impacts are mainly going to be occurring on the marine environment, the monitoring programme for this project will mainly focus on marine components. For this reason, sedimentation levels on the marine environment, water quality and visibility and the coral cover has been considered in the monitoring programme.

Therefore, it appears justified from a technical and from a developmental point of view, to carry out the proposed project. There are good reasons from an economic and environmental point of views, to extend the harbour basin and move the breakwaters further north. The adverse environmental effects of the project therefore appear to be limited and acceptable, including the effects of dredging the basin, assuming that the mitigation measures proposed is implemented.
15 Acknowledgements

Water Solutions acknowledge the support and assistance of the following team members who made this project a successful project.

- Ahmed Jameel, Environmental Engineer (EIA Registration No: EIA 07/07)
- Abdul Aleem, Environmental Consultant (EIA Registration No: EIA 09/07)
- Hassan Shah, Environment Consultant
- Ibrahim Faiz, Junior Environment Consultant (EIA Registration No: EIA T06/15)
16 References


Ministry of Housing and Infrastructure, 2015, EIA for the harbour development at Kelaa, Haa Alifu Atoll.


UNEP, 2005, Maldives: Post-Tsunami Environmental Assessment, United Nations Environment Programme


Binnie Black and Veatch 1999, Environmental/Technical Study for Dredging/Reclamation Works under the Hulhumalé Project, Maldives


17 List of Abbreviations

List of Abbreviations and Acronyms

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<th>Abbreviation</th>
<th>Meaning</th>
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<td>Environmental Impact Assessment</td>
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<td>EPA</td>
<td>Environmental Protection Agency</td>
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<td>MEE</td>
<td>Ministry of Environment and Energy</td>
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<td>MSL</td>
<td>Mean Sea Level</td>
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<td>TOR</td>
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<td>UNFCCC</td>
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<td>National Environment Action Plan</td>
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<td>EMP</td>
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18 Annex 1: Terms of reference
Terms of Reference for Environmental Impact Assessment for Th. Omadhoo Harbour Development Project

The following is the Terms of Reference (ToR) following the scoping meeting held on 29 February 2015 for undertaking the EIA of the proposed harbour development project at Omadhoo Island, Thaa Atoll. This ToR is based on the draft ToR submitted by the consultant on 16 February 2016. The Proponent of this project is Ministry of Housing and Infrastructure. While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction and rationale** – Describe the purpose of the project 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 link other activities that are carried out or that is being carried out within the project boundary. Identify the institutions arrangements relevant to this project.

2. **Study area** – Submit a minimum A3 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. Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – Identify and number tasks of the project including preparation, construction and decommissioning phases.

   **Task 1. Description of the proposed project** – Provide a description and justification of the relevant parts of the harbour development works, using maps at appropriate scales where necessary. Information on the following activities should be provided where appropriate:

   - Dredging of material from harbour area and entrance channel and depositing at appropriate site(s);
   - Harbour area construction and surrounding infrastructure which may include land reclamation works;
   - Measures to protect island’s environment during construction
   - Project management (include scheduling, duration of the project, construction details, labour requirement, housing of temporary labour, emergency plan in case of spills (diesel, grease, oil) access to site, safety, equipment and material storage, fuel management and emergency plan in case of spills)

   **Details of the Harbour/channel**
   - Location of the harbour/channel on an A3 scaled map
   - Design parameters of the harbour /channel (size, depth, profile of channel)
   - Justification for the location of harbour/channel

   **Dredging/Excavation:**
   - Location and size of burrow areas (s) on a scaled map;
   - Justification for the selection of the location, depth and size of burrow area(s);
   - Equipment and methodology used for dredging;
   - Dredged material disposal/ usage details,
The EIA report should investigate possibilities for alternatives:

- Alternative methods/equipment for dredging
- Alternative borrow area locations: have these been considered and if so, give arguments why these alternatives have not been selected, and
- Alternative disposal sites

**Coastal structures**

- Locations and designs of the seawall and quay wall
- Locations and designs of additional coastal protection measures (if required)
- Justification and details of flood mitigation measures (if required)
- Method and equipment used for construction of coastal structures

**Task 2. Description of the environment** – Assemble, evaluate and present the environmental baseline study/data regarding the study area and timing of the study (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.

All sampling/survey locations shall be geo referenced including but not limited to water sampling points and reef transects/photo quadrats for monitoring data comparison.

All data must be collected as per the requirements of the EPA Data Collection Guidelines (published on [www.epa.gov.mv](http://www.epa.gov.mv)). The report should outline detailed methodology of data collection utilized.

Information may be divided into the categories shown below:

**Climate**

- Temperature, rainfall, wind, waves,
- Natural Hazard Risks including flooding;

**Geomorphology**

- Low tide line, high tide line and the vegetation line
- Bathymetry of the required sites;
- (Seasonal) patterns of coastal erosion and accretion, and
- Characteristics of seabed sediments to assess direct habitat destruction and turbidity impacts during construction;

**Hydrography/hydrodynamics (use maps)**

- Wave climate
- currents;

**Ecology**

- Benthic and fish community at the proposed project area of the island;
- seascape integrity, and
- marine sea water quality measuring these parameters: temperature, pH, salinity and turbidity at the project site.

**Socio-economic environment**

- Demography: total population, sex ratio, density, growth and pressure on land and marine resources;
- Income situation and distribution
Environmental Protection Agency

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. 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.

Legal requirements:
- Approval from the Ministry of Housing and Infrastructure,
- Dredging and Reclamation permit from EPA

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify significant 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 erosion / accretion patterns, which may impact shore zone configuration/coastal morphology;
- Loss of marine bottom habitat, both in the borrow area as well as due to enlargement of the islands, resulting in loss of bottom life, which may impact fish stocks and species diversity and density of crabs, shellfish etc.;
- Sediment dispersal in water column (turbidity at the dredging site (overflow), the reclamation areas and related to shore protection activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish 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
- Benefits and impacts of the works in fishing activities;
- Impacts of the dredging and reclamation works on resource users (adjacent businesses, nearby resorts and dive sites);
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Employment and economic opportunities and diversification;

Construction related hazards and risks
- Pollution of the natural environment;
- Risk of accidents and pollution on workers and local population, and
- Impacts on social values, norms and belief due to presence of workers of dredging company on local population.

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.
Task 5. Alternatives to proposed project – Describe alternatives including the “no action option” should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the “no action alternative”. In addition to his, two harbour concepts discussed during the scoping meeting on 17th May should be studied and presented as alternatives including the mitigation measures for each concept separately. This should include location of the harbour, technologies, materials, designs, timing, etc. environmental, social and economic factors should be taken into consideration. All alternatives must be compared according to commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

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. Mitigation measures to avoid or compensate habitat destruction. Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan (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 will be submitted to the EPA to evaluate the damages during construction, after project completion and every and on a yearly basis for five years after. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter and methods of undertaking the monitoring program must be provided.

Monitoring is required in;

- Coastal erosion around the island
- Water quality assessment (seawater quality)
- Marine ecosystems monitoring (coral reef, seagrass and fish and invertebrates communities), and
- Socio-economic monitoring for project success or improvement requirements

Task 8. Stakeholder consultation – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities such as Ministry of Housing and Infrastructure, Ministry of Environment and Energy, Tha Atoll Council, Th.Omadhoo Council and general public. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes.

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 of any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2012 and the relevant amendments.

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

29th February 2016
19 Annex 2: Shoreline
Annex 3: Bathymetry of the Site
Omadhoo Harbour Project

Legend
- Existing Seawall
- Vegetation
- Shoreline

Bathymetry

Value
- Shallow: -0.2
- Deep: -3.50

Scale:
Client:
Contractor:

Water Solutions Pvt Ltd
Ma.Shah, Dhihdhee Goalhi, Male', Maldives
Tel: +(960)3341643, Fax: +(960)331643
www.water-solutions.biz

Geodetic Parameters

Coordinate Systems: Universal Transverse Mercator (UTM)
Projection: Transverse Mercator (TM)
Longitude of Origin: 0.000000000
Central Meridian: 75 W
Semi-Major Axis (a) (Meters): 6378137.000
Semi-Minor Axis (b) (Meters): 6356752.3142451793
Scale Factor: 0.999600000000000040
False Northing: 0.00000000
False Easting: 500000.000
Datum: WGS 1984
21 Annex 6: Letter from Thaa Atoll Council