ENVIRONMENTAL IMPACT ASSESSMENT

For the proposed coastal protection at Embudhoo Village, South Male Atoll, Maldives

Proposed by
Kaimoo Travel and Hotel Services

Prepared by
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For Water Solutions Pvt. Ltd., Maldives

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1 Table of Contents

1.1 TABLE OF CONTENTS 2
1.2 TABLE OF FIGURES 4
1.3 LIST OF TABLES 5
1.4 NON TECHNICAL SUMMARY ................................................................. 6
1.5 INTRODUCTION ................................................................................. 7
1.5.1 TERMS OF REFERENCE ................................................................. 7

6 PROJECT SETTING ........................................................................... 8
6.1 APPLICABLE POLICIES, LAWS AND REGULATIONS .......................... 8

7 PROJECT DESCRIPTION ..................................................................... 10
7.1 PROJECT PROPOLENT ................................................................. 10
7.2 LOCATION AND STUDY AREA ....................................................... 10
7.3 NEED AND JUSTIFICATION .............................................................. 10
7.4 STUDY BOUNDARY ......................................................................... 10

DESCRIPTION OF THE PROJECT COMPONENTS ..................................... 10

7.1.1 Construction of Groynes ................................................................. 10
7.1.2 Replenishment of the eroded beach ............................................. 11
7.1.3 Construction of new breakwaters ................................................. 12

7.5 PROJECT DURATION ......................................................................... 14

7.6 CONSTRUCTION METHODOLOGY ................................................. 14

7.6.1 Construction Strategy .................................................................. 14
7.6.2 Breakwater .................................................................................. 14
7.6.3 Beach replenishment methods ...................................................... 14
7.6.4 Management of Waste ................................................................. 15
7.6.5 Expected Environmental Conditions during the Project Implementation Period .................................................. 15
7.6.6 Risks Associated with the Project ................................................. 15

7.7 PROJECT INPUTS AND OUTPUTS .................................................. 15
EIA for the coastal protection of Embudhoo Village, South Male’ Atoll – January 2011

7.7.1 Project Inputs ............................................................................................................................ 15

7.7.2 Project Outputs ........................................................................................................................... 16

8 METHODOLOGY 17

8.1 General Methodologies of Data Collection .............................................................................. 17

8.2 Mapping and Location Identification ....................................................................................... 17

8.3 Marine Water Quality .................................................................................................................. 17

8.4 Marine Environment Surveys .................................................................................................... 17

8.5 Coastal Environment .................................................................................................................. 18

8.6 Bathymetry .................................................................................................................................. 18

8.7 Aerial Photos .............................................................................................................................. 18

8.8 Available Long Term Weather Data .......................................................................................... 18

9 EXISTING ENVIRONMENT 19

9.1 Existing Coastal Environment .................................................................................................... 19

9.1.1 Geological Setting and Island Formation .............................................................................. 19

9.1.2 Climatic Setting ...................................................................................................................... 20

9.1.3 Features of the Coastal Environment ..................................................................................... 28

9.1.4 Lagoon ...................................................................................................................................... 28

9.1.5 Beach ........................................................................................................................................ 29

9.1.6 Beach erosion ........................................................................................................................... 31

9.2 Marine Environment .................................................................................................................. 32

10 ENVIRONMENTAL IMPACTS ........................................................................................................ 34

10.1 Impact Identification .................................................................................................................. 34

10.2 Assessing Impacts ..................................................................................................................... 34

10.3 Uncertainties in Impact Prediction ............................................................................................ 34

10.4 Impacts on the Coastal Environment ....................................................................................... 35

10.4.1 Breakwater construction ........................................................................................................ 35

10.4.2 Replenishment of the beach .................................................................................................. 35

11 STAKEHOLDER CONSULTATIONS .............................................................................................. 38
12 ALTERNATIVES 39

12.1 NO PROJECT OPTION .................................................................................................................... 39
12.2 ALTERNATIVE BORROW AREAS .................................................................................................... 39
12.3 ALTERNATIVE METHODS TO PROTECT THE BEACH ................................................................. 39
   12.3.1 Emerged Breakwater ................................................................................................................. 39
   12.3.2 Continuous Re-nourishment of the beach ................................................................................. 40
12.4 ALTERNATIVE MATERIALS FOR BREAKWATERS ..................................................................... 40
12.5 PREFERRED OPTIONS ..................................................................................................................... 40
   12.5.1 Mitigation measures for the proposed alternative ................................................................. 40

13 ENVIRONMENTAL MONITORING ................................................................................................. 41

13.1 COST OF MONITORING ............................................................................................................... 41
13.2 ASPECTS OF MONITORING ......................................................................................................... 41
13.3 METHODS OF MONITORING ......................................................................................................... 41

14 CONCLUSION 43

15 DECLARATION OF THE CONSULTANTS ......................................................................................... 44

17 REFERENCES 45

19 ANNEX: BEACH PROFILES 47

20 ANNEX: PHOTO REPRESENTATION OF EXISTING ENVIRONMENT ............................................. 48

21 ANNEX: BATHYMETRY OF THE LAGOON ....................................................................................... 49

2 Table of Figures

FIGURE 1: CROSS-SECTIONAL DESIGN OF A GROYNE ..................................................................... 11
FIGURE 2: FILL PROFILE FOR THE NOURISHED AREA ....................................................................... 11
FIGURE 3: COASTAL PROTECTION PLAN ............................................................................................ 13
FIGURE 4: CROSS-SECTION OF A BREAKWATER MADE FROM GEOTEXTILE BAG ......................... 13
FIGURE 5: PROJECT LOCATIONS ......................................................................................................... 19
FIGURE 9.6: MONTHLY WIND ROSE DIAGRAMS FOR HULHULÉ STATION, 1990-2010 .................. 22
FIGURE 7: MONTHLY WIND ROSE DIAGRAMS FOR HULHULÉ STATION, 1990-2010 .................... 24
FIGURE 8: PREDICTION OF LEES OF THE ISLAND DURING THE TWO MONSOONS ....................... 25
FIGURE 9: SUMMARY OF WAVE CONDITION IN EMBUDHO .......................................................... 26
FIGURE 10: LONGSHORE CURRENTS AROUND THE ISLAND DURING THE SOUTHWEST MONSOONS 28

3 List of Tables

TABLE 1: MATRIX OF MAJOR INPUTS DURING CONSTRUCTION PERIOD ................................................................. 15
TABLE 2: MATRIX OF MAJOR OUTPUTS OF ENVIRONMENTAL SIGNIFICANCE DURING CONSTRUCTION STAGE ................. 16
TABLE 3: KEY METEOROLOGICAL INFORMATION ........................................................................................................ 20
TABLE 4: SUMMARY OF GENERAL WIND CONDITIONS IN EMBUDHOO ........................................................................... 24
TABLE 5: CHANGE OF EMBUDHOO’S LAND AREA .......................................................................................................... 31
TABLE 6: SUMMARY OF THE IMPACTS AND THEIR CHARACTERIZATION ........................................................................... 37
TABLE 7: ADVANTAGES AND DISADVANTAGES OF THE NO PROJECT OPTION ........................................................................ 39
TABLE 14: ASPECTS OF THE ENVIRONMENTAL MONITORING PROGRAM WITH COST BREAKDOWN ............................................. 42
4 Non Technical Summary

This report discusses the findings of an environmental impact assessment undertaken by Water Solutions Pvt. Ltd for undertaking the coastal protection works at Embudhoo.

The environmental monitoring that had been carried out at Embudhoo for the past 3 years indicates that the western side is undergoing chronic erosion and the coastal protection structures on the island are not functioning. Hence, there is a need to modify the existing coastal protection around and undertake beach replenishment as to recover the lost beach.

It is proposed that a set of groynes will be established on western side and a breakwater on eastern side of the island using geotextile material. Beach nourishment will be undertaken using a sand pump aided by excavators. The material required for the beach nourishment works will be obtained from the proposed borrow areas on western side of the island. The total volume of material that needs to be obtained for beach nourishment on western and eastern side of the island is estimated to be 6400 m³.

Environmental impacts were assessed for both the construction and operation phase of the project. Most of the environmental impacts of the project have been identified as resulting mainly from breakwater and beach replenishment. The main impact would be that of sedimentation on the lagoon. This impact is considered to be short-term and cumulative. Nevertheless, mitigation measures have been proposed for anticipated negative impacts.

Mitigation measures for these negative impacts have been identified and outlined in detail, especially sedimentation control methods. The most important mitigation measure is the use of bund walls in the replenishment areas. The measures proposed to minimize or mitigate environmental impacts may be considered to be quite appropriate, thereby minimizing the impact by about 90%. The main negative environmental impact of the proposed project would be sedimentation, which may cause death or partial death of corals.

The proponent commits to undertake the mitigation and monitoring programme set out in this EIA report knowing that monitoring will help to identify the effectiveness of the mitigation measures and take precautions to minimize any damage to the main tourist attraction of the island, which is its environment. Therefore, it appears justified from a technical, social, economic and environmental point of view, to carry out the proposed modifications.
5 Introduction

This Environmental Impact Assessment report (EIA) has been prepared to fulfil the requirements of the Environmental Protection and Preservation Act, law no. 4/93 for the proposed concept coastal modification in Embudhoo Village, located in south Malé Atoll.

The report has been structured to meet the requirements of the EIA regulations 2007 issued by the Ministry of Environment, Energy and Water. This EIA report discusses the outcomes and findings with regard to coastal protection in Embudhoo.

This EIA has been prepared by a local environmental consulting firm, Water Solutions. Water Solutions have been chosen by the proponent as the environmental consultants for this project. The team members were:
- Abdul Aleem, BSc, MPH – Mapping and GIS
- Ahmed Jameel, B. Eng (Environmental), MSc – Environmental Engineer
- Mohamed Riyaz, - surveyor
- Hamdhulla Shakeeb, Surveyor

5.1 Terms of Reference

Terms of Reference for the this assessment has been included in the Appendix of this report
6 Project Setting

This section outlines the relevant environmental legislation pertaining to this project.

6.1 Applicable Policies, Laws and Regulations

<table>
<thead>
<tr>
<th>Relevant environmental laws for this project</th>
<th>Implications of the project and its relevance to the law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection and Preservation Act</td>
<td>The proposed project will abide to the Environmental Preservation and Protection Act. Disposal of dredge spoil (from pumping activities) will be strictly controlled and managed as per the project concept. No hazardous materials will be disposed in to the local or the regional environment. With regard to waste oil and other waste streams resulting from the coastal projection component, they will be strictly disposed to Thilafushi.</td>
</tr>
<tr>
<td>National Biodiversity Strategy and Action Plan</td>
<td>In implementing the proposed project activities due to care has to 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 coral reef, especially in close proximity to the proposed development area. Hence, the coastal protection will take in to account the conservation of biological diversity. Practical mitigation measures and solutions have been identified to conserve and protect the biodiversity.</td>
</tr>
<tr>
<td>Waste management policy</td>
<td>Waste management for the proposed project has been considered during the construction and operational stage. Since the island is a operating resort, measures are already in place to manage the waste, such as incineration and regular transfer of waste to Thilafushi. There is already an established waste management mechanism in the island. Therefore, this project will also confirm to this policy.</td>
</tr>
<tr>
<td>Regulation on sand and aggregate mining</td>
<td>Neither coral nor aggregate will be mined for this project. This regulation would not have any</td>
</tr>
<tr>
<td>Relevant environmental laws for this project</td>
<td>Implications of the project and its relevance to the law</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>implication on the proposed project.</td>
<td></td>
</tr>
<tr>
<td>Sand will be pumped from designated areas</td>
<td></td>
</tr>
<tr>
<td>from the lagoon to nourish the beach and</td>
<td></td>
</tr>
<tr>
<td>control erosion. Sand will not be used for</td>
<td></td>
</tr>
<tr>
<td>any other construction purpose at the island.</td>
<td></td>
</tr>
<tr>
<td>Ban on coral mining</td>
<td>Corals would not be mined in any stage of the project.</td>
</tr>
<tr>
<td></td>
<td>The existing, groynes and sea walls made from coral</td>
</tr>
<tr>
<td></td>
<td>rubble will be used as part of the coastal protection of</td>
</tr>
<tr>
<td></td>
<td>the island.</td>
</tr>
<tr>
<td>Environmental Impact Assessment Regulation</td>
<td>The guidance provided in this Regulation was followed in</td>
</tr>
<tr>
<td>2007</td>
<td>the preparation of this EIA report. The EIA has also been</td>
</tr>
<tr>
<td></td>
<td>prepared by registered consultants.</td>
</tr>
</tbody>
</table>
7 Project Description

7.1 Project Proponent

Kaimoo Travels and Hotels Service Ltd is a private company registered at the Ministry of Trade and Economic Development. It operates Emboodhoo Village Resort as well as other resort islands in the Maldives, like Summer Island Village and Equator Village. This EIA has been prepared by Kaimoo Hotels, Travels and Service.

7.2 Location and Study Area

The project is located at Emboodhoo Village Resort at K. Emboodhoo. The island has a registered land area of 42,340.00 m² as of April 2010.

7.3 Need and Justification

Embudhoo is exposed to strong winds and waves during both monsoons and as a result, coastal protection measures have been undertaken in the island. However, the coastal protection measure does not adequately address the western and eastern side where erosion persists. Hence, modification to the existing coastal protection measures need to be undertaken and new structures have been proposed to manage the coastline. Thus it requires beach replenishment as an enhancement measure together with coastal protection.

To further justify the coastal protection, the environment of Embudhoo, especially the coastal environment has been monitored for the past three years. The results of the monitoring indicate that the western coastline is undergoing chronic erosion and that some of the coastal protection measures such as groynes are not functioning. Hence, there is a need to modify the coastal protection around the island that will include new structures as well as improvements to existing structures.

7.4 Study boundary

The boundary of the study is limited to the boundary of the island of Emboodhoo.

Description of the Project Components

1.1.1 Construction of Groynes

It is proposed that a set of groynes will be established on western side of the island to create and maintain a beach. Groynes fields have been utilized as a soft engineering solution to the erosion issue by building these when and where it was needed. The groynes will function well, when the area between the groynes are nourished with sand.

The gap between groynes is usually about two or three groyne lengths, where groyne length is defined as the distance from the beach berm crest to the groyne’s seaward end. Groyne spacing is often selected based on an analysis of desired shoreline alignment following groyne construction, which depends on the wave and long-shore transport at site. Shoreline alignment following groyne construction depends mainly on prevailing wind direction and subsequent incident waves. When
incident wave crests are nearly parallel larger groyne spacing can be used; when incident wave crests make a larger angle with the shoreline, closer groyne spacing is required. In the case of Embudhoo, the wave crests on the western beaches shores are primarily parallel to the shoreline. Therefore, it is proposed to keep groynes as far away as possible given the short length that can be achieved. The effectiveness of the proposed groynes will be assessed in the monitoring programme.

The design of the groynes is given in Figure 1. These design considerations take into account existing long-shore currents and wave overtopping. The crest of the groynes is based on the “significant wave height”. However, under calmer conditions with low crested waves, structures are designed to allow for overtopping. Overtopping often helps to minimize the effects of stagnation in the lee of the breakwater thereby improving water quality in the leeward side. In fact, a significant increase in strength of the crest can be achieved by careful placement of the geotextile rocks to ensure good interlocking.

![Figure 1: cross-sectional design of a groyne](image)

**1.1.2 Replenishment of the eroded beach**

The main problem with the eastern and western beach face is that the beach face has not been nourished with fine sand to maintain the loss that had occurred due to erosion on the western and eastern side. Hence, it is proposed to replenish the beach with approximately 6,400 m³ of beach. The replenishment would be carried out so that the berm at the replenished area would have a height of at least 0.5m. Fill profile for beaches around the nourished area of the island is shown in Figure 2.

![Figure 2: fill profile for the nourished area](image)
Beach nourishment will be undertaken using a sand pump aided by excavators. This is to ensure that beach material is not compacted and that the beach is softer. It is generally considered appropriate that deposition of material should be along the upper beach, above the high water line and along the eroding berm face. Natural redistribution of the placed material along shore and cross-shore will occur, particularly for sand. The beach replenishment will be undertaken as such that the total increase of the beach will not be more than 10m from the existing high tide line of the island.

The material required for the beach nourishment works would be obtained from the proposed borrow areas. The total volume of material that needs to be obtained for beach nourishment is 6400 m$^3$.

The following table outlines the volumes of sand required for the beach replenishment and the amount of sand required from the three borrow areas proposed.

### 1.1.3 Construction of new breakwaters

It is proposed that a submerged breakwater be built on eastern side of the island to protect the beach.

Offshore breakwaters are structures built approximately parallel to the beach but some distances offshore. The purpose of offshore breakwaters is to reduce the intensity of wave action in near shore waters and thereby reduce coastal erosion. Submerged breakwaters act like artificial reefs, unlike emerged breakwaters, allow sand to pass over their crest and aids long-shore transport between the reef and the shoreline. Then beach would be replenished with sand. This is good in the sense that it allows sediment transport along the coastline. However, in order for a submerged breakwater to function, they will have to have a very wide base. The whole idea of a submerged breakwater is to mimic a natural reef and it cannot do that unless the base is wide.

Based on existing wave conditions in the area, the following design has been suggested. The breakwater will be at mean sea level as to make it submerged at high tide.
Figure 3: coastal protection plan

The breakwater has been designed to create an artificial reef using geotextile bags. The geotextile bags will be filled with sand and placed in three rows. The distance between rows would be 5 meters. A row is made of discrete geotextile bags. The distance between bags in a row is about 4 – 5 meters.

Figure 4: cross-section of a breakwater made from geotextile bag
The length of the new breakwater on eastern side of the island is 80. The gap between the geobags is about 2-5 m. Figure 4 shows the location of the submerged breakwaters and their possible orientation.

7.5 Project duration

The proposed project could be undertaken in two months.

7.6 Construction Methodology

7.6.1 Construction Strategy

The construction could be undertaken in low seasons, which starts in April. Hence, it is planned to undertake the construction of the groynes on western side as first activity. This will help to use the beach that had been moved to the western side during the north east monsoon. The construction of the breakwater would start following the completion of the groynes. This would help to capture as much as beach as possible on eastern side of the island. Beach replenishment would start when the groynes field and breakwaters are completed.

7.6.2 Breakwater

A breakwater of approximately 75 meters long will be constructed on the eastern side of the island on lagoon to provide coastal protection. The breakwater would be constructed using geotextile bags filled with sand. There are also other choices and options for breakwater construction and they are sand cement bags or rock boulders. These have been considered as alternatives and may be used for construction of breakwaters depending on the cost.

7.6.3 Beach replenishment methods

Beach replenishment will be undertaken by pumping sand into the areas to be replenished. The pumped sand will be spread evenly at the end of pumping and spreading using excavators. The replenishment works for the beach will be undertaken in a similar manner to that described below.

- Mark the perimeter of the area to be replenished, which will be 10 m from the high tide line.
- Erect a temporary seawall of adequate height using sandbags around the area to be replenished to minimize sediment flow onto the reef.
- Pump sand within 5m from the sandbags to create an inner bund.
- Move sandbags as the inner bund progresses until the inner bund is complete.
- Remove sandbags and keep aside for use in top fill on the foreshore
- Continue pumping to fill the enclosed area.
7.6.4 Management of Waste

All wastes will enter the present waste management cycle in the island, which is stockpiling and then transferring them to Thilafushi.

7.6.5 Expected Environmental Conditions during the Project Implementation Period

The project activities will take place in south-west monsoons, and hence environmental conditions are expected to be both favourable and unfavourable during the construction period. Therefore, the strategy would be to complete the replenishment works after the construction of the breakwater.

7.6.6 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 erosion.

There is also the risk of project delays caused by bad weather. The construction period falls in the south-west monsoon which is the wet season, unpredictable rainfall and storms are expected. This risk can be minimized if the works could be completed within the minimum period. The breakwater construction is undertaken in the lagoon with maximum depths of 2 meters and hence do not pose major difficulties. This risk will also be minimized by awarding the contract to only experienced contractors with experience in working in similar situations. Therefore, work delays will be least impacted.

The most important risk associated with this project is the possible damage to the marine environment as a result of not only construction of breakwater, but due to pumping of sand and replenishment of the beach. The areas where breakwater will be constructed does not have coral and is only fine sediment and hence, there is no direct coral reef damage due to breakwater construction. However, sedimentation will be an issue but will be minimized by limiting the pumping period as well as undertaking work during low tide hours.

7.7 Project Inputs and Outputs

7.7.1 Project Inputs

The types of resources that will go into the project and from where and how these will be obtained are given in table 1 & 2.

Table 1: Matrix of Major Inputs during Construction Period

<table>
<thead>
<tr>
<th>INPUT RESOURCE(S)</th>
<th>SOURCE/TYPE</th>
<th>HOW TO OBTAIN RESOURCES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction workers 8</td>
<td>Maldivians and foreigners</td>
<td>Open bidding by advertising in local papers/other sources</td>
</tr>
</tbody>
</table>
### INPUT RESOURCE(S) | SOURCE/TYPE | HOW TO OBTAIN RESOURCES
--- | --- | ---
Water supply | Already used in the island for construction. | Already used in the island for construction.
Electricity/Energy | Existing Diesel generators in the island. | Already used in the island for construction.
Construction machinery | excavators, sand pumps and general construction tool | Local suppliers
Transport (sea) | Sea transport by dhoni and speed boats. Materials to be transported in cargo vessels/dhoni or large barges. All construction debris will be transported to Thilafushi via cargo vessels/dhoni | Already established.

#### 7.7.2 Project Outputs

The type of outputs (products and waste streams) and what is expected to happen to the outputs are given in the Table below.

**Table 2: Matrix of major outputs of environmental significance during construction stage**

<table>
<thead>
<tr>
<th>PRODUCTS AND WASTE MATERIALS</th>
<th>ANTICIPATED QUANTITIES</th>
<th>METHOD OF DISPOSAL / CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>6,400 cbm</td>
<td>Replenishment of the beach</td>
</tr>
<tr>
<td>Breakwater</td>
<td>75 meters by 4 meters wide</td>
<td>Placement in the appropriate areas</td>
</tr>
<tr>
<td>Noise</td>
<td>Localised to the island environment</td>
<td>No control required as the noise will not be an issue</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Limited quantities of dust</td>
<td>Mainly arising as a result of dust emission from the construction work such as cement mixing and pumping of sand. Localised to the island environment only.</td>
</tr>
</tbody>
</table>
8 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental components of the project under consideration are coastal environment areas and the marine environment.

8.1 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 focused for marine and coastal environment. The marine environment of the island covered the coral reef and the lagoon.

Coastal environmental data collection involved taking beach profiles from selected locations and assessing the coastal environment

8.2 Mapping and Location Identification

The island, including shore line, vegetation line, reef lines, coastal defence structures were mapped for the assessment. Mapping was undertaken using hand held differential GPS and available aerial photos. The location of data collection sites were marked using handheld GPS. These data collection points include marine water sampling locations, marine survey locations, existing groynes and sea walls.

8.3 Marine Water Quality

Water quality was assessed by collecting samples and testing them at National Health Laboratory. Water quality was assessed from locations marked on the map. The locations, frequency and parameters to be monitored are given in the monitoring programme outlined later in the EIA report.

8.4 Marine Environment surveys

The purpose of the marine survey is to define and establish marine environmental baseline conditions in areas of the proposed coastal protection measures. Surveys are based on standard marine environmental surveys so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities. They include quantitative and qualitative methods.

Two methods were primarily used to collect data, namely:

- Quantitative assessment of the benthic composition with a 60x60cm photo frames
- Qualitative surveys through visual observations and photos taken

A quantitative study was undertaken in the area where a breakwater is proposed, i.e. on the eastern side of the island, as well as on the north-eastern side around a sewerage outfall. A photo quadrat of 60x60cm length and 12 replicates were positioned on the seafloor and photos were
taken with a digital camera. These photos were then evaluated on the PC using CPCe software (Kohler and Gill 2006).

The sand burrow areas were examined by visual inspection and by taking digital photos of the substrate.

**8.5 Coastal Environment**

Data collected on coastal environment included beach profiles, existing sea walls and groynes, shore line and vegetation line. All beach profile locations were marked on GPS maps and their geographical coordinates were marked on a map. Beach profiles were taken as baseline data to make comparisons during monitoring programme so that any changes resulting from the coastal component of the proposed project can be assessed accurately. Beach profiles were measured using auto levels and a staff.

**8.6 Bathymetry**

A detailed bathymetric survey was undertaken in the lagoon using Echosounder attached to a boat. The levels were then corrected for mean sea level and represented in a map. Bathymetric map is attached as an annex.

**8.7 Aerial photos**

Recent aerial photos acquired were used in the assessment. Aerials photos provide useful information such as assisting the analysis of marine environment, identifying wave patterns and changes to shoreline and also vulnerable areas of the island. Aerial photos were purchased from DigitalGlobe. They have been used extensively in this EIA and have been presented in different sections of the report.

**8.8 Available long term weather data**

Long term available weather data was obtained from the nearest weather station, which is based in Male’ International Airport, Hulhule. These data sets were used to develop a regional model in ArcGIS to assess the vulnerable areas of the island during both monsoons, thus helping the EIA team to assess the vulnerable areas of the island for erosion.
9 Existing Environment

This section discusses the existing environmental conditions. In doing so, the section will begin with an outline of the general environmental conditions in Maldives, including the climatic settings, tides, wind and wave. As there are no specific such data for individual islands, these data will form the basis for describing the conditions for the islands of the Maldives. The data collection on climate and sea level are undertaken from weather stations based strategically throughout the Maldives, including Male’, international airport, Hulhule. The nearest weather station to Embudhoo is located in Hulhule island. Therefore the climatic data from Hulhule has been applied for Embudhoo as it is the closest weather station. Existing coastal and the marine environments are described later.

9.1 Existing Coastal Environment

9.1.1 Geological Setting and Island Formation

Emboodhoo Village Resort is a slightly elongated island located on the north eastern side of South Malé Atoll. Emboodhoo Village Resort sits slightly inside, in between Finolhu falhu and Fushidiggaru falhu.

Figure 5: Project Locations

The reef on which the island sits is located inside the atoll and divides the flow of the Emboodhoo kandu. This flow is dominated by the inward current during the flood. Strong currents are experienced on either side of the reef. The reef on the southern, eastern side and northern side is
very close to the island separated by a narrow and a shallow lagoon. A bottom reef is located from the southern side to the western tip of the reef, separated by a deep lagoon.

Coastal Protection work has been undertaken on the island in order to stabilize the coast. The most obvious is the concrete revetment constructed on the eastern and northern side of the island and southern side of the island. These coastal modifications appear to have altered the hydrodynamics and sediment processes of the island.

Severe erosion is evident on the eastern side of the island; concrete revetment has been constructed on this side to counter loss of sediment. It is noticeable from the abrupt appearance of the height of the revetment that some land has been lost by erosion. Erosion is seen on the northern side of the island, this probably a seasonal process, since the sediment appears to be moving west towards the western tip.

The western tip of the island shows good signs of sediment accretion, forming a sandy beach; this is probably a seasonal formation during the northeast monsoon. This tip would probably change direction in southwest monsoon or loose some amount of sediment to the northern part of the island.

This accretion is less and less felt as one moves towards south although erosion is evident all along the southern side of the island. A relatively high berm is seen at southern tip of the island; this sandy beach process is probably formed by the sediment produced on eastern side reef flat during the northeast monsoon.

9.1.2 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 about 2000mm. There is considerable variation of climate between northern and southern atolls. Table 3 provides a summary of key meteorological findings for Maldives. General studies on climatic conditions of Maldives were taken into account during study as local level time-series data are limited for longer periods at the nearest meteorological station.

Table 3: Key meteorological information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Rainfall</td>
<td>9.1mm/day in May, November</td>
</tr>
<tr>
<td></td>
<td>1.1mm/day in February</td>
</tr>
<tr>
<td>Maximum Rainfall</td>
<td>184.5 mm/day in October 1994</td>
</tr>
<tr>
<td>Average air temperature</td>
<td>30.0°C in November 1973</td>
</tr>
<tr>
<td></td>
<td>31.7°C in April</td>
</tr>
<tr>
<td>Extreme Air Temperature</td>
<td>34.1°C in April 1973</td>
</tr>
<tr>
<td></td>
<td>17.2°C in April 1978</td>
</tr>
<tr>
<td>Average wind speed</td>
<td>3.7 m/s in March</td>
</tr>
<tr>
<td></td>
<td>5.7 m/s in January, June</td>
</tr>
</tbody>
</table>
### Parameter Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum wind speed</td>
<td>31.9 m/s in November 1978</td>
</tr>
<tr>
<td>Average air pressure</td>
<td>1012 mb in December</td>
</tr>
<tr>
<td></td>
<td>1010 mb in April</td>
</tr>
</tbody>
</table>

### 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.

### 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.

### 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 1967-1995 was 30.4°C and the annual mean minimum temperature for the same period was 25.7°C. The highest recorded temperature for Male’ was 34.1°C on 16th and 28th of April 1973. The hottest month recorded was April 1975 with a maximum monthly average temperature of 32.7°C, the next highest being 32.6°C in April 1998. The lowest minimum average temperature of 23.7°C was recorded in July 1992.

### Wind

The National Meteorological Centre provides data for wind speed as recorded at Hulhulé meteorological station, for the period 1990-2010. The month wise windrose for the period of 20 years.
The leeward sides for the island as shown in the following figure have been depicted based on the wind-rose diagram shown above. The western side would be usually in the lee of the island especially during the peak tourist season, which is the northeast monsoon. It is illustrated here that the existing thundi area will see huge accretion during the northeast monsoon. However, due to the low sand budget and the seawall on eastern side of the island, erosion from this area during the creates a net deficit of sediment movement from eastern to western side resulting in erosion on eastern side of the island.

![Figure 8: Prediction of lees of the island during the two monsoons](image)

**Waves**

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

Studies by Lanka Hydraulics on Malé reef indicated that two major types of waves on Maldives coasts: wave generated by local monsoon wind and swells generated by distance storms. The local monsoon predominantly generates wind waves which are typically strongest during April-July in the south-west monsoon period. During this season, swells generated north of the equator with heights of 2-3 m with periods of 18-20 seconds have been reported in the region. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.
Distant cyclones and low pressure systems originating from the intense South Indian Ocean storms are reported to generate long distance swells that occasionally cause flooding in Maldives (Goda, 1988). The swell waves that reached Malé and Hulhule in 1987, thought to have originated from a low pressure system of west coast of Australia, had significant wave heights in the order of 3 metres.

In addition, Maldives has recently been subject to earthquake generated tsunami reaching heights of 4.0m on land (UNEP, 2005). Historical wave data from Indian Ocean countries show that tsunamis have occurred in more than one occasion, most notable been the 1883 tsunami resulting from the volcanic explosion of Karakatoa (Jameel, 2006). Embudhoo was not severely affected by the tsunami of 26 December 2004.

Embudhoo is exposed to swells and high waves generated by swells from Indian Ocean during the northeast monsoon and short wind-generated waves from the atoll lagoon on the western side during the southwest monsoon. Impact of waves is strongest on the eastern side of the island as this side would be prone to waves during northeast monsoon.

Waves breaking on the eastern side are stronger because of the narrow reef extent and wave formation patterns on this side. Due to severe erosion at the eastern side of the island a breakwater had been build. This has resulted the built of beach on this side of the island.

Figure 9: Summary of wave condition in Embudhoo

<table>
<thead>
<tr>
<th>Season</th>
<th>Total</th>
<th>Long Period</th>
<th>Short Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE - Monsoon</td>
<td>Predominantly from E-S. High Waves from W</td>
<td>From S-SW</td>
<td>Mainly E-NE. High waves from E</td>
</tr>
<tr>
<td>Transition Period 1</td>
<td>Mainly from SE-E</td>
<td>From S-SW</td>
<td>Mainly from NE-SE</td>
</tr>
<tr>
<td>SW - Monsoon</td>
<td>From SE-SW. Mainly from S. High Waves also from W</td>
<td>From S-SW</td>
<td>Mainly from SE-S. High waves from E</td>
</tr>
<tr>
<td>Transition Period 2</td>
<td>As SW monsoon</td>
<td>From S-SW</td>
<td>From SE-W. Higher waves from E</td>
</tr>
</tbody>
</table>

This aspect of climate will therefore have an effect on the design of any coastal infrastructure such as jetties and water sports activities planned for the resort.

Tides

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

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

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westwardly flowing currents are dominated from January to March and eastwardly from May to November. The change in currents flow pattern occurs in April and December. In April the westward currents flow are weak and eastward currents flow will slowly take place. Similarly in December eastward currents flows are weak and westward currents will take over slowly.

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

Data on current speed and direction around Embudhoo was measured during field visits. These are given in Figure 10. However, spot data taken on a single day would not yield sufficient data to understand coastal dynamics. Therefore, long term monitoring of data will be recommended in the monitoring programme proposed for the resort. Figure 10 provides an analysis of longshore currents around Embudhoo, based on past data from other projects and experience.
9.1.3 Features of the Coastal Environment

The coastal environment was considered as a main component that would be affected by the development. The existing coastal dynamics were studied during field visits. Site specific data on the coastal environment including currents and sediment movement patterns were measured and studied. Beach erosion and accretion patterns around the island were studied using aerial photographs taken in 1969 and 2008 and survey of 2009 and 2010. Also, interviews with the manager who has been on the island for a considerable period of time has been useful.

The coastal environment of Embudhoo comprised of mainly white sandy beaches, coastal protection structures, shallow lagoon or *falhu*, deep lagoon or *vilu* and coral patches. The figure represents the different features of the coastal environment of Embudhoo and a description of these different features is given in the following sections.

9.1.4 Lagoon

Clear lagoon exists all around Embudhoo covering an area of 366,064 square meters. The lagoon has average depths of 1.0 to 2m around the island. The lagoon on western side of the island lagoon consists of medium-fine size sandy floor, and scattered patches of coral colonies (patch reefs). The reef system has a large reef flat on western side of the island.
9.1.5 Beach

There is no distinctive variation in beach composition around the island. However, the beach extent can be seen to vary monsoonally. The beach material is mainly composed of loose skeletal carbonate sediments, mainly fragments of green calcareous algae *Halimeda* sp., encrusting and branching red algae, molluscs, foraminiferans, echinoderms and bryozoans. Based on observations, survey data and discussions with island management, it is estimated that approximately 10m wide white sandy beach exists on the north and south side of the island throughout the year. The beach on this side of the island gets wider to 15 m on south west monsoon.

Plate 1: wide beach on southern side of the island

The eastern side shows severe erosion as a result of northeast monsoon weather. This area sees most erosion as a result of which the area has a. The seawall seem to serve the purpose of protecting the infrastructure on the island but their is no beach throughout the year.

Plate 2: seawall on eastern side of the island.
There is a seawall on northern side of the island. This sea wall has been constructed when the island faced severe erosion on northern side of the island during the NE monsoon.

Plate 3: groynes and seawall built on northern side of the island

Plate 4: erosion is causing felling of trees on southern side of the island
9.1.6 Beach erosion

Embudhoo has undergone severe erosion in the past 50 years. Table 5 show that the area covered by the vegetation line and the land area covered by the low tide line has fallen since 1969. According to the survey that was carried out by Water Solutions in May 2008 and Dec 2009, the total vegetation area of the island has been reduced by 3,870 m², that of earliest record that is available for the island. similarly the land area of the island measured from the low tide has indicated a reduction of the island size by 13,790 m² since 1969 by erosion.

<table>
<thead>
<tr>
<th>Period</th>
<th>Vegetation (m²)</th>
<th>Island Area (m²)</th>
<th>% of change (land area)</th>
<th>Beach Line (m)</th>
<th>% of change (Beach Length)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1969</td>
<td>46,211</td>
<td>58,906</td>
<td></td>
<td>1,282</td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td>44,108</td>
<td>49,060</td>
<td>-16.7</td>
<td>947</td>
<td>-26.1</td>
</tr>
<tr>
<td>May-08</td>
<td>42,340</td>
<td>52,400</td>
<td>6.8</td>
<td>1,098</td>
<td>15.9</td>
</tr>
<tr>
<td>Oct-08</td>
<td>42,340</td>
<td>45,116</td>
<td>-13.9</td>
<td>987</td>
<td>-10.1</td>
</tr>
<tr>
<td>Dec-09</td>
<td>42,340</td>
<td>52,693</td>
<td>16.8</td>
<td>1,055</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Table 5: change of Embudhoo’s land area

Figure 11: the changes to the shoreline of the island from 1969 – 2010
9.2 Marine Environment

Sand burrow areas are free of any epifaunal growth and consist 100% of sand.

Site C on the eastern side of the island, where a large breakwater is proposed, consists of $22 \pm 3.49$ % Live coral coverage (mean ± SE). Abiotic categories dominate the benthic substrate with $65\% \pm 4.23\%$ (32% coral rock, 33% rubble). Most of the live corals observed belong to the Acropora genus (12.15% of the surveyed area).

The substrate around the sewerage outfall on the northeastern side of the island consists to a great extend ($95.6 \pm 1.83\%$) of coral rubble and dead rock, whereas live corals are only rarely encountered there ($3.6 \pm 1.73\%$), which are mainly young Acroporidae.

Plate 5: Sand burrow areas - 100% sand

Plate 6: Coral cover at reef flat which is 25 m east of area where proposed breakwater on the eastern) – 25% of a photo quadrat shown in the picture
Plate 7: Seafloor at the sewage outfall, mainly coral rubble and sand
10 Environmental Impacts

10.1 Impact Identification

Impact identification has been undertaken by considering the proposed activities and examining the level of impact the project will have on the environment. Each activity was then examined in detail to identify the construction methods, technology and other factors that would determine the potential impact of the various activities.

10.2 Assessing Impacts

Environmental impacts of the proposed coastal protection work have been examined through a number of processes. These include consultations with the stakeholders, field surveys, observations and assessment, and field experience gained from similar development projects implemented throughout the country. Potential positive and negative impacts on the environment have been considered.

The impacts are categorized into short-term and long-term. Most of the short-term impacts are related to constructional phase, while the long-term impacts are associated with the operational phase.

Possible negative impacts on the environment have been considered in worst-case scenario to recommend mitigation measures in the best possible ways so that these impacts would be minimized and perhaps eliminated in both constructional and operational phase.

This EIA identifies and quantifies the significance of adverse 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 judgement 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.

10.3 Uncertainties in impact prediction

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, geomorphologic or social conditions in a particular place. There is also limited data and information regarding the particular site under consideration, which makes it difficult to predict impacts.

However, the level of uncertainty, in the case of Embudhoo is expected to be low as many similar projects have been undertaken elsewhere in the Maldives. The areas where coastal protection and
beach replenishment will be undertaken is a sandy bottom and coral rubble. There is no live coral cover in this area.

Construction of breakwaters, and nourishment of beaches are developments that had been undertaken in other parts of the Maldives and their impacts are well known and have been well documented. Therefore, there is very little uncertainty involved in this project. Therefore, there is a high degree of accuracy in prediction of the impacts.

10.4 Impacts on the Coastal environment

The development of breakwater on eastern side of the island would help to reduce the existing erosions, which the island is presently faced, and facilitate to create beach on this side of the island. The creation of the beach will be further assisted with subsequent nourishing of the lost beach.

10.4.1 Breakwater construction

Impacts

The construction of the breakwater will have a significant positive impact on the southern side beach line in stabilizing the beach. The impact of proposed breakwaters would be mainly related to changes to hydrodynamics and sand transport. Since the breakwater can be dismantled and removed if necessary, the impact of constructing breakwaters is considered reversible. The impact on sand transport around this area would be significantly reduced, and hence the impact but a desirable one. Wave energy will be reduced by the breakwaters and therefore long shore transport sedimentation will be reduced resulting in the stabilizing of the shoreline. The breakwaters proposed on the southern side is therefore going to reduce the long shore currents and reduce erosion.

Mitigation Measures

It is important to undertake the placement of the breakwaters at the preferred location at low tide hours.

10.4.2 Replenishment of the beach

Impacts

The replenishment of the eroded beach will be undertaken by using sand pumped from the lagoon. Refer to the project description section for details of the locations and their volumes. Beach erosion is a critical environmental issue facing the island. Even at present, several large trees is under threat from erosion, mainly on the southern side.

Beach replenishment will be undertaken on southern side and north-east side of the island. Therefore, the lagoon in this area will be directly impacted due to complete alteration of the lagoon bottom and spreading of sediment plumes from the filling material.
Beach replenishment and filling is usually associated with the direct and permanent alteration of the fill area and indirect impacts resulting due to sedimentation. Turbidity increase is almost an unavoidable consequence but can be minimized. In general, the following impacts will be felt.

- Turbidity increase in the water column from spreading of silt plumes. When lagoon floor is disturbed by filling, fine sediment and silt may be released into the water column.

- Lagoon sediments consisting of varying sizes of particles may be suspended for hours in the water column cutting down light to photosynthetic reef benthos. The magnitude of this impact will depend on various factors such as size of particles; hydrodynamic conditions; and reef and lagoon topography. In addition to this many infauna and their habitats will be lost.

- Possible siltation and excessive sedimentation in the lagoon system

- Excessive sedimentation and siltation on coral reefs is detrimental to corals and other reef benthic organisms as it cuts down necessary light and physically smothers corals. It is not expected that the beach replenishment will have any significant direct impact on the coral reef system of the island.

Long-term ecological impact arising from the proposed work activities is not predicted to be significant as the proposed work is limited and localized in a small part of the island system. However, long-term monitoring is required to identify ecological impacts more completely and thoroughly.

**Mitigation Measures**

The mitigation measure to control sedimentation as it is the main factor that can cause the greatest impact on the reef. Hence, most of the mitigation measures proposed are centred around reducing sedimentation. More specifically the following measures will help to reduce the impacts.

- Working during low tide hours.

- Creating a bund wall around the replenishment area initially and then filling inside this bund using pumped sand. The bund will be removed after the beach replenishment work.

- Completing the filling works in the shortest possible time period.

- Only replenish the required area of the beach

- Using coarse material to make the bund rather than fines.
Table 6: Summary of the impacts and their characterization

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Nature of impact</th>
<th>Magnitude of impacts (negligible/minor /minor adverse/moderate adverse/major adverse/ positive)</th>
<th>Significance of the impact (low/moderate/high)</th>
<th>Duration of Impact</th>
<th>Reversibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact of beach replenishment</td>
<td>Cumulative</td>
<td>Positive</td>
<td>High</td>
<td>Long-term</td>
<td>reversible</td>
</tr>
<tr>
<td>Construction of the break water</td>
<td>Cumulative</td>
<td>Major</td>
<td>High</td>
<td>Short to long term</td>
<td>irreversible</td>
</tr>
<tr>
<td>Construction of groynes</td>
<td>Cumulative</td>
<td>Major</td>
<td>High</td>
<td>Short to long term</td>
<td>irreversible</td>
</tr>
</tbody>
</table>
11 Stakeholder Consultations

For the purpose of this project, stakeholder consultations were limited to relevant government agencies and the proponent. Methodology for undertaking these discussions was through interviews and discussions.

11.1 Consultation with the relevant government agencies

During the scoping meeting, the proponent, Ministry of Tourism and EPA officials participated and discussed the project in detail after which the scope of the project was outlined. During the meeting, EPA raised the issue of breakwater construction and especially beach replenishment and indicated that the beach length should not be more than 10 meters from the high tide line.

In general, there were no major issues raised and since the project concept was finalized by the Tourism Ministry, MOT, did not have any reservations for the project at all.

11.2 Consultation with the proponent

In general, discussions were held with the proponent to obtain information about the need for this project. The major outcome of these consultations is outlined below.

- The island has lost significant amount of beach on eastern and western side of the island. Hence bringing back the beach is important to sell the island as a beach resort
- The proponent is not interested in reclaiming land, however does propose a beach replenishment program to recover the beach lost due to erosion.
- Construction of breakwaters to prevent beach erosion. Breakwater will be submerged structures rather than emerged breakwaters. The submerged breakwaters will need to be created with a larger base. submerged breakwaters are aesthetically appealing to resorts than emerged breakwater.

11.3 Consultations with a contractor

For this project, Hussain Mohamed of Island projects was consulted to obtain views on beach replenishment and coastal protection. Following is the outcome.

- Erosion cannot be controlled by beach replenishment alone, but need to be coupled with coastal protection in order to control and mange erosion totally.
- Beach replenishments that require sand quantities less than 10,000 cbm can be done cost effectively using sand pumps.
12 Alternatives

EIA Regulation requires two alternatives to be suggested for such developments and therefore two alternatives have been suggested in addition to the no project alternative. These alternatives are discussed below:

12.1 No Project Option

The no project option takes the following into account.
- The resort will be operated with the existing coastal protection infrastructure.
- No additional coastal infrastructure will be introduced.

The main advantages and disadvantages of these are given in Table 7.

Table 7: Advantages and disadvantages of the no project option

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allow the resort to be operated with the present coastal infrastructure</td>
<td>Environmental problems related to additional coastal protection can be avoided No upgrading costs to the proponent, short term benefit</td>
<td>With the existing coastal infrastructure, erosion cannot be controlled and hence it is going to affect the marketability of beach and affect the operations.</td>
</tr>
</tbody>
</table>

12.2 Alternative borrow areas

Sand could be borrowed from outside reef on eastern side of the island to replenish beach on eastern side. The advantage of this borrow site is that it is close to the area where it need to be replenish. However, the disadvantage is that the sand is found around 30 m deep and cannot be easily pumped with sand pumps available in Maldives. Pumping sand at this depth requires special technologies, which makes this option very expensive.

12.3 Alternative methods to protect the beach

There are a number of options for shore protection on the western side of the island. These include emerged breakwaters, near shore breakwaters, seawall, revetment or continuous nourishment.

12.3.1 Emerged Breakwater

The emerged breakwaters are popular coastal protection features in the resorts. However, the emerged breakwater has an aesthetic impact that had become unpopular. The emerged breakwaters are designed to prevent overtopping of waves and keep the leeward side of it calm.

For an operational resort and from the perspective of managing the shoreline, emerged breakwaters provide a guaranteed solution with their characteristic disadvantages. Emerged
breakwaters will ensure that erosion is totally or almost 100 percent controlled and for Emboodhoo, it is the wish of the client to ensure that erosion does not take place on the eastern side and to alleviate the problem in most days of the year.

For this project, emerged breakwaters have not been preferred for these reasons.

12.3.2 Continuous Re-nourishment of the beach

Re-nourishment would be an ongoing process, but the proposed coastal protection measures such as the breakwaters would help to minimize the frequency of re-nourishment. It is estimated that re-nourishment will be required more than twice a year if no coastal protection is undertaken as the western side is exposed to severe erosion. If erosion continues in this area, then it will become a burden for the operations as well as it would be very difficult for the management to market the resort as replenishment works during operation is going to be an issue with most tour operators and clients. Continuous nourishment is also more environmentally damaging as periodic nourishment will create continuous sedimentation of the reef thereby preventing the reef from getting adequate time to recover.

12.4 Alternative materials for breakwaters

There are some options as materials for coastal protection structures. First, there is coral rubble as used in existing seawall structures. However, coral mining is banned and this option shall not be considered. The reuse of coral used for existing structures may be considered. However, they would not be sufficient or may not provide adequate protection. Second option is the use of rock boulders which would be strong enough to survive strong waves.

12.5 Preferred options

The preferred alternative for this project is to construct emerged breakwaters instead of submerged breakwaters.

12.5.1 Mitigation measures for the proposed alternative

Following mitigation measures are proposed for preferred alternative.

- They are to be constructed as per the proposed concept.
- Need to be undertaken with care so as to ensure that their dimensions are right.
- Undertake the construction during low tide hours.
- They should not be continuously placed, meaning that there should be gaps placed in between them to allow waves and water flow.
13 Environmental Monitoring

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. Monitoring will be carried out as part of the environmental impact assessment and monitoring requirements addressed in this EIA report. Monitoring responsibility will be with the client and financial provisions will be made in the project to undertake the monitoring.

13.1 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.

13.2 Aspects of monitoring

Monitoring will include marine aspects and coastal aspects only. Summary monitoring reports will be provided every three months and final report would be provided at the end of the construction stage.

13.3 Methods of monitoring

Environmental monitoring will be undertaken using standard methods described in the Methodology section. Monitoring is only recommended for marine and coastal environment.
Table 8: Aspects of the 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>Marine water visibility in the lagoon</td>
<td>Visibility</td>
<td>Secchi Disc &amp; Tow line distance</td>
<td>Every 3 month</td>
<td>No cost. Contractor to undertake this during construction period.</td>
</tr>
<tr>
<td>Coral cover at survey sites</td>
<td>Percentage live cover</td>
<td>Qualitative &amp; Quantitative</td>
<td>Once during the construction stage.</td>
<td>3,000 per quarter</td>
</tr>
<tr>
<td>Marine water quality</td>
<td>suspended solids, pH, temp, COD, DO, Salinity, turbidity, nitrates, phosphates,</td>
<td>Onsite or Lab analysis</td>
<td>Every two months during work; twice a year thereafter</td>
<td>250 per quarter</td>
</tr>
<tr>
<td>Movement of beach</td>
<td>Low, medium and high tide line</td>
<td>GPS survey</td>
<td>Every 3 month</td>
<td>500 per quarter</td>
</tr>
<tr>
<td>Beach profiles</td>
<td>Changes to the beach</td>
<td>Using auto level</td>
<td>Every 3 months after construction</td>
<td>750 per quarter</td>
</tr>
<tr>
<td>Currents</td>
<td>Changes to the current</td>
<td>Using drogues</td>
<td>Every 3 months after construction</td>
<td>500 per quarter</td>
</tr>
</tbody>
</table>
14 Conclusion

Embudhoo is presently facing severe beach erosion and had removed significant length of beach on the eastern and western side of the island. Existing beach protection structures that had been placed on the island seems not to be functioning properly and have not created beach that had been lost.

If the coastal protection measures proposed is not undertaken, the resort will face significant operational and environmental issues further. Environmentally, the erosion will threaten the island by destroying the coastal vegetation and inundation by waves on the western and eastern side. This will not only be an issue for the plants, but the infrastructure nearby and the guest activities will be affected badly. The result would be to take temporary control measures, which do not last long. In the event, the resorts operation will be heavily affected due to erosion. Guests will be unable to utilize these areas and hence put more burden on other areas of the coastline. This will reduce the usable beach in the island and it is something that no resort operations would want to experience.

Hence, it is proposed to undertake the proposed coastal protection with beach nourishment. The coastal protection has been proposed in order to control erosion on the western side and eastern side. This can be achieved by placing submerged breakwaters on the eastern side and a groyne field on western and southern side. Beach replenishment is proposed to bring back the beach that had been lost from the island.

The proposed coastal protection is urgently required and the project is justifiable.
15 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water. The EIA was carried out by a multidisciplinary consulting team representing Water Solutions Private Ltd. In preparing this report, no data has been manipulated. All data has been collected by field visits.

We certify that the statements in this Environmental Impact Assessment study are true, complete and correct.

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Signature:

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Signature:
17 References


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18 Annex: Terms of reference
19 Annex: Beach Profiles
20 Annex: Photo Representation of Existing Environment
21 Annex: Bathymetry of the lagoon