ENVIRONMENTAL IMPACT ASSESSMENT

For the Development of Gulhifalhu, Kaafu Atoll Maldives

August 2010

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FOR THE DEVELOPMENT OF GULHI FALHU

KAAFU ATOLL, MALDIVES

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1 Executive Summary

This Environmental Impact Assessment (EIA) is an evaluation of the potential environmental, socio-economic and natural impacts of the proposed development of the lagoon at Gulhi Falhu. The Project is being undertaken by Capital Investment and Finance Ltd (CIFL) registered in the UK. CIFL has signed a concession agreement with the owner of Gulhifalhu – Gulhifalhu Industrial Zone Limited – a state-owned company with objective to privately develop a qualitatively high and attractive residential and commercial area in the Maldives and lease out reclaimed land for 35 years.

1.1 Introduction

Project Background

The Government of Maldives in its efforts to enhance the economic potential of the Maldives has been considering the reclamation and the development of the lagoon at Gulhi Falhu as a potentially attractive investment opportunity in infrastructure, for the past several years. The first phase of the Gulhi Falhu development project includes the reclamation of approximately 10 hectares of land.

1.2 Project Description

Project location

The project location is Gulhi Falhu Reef located on the southern rim of the North Male' Atoll. Gulhi Falhu is in about 400m away from Villigili Island and about 300m east of Thilafushi Island. The nearest resorts are Giraavaru Tourist Resort (5km) and Kurumba Maldives (6.7km).

Project Outline

The proposed overall project involves the reclamation of over 110 ha over Gulhi Falhu. In Phase 1 of the project include dredging of approximately 300,000m^3 of coral sand within atoll lagoon and pumping of the materials into reclamation area.

Selected method for the dredging

The method proposed is sourcing sand from the bed of the atoll lagoon using a Trailing Suction Hopper Dredger (TSHD). A TSHD is a normal sea-going ship equipped with one or two suction pipes. The material loosed by the drag head, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump. The TSHD will transport the sediments to the reclamation where they will be brought to shore.

Stability of reclamation

Rate and volume of pumping sediment will be faster than the rate of erosion. Erosion is predicted to be severe in the short-term. For the south side revetment and optimization has shown that a 50-70 m wide strip of reef area will be left untouched in order to allow wave energy dissipation and a resulting reduction of cost of the revetment. A quay wall length in phase 1 will be between 200 and 600 m and will be located at the western side of Gulhi Falhu.

Work Plan

The project is planned to be carried out in four phases. Both phase 1 and phase 2 are expected to take six to seven months each phase. The preparatory work is expected to take one month. The Dredging activity is expected to take one week and reclamation work is expected to take two months.

1.3 Legal Framework

The main legal instruments of concern are the Environmental Protection and preservation Act (4/93), which is an umbrella law that provides wide statutory powers to the Environment Ministry regarding environmental regulation and enforcement and the Environmental Impact Assessment Regulation 2007 which provides comprehensive outline of the EIA process. Other important policy tools include "Aneh Dhivehi Rajje' – The Strategic Action Plan (SAP), National Environmental Action Plan II (NEAP II), National Strategy for Sustainable Development, waste management Policy and population policy.

1.4 Description of the Natural Environment

Gulhi Falhu is a submerged reef, located in the southern part of the Kaafu Atoll. The size of the reef structure is about 2800m by 1600m and has no land surface above MSL. Gulhi Falhu has no top soil. The water depth over the reef flat varies between 1.0 and 2.0m.

Marine Environment

A coral survey was conducted at 6 locations on the Gulhi Falhu reef. Overall, the live coral cover is not great, averaging 18% on all transects. The massive and encrusting life forms represent the bulk of the coral cover. The reef top on the northern side is rather bare and consists of a flat rocky substrate in the 2.5 to 3m depth range. As a general rule, the coral cover was quite better in the reef edges and poor in the lagoon side. At the depth the coral cover seems to be quite even all around the reef with a cover in the range of 20%.

The dive sites of Vadoo Island, Taj Exotica and Embudu Village are mainly located in the South male atoll. Eight marine protected areas are located in the North Male' Atoll and two in the South Male' Atoll. The Closest marine protected area to Gullhi Falhu is Hans Hass Place located just south of the Gulhi Falhu reef.

Some of the protected species were observed in the waters around Gulhi Falhu reef. Gulhi Falhu is currently completely submerged and has therefore no beaches and no function as a turtle nesting area.

1.5 Economic and Social Environment

The present socio-economic environment of Gulhi Falhu is outlined in relation to Male', Villigili, Thilafushi and nearby resorts. Socio economic changes caused by the establishment of Gulhi Falhu Island cannot be evaluated at this stage because details of land leasing, types of industries and such information are unknown.

A public consultation was carried out in Villigili Island interviewing total of 53 persons. The General attitude was positive and important areas of their concern were strong increase in traffic between Gulhi Falhu and Male', noise from dredging during construction and about the fisheries in the area.

Gulhi Falhu is located about 5 km away from Capital Male', which is considered as the main gateway to the country and all the service related industries within the community including civil service, construction activities, retail and whole sale trade and cargo transport to other international hubs.

Thilafushi Island is located about 0.36 km away from Gulhi Falhu. The primary purpose of Thilafushi is to solve the issue of waste on Male' and has been in use for landfilling for the last 18 years.

Kurumba Maldives (6.5 km north east of Gulhi Falhu) and Giraavaru Island Resort (5 km to the west of Gulhi Falhu) are the two resorts located in close proximity to Gulhi Falhu.

1.6 Public Consultation

Stakeholder consultations were carried with the VIligilli Island population, recreational fishermen, Divers Association of Maldives (DAM), nearby resorts, Ministry of Tourism, Thilafushi Cooperation and Male' Municipality Waste Management Section. In general, all groups welcome the development and would like the project completed as it is beneficial to the Maldives. The DAM members noted that, if the proposed reclamation goes ahead, they do not foresee the dive sites operating in the future due to the significant impacts likely on the marine environment. The waste management section will incur additional costs for rerouting the waste transfer route but said that they were anticipating this change once Gulhi Falhu development begins.

The fact that no plans have been devised yet for the phases 2 and 3 and the operations stage of phase 1, made it difficult to conduct consultations for these specific phases. Hence, only phase 1 was considered in the public consultation, covering land reclamation and coastal protection. A separate EIA with detailed socio-economic assessments are recommended for phases 2, 3 and 4.

1.7 Environmental Impacts and Mitigation Measures

Proposed project will have both negative impacts as well as positive impacts to the country in general. This chapter involves a closer analysis of the major environmental impacts of the project. This is represented in a flow chart in a chronological and logical manner. This order starts from the activity to casual factor, leading to the negative environmental impacts and finally duration of the impacts.

Sedimentation is highlighted as the major impacts to the natural environment; this is mainly due to the dredging and reclamation activities. These cause several impacts ranging from smothering of coral to permanent loss of marine habitats. Other impacts include pollution to the environment, impacts to the protected coral reef area. During the project it is also expected there will be change in the current patterns which is experienced by similar projects in the past. The methodology adopted by the project is TSHD this ensures the project to be more environmentally sound. Several mitigation measures are also taken prior to commencement of the project and during and after the project. This ensures the project to be following EIA process. Measures with their respective costing like developing sedimentation basins, silt screen and bund walls during the reclamation process are used.

1.8 Environmental monitoring

The monitoring programmes include three main sections, they are;

- Information needs

  In this monitoring plan, this includes both the construction phase and the long term monitoring.

- The monitoring program including the equipment, the locations and frequencies

  In this section, the requirements, methodology, equipment and monitoring locations and frequency for the monitoring components are presented.

- The monitoring reports

  The weekly reporting will be based on the monitoring results, site inspections and the evaluations/ interpretation of the monitoring results.

1.9 Conclusion

The reclamation of Gulhi Falhu with revetments on the exposed sides can be done with medium impacts on the surrounding environment in the phase 1, however during the dredging and reclamation activities, good care should be taken to minimize the impacts of the suspended sediments. Preventives measures will be in place to ensure minimal loss of suspended sediments. All the feasible measure will be taken to minimize the amount of coral damage by dredging.

The Socio economic benefits are large in relation to the duration of dredging and reclamations works needed. This project will provide new land for warehousing, logistics and distribution and housing. And it is believed that an existing and immediate need for the land and space in the Male' region would be fulfilled by this project.

2 Introduction

2.1 General

The Republic of Maldives consists of some 1,200 coral islands grouped in a double chain of twenty-seven atolls. Most atolls consist of a large, ring-shaped coral reef supporting numerous small islands. Islands average only a few hectares in size, and lie between one and 1.5 meters above mean sea level. The Maldives have no hills or rivers. Some larger atolls are approximately fifty kilometers long from north to south, and thirty kilometers wide from east to west; no individual island is longer than eight kilometers. Each atoll has approximately five to ten inhabited islands; the uninhabited islands of each atoll number approximately twenty to sixty.

Only part of the surface area of the Maldives is inhabited. The population is concentrated on a limited number of rather densely populated islands, thereby providing a reasonable basis for social subsistence. Twenty atolls are populated ranging from 1,600 to 18,000 people (not including Malé). The entire population of the Maldives is scattered over 200 inhabited islands. In 2006 the population was calculated at 290,000, with about one-third of the population concentrated in the capital. The population growth in the Maldives has recently been as high as 2 to 3%. In the outer atolls the majority of the population is below 20 years of age. These outer atolls experience a large outward migration notably to Malé.

There are two main (international) ports in the Maldives. The most important port is Malé, located on the north- west side of Malé Island. This port has been improved during the First Malé Port Development Project completed in late 1992. The other larger port is Gan, located in the South of the Maldives; until the 1970□s the Port of Gan was a Military/Air Force Base of the British. Until very recently, the port of Malé was the only port of the country where international cargo was handled. Since industrial activities began expanding to other islands, other ports have begun to be used for exports. With about one third of the country's population living in the greater Malé area, the Port of Malé retains its status as the central and the most important port of the country. Gulhi Falhu (GF) reef and lagoon are located about 2.5 km west from Malé.

2.2 Background of the Study

The Government of the Maldives (GOM) in its efforts to enhance the economic potential of the Maldives has been considering the reclamation and development of the lagoon at Gulhi Falhu (GF) as a potentially attractive investment opportunity in infrastructure, for the past several years. The rationale for the development of GF lagoon is to provide an alternative location in the proximity to Malé, to carry out various commercial and light manufacturing activities, easing out the current congestion in Malé.
Gulhifalhu Industrial Zone limited, Maldives and Capital Investment and Finance Limited, United Kingdom, have entered into a concession agreement with GOM, represented by the M inistry of Economic Development & Trade to reclaim and develop the GF lagoon on March 18th 2010.

The complete reclamation of Gulhifalhu will consist of 4 phases. The first phase of the GF development project includes the reclamation of approximately 10 hectares of land along with the necessary shore protection. The second phase of the GF project concerns the development of a further 30 hectares. Phase 3 will consist of a 75 hectares and phase 4 of 115 hectares.

Planning of the phases will be in agreement of the concession agreement between the developer and the GOM.

The planned activities for these phases of the project are restricted to dredging, land reclamation, and shore protection. The impacts of the development of houses, roads and warehouses will be assessed in a separate EIA.

The GOM will offer the Joint Developers a long term lease on the land with the right to sub-lease the land for undertaking selected investments approved by the GOM. The GOM will also accord other incentives to the investors operating on the newly reclaimed land.

The present report contains a proposal for the Environmental Impact Assessment (EIA) for the dredging, reclamation and shore protection works of phases 1 to 3 of the GF land development. For the reclamation of phase 4 a separate EIA will be made. This report has been prepared by Hydronamic bv of Papendrecht, the Netherlands.

2.3 Project Proponent

The project proponent is Capital Investment and Finance Ltd (CIFL) registered in the UK. CIFL has signed a concession agreement with the owner of Gulhifalhu – Gulhifalhu Industrial Zone Limited – a state-owned company with objective to privately develop a qualitatively high and attractive residential and commercial area in the Maldives and lease out reclaimed land for 35 years.

Global Projects Development Company (pvt) ltd, Maldives, a subsidiary of CIFL, is the local SPC currently being registered to execute the development of the Gulhifalhu.

2.4 Aim and scope of EIA

The present scope of the EIA is based on the EIA Regulations from the Ministry of Housing, Transport and Environment (EIA Regulations 2007, ref. 1) and on EIA□s for several other, similar, projects in the Maldives (Vilufushi Island Reconstruction and Viligili Island Reconstruction, ref. 2, ref. 3, Three Islands Project, refs. 4, 5). The EIA report covers both the natural and the social environment and includes the following main aspects:

- a description of the project including the usefulness and need of the project
- the policies and plans of which the project is a part and the legal framework of the project;

- information about the general environmental settings of the project area, covering both the marine and terrestrial environment and including physical and climatological characteristics;
- information on the social and economic baseline conditions;
- information on potential impacts of the project and the characteristics of the impacts;
- information on potential mitigating measures to minimise undesired environmental and social impacts;
- assessment of the best alternative for the project or for certain project components;
- basic information for formulating the environmental monitoring program and the environmental and social management plan;
- inventory of possible gaps in presently available information.

The focus of this EIA is very much on the construction stage of the first phase of the project. This is limited to dredging, land reclamation and the coastal protection of a 10 ha area designated for the first phase of the project.

It is difficult at this stage to undertake a full scale assessment of the remaining phases of the project as they are the detailed plans for them are yet to be finalized. Moreover, the detailed plans for further development of the first phase of the project are yet to be finalized. Hence, this EIA explicitly looks into the construction stage of the phase one of the project.

2.5 Terms of Reference

The Terms of Reference (TOR) for this EIA were submitted to the Ministry of Housing, Transport and Environmenton 20 May 2010. A scoping meeting was held on 9 June 2010. Based on this meeting the TOR were adjusted and a final version was submitted on 27 June 2010 and approved by the EPA on June 30th 2010. The TOR follow the Environmental Impact Assessment Regulations 2007, as prepared by the Ministry of Environment, Energy and Water.

The approved Terms of Reference can be found in Annex 1.

It has to be noted that the implication on the socio-economic environment and the operations stage as detailed out in theToR was not possible since the exact details of the land based development are yet to be finalized. Hence, issues like implications on demographics, housing market and transportation in the Male' area cannot be predicted for the proposed activities of the phase one of the project. Hence, it is recommended that a separate EIA be undertaken for developments proposed on the site and for the phase 2, 3 and 4 separately. These EIAs should cover a comprehensive socio-economic assessment.

2.6 Experience of proponents with similar projects

The project proponent, Capital Investment and Finance Ltd.(CIFL), has contracted Royal Haskoning, an internationally renowned engineering and consultancy, to make engineering designs for the project.

Royal Haskoning is one of the largest port development consultants in the world and has wide experience in the fields of urban development and water & environment.

CIFL has also contracted Royal Boskalis Westminster to do the dredging and reclamation works necessary for the development of Gulhi Falhu. Boskalis has worldwide experience in dredging and reclamation works and has worked for the Government of the Maldives on tsunami reconstruction projects at Vilufushi, Thaa Atoll (2005-2006) and Viligili, Gaafu Alifu Atoll (2007-2008).

2.7 EIA Methodology

The process followed in the preparation of this environmental impact statement consists of five components: scoping consultations; literature review; field surveys; analysis of results; and output.

The first step of the process covered consultations with client and government agencies to determine the scope of the impact assessment. The scope was decided and the ToR was finalised on 30 June 2010 based on the information contained in the EIA Regulations 2007. During this stage the client clearly outlined their development needs and assessment was geared to match the development plan and environmental assessment needs.

During the second stage, a literature review was conducted to acquire background information on the site and its environment as well as to identify possible environmental impacts of the proposed developments in similar island settings. In this context, the Draft Environmental Guidelines for Tourist Resort Development and Operation issued by the MTCA, the EIA Regulations 2007. The timeframe for assessment was small given the geophysical setting of Maldivian coral islands. Hence, a reliance on scientific studies undertaken in similar settings around Maldives and historical publications are a necessity during assessments in Maldives.

The third stage involved field assessment both on the island and in neighbouring areas covered by the EIA scope. Conditions of the existing environment were analysed using established appropriate scientific methods. Coastal and hydrographical conditions were studied through field surveys which involved using DGPS, echo-sound meters and remote sensing applications. Aspects of the marine environment were assessed using established surveying and recording procedures such as Manta tows, random swims, line transects and photo quadrates. In addition, data from regional studies, particularly climate and wave data were used to assess environmental impacts.

In addition, field assessments were undertaken in the Viligilli community to determine the socio-economic impacts on them using established social assessment methods such as random interviews.

The fourth stage involved in-house analysis using scientific analysis methods. These methods will be explained in detail in later sections.

The final stage involved compilation of individual consultant findings and consultations with the developer to adjust certain elements of the designs which were deemed to have significant affects on the operation of the islands and the resorts.

The field work necessary for the environmental and social impact assessment was carried out by expert professionals. The environmental field work (coral surveys) in June 2010 was done by 2 divers and a snorkeler from Multi Marine Services Pvt. Ltd., in charge of the underwater photography and dive safety, and 1 marine biologist from Seamarc Pvt. Ltd. to organize the survey layout with the Boskalis environmental engineer. The social consultations were done by Mr. Chris Geerling PhD, of Carnbee Consult. Previously, Mr Geerling was in charge of the social impact studies for the projects in Vilufushi and Viligili and for the Three Islands Project. Additional consultations with Male' Municipality Waste management Section and Diver Association were undertaken by CDE Consulting.

This report was compiled by Ms. Stephanie Ross and revised by CDE Consulting following comments from the EPA.

2.8 Report Outline

This EIA is organised into nine sections. They are:

Chapter	Brief Description
Chapter 1	Executive Summary
Chapter 2	Introduction
Chapter 3	Problem analysis and justification for the project
Chapter 4	A description of the project including the project location, detailed description of project components including site conditions, site plans, implementation schedules, work methods, waste management and summary of inputs and outputs.
Chapter 5	A summary of the policy, planning and legal framework applicable to the project and a demonstration of how the project conforms to these aspects.
Chapter 6	Detailed description of the existing baseline environmental conditions on the site.
Chapter 7	Description of the economic and social environment
Chapter 8	Information regarding stakeholder consultations
Chapter 9	Information on the potential impacts and mitigation measures of the project.
Chapter 10	Assessment of best alternatives for the project or for certain project component.
Chapter 11	Details of the environmental monitoring program
Chapter 12	Conclusions

3 Problem Analysis and Justification of Project

3.1 General

In the Maldives in general and also in Kaafu Atoll and the greater Malé area, there are significant problems directly related to the natural environment. The most important problems are caused by population pressure and lack of space for future development, but also by natural phenomenons such as increasingly extreme weather conditions and sea level rise. The tsunami of 26 December 2004 and the damages caused have created a further threat to the environment in the area; although the direct damages were large but in general manageable, the migration from the outer atolls to Malé increased substantially. In this chapter the relevant problems will be shortly analysed and the need for the project and its general outline and dimensions will be discussed.

3.2 Problem Analysis

3.2.1 Land scarcity in the Malé area

Land is extremely scarce in the Maldives, which acts as a constraint on the development of the country. This is especially true for Malé, the capital city of the country, with a population of more than 100,000 people, concentrated in just two square kilometers. Due to a lack of employment opportunities in the outer atolls in recent years, many people migrated from small islands towards Malé. The percentage of the country's total population living in Malé has increased from 25% to 35% during the period 1990 - 2006. This concentration seems to continue, especially after the 2004 tsunami, despite efforts of GoM to discourage people coming to Malé. The continuing overcrowding in Malé has resulted in a lot of economic and social problems: high land rental rates, no room for industrial/commercial development, environmental issues, crime, etc. To ease out the current congestion and enhance the economic potential of Malé, the GoM is considering and/or has undertaken several land development projects in the Malé area. The Gulhi Falhu land development project is one of them.

3.2.2 Population pressure

The population growth in the Maldives has recently been as high as 2 to 3%; in the outer atolls the majority of the population is below 20 years of age. Due to the significant population growth, many of the islands are completely full. This means that there is no place for additional people, for further communal and/or commercial activities, and for migration from smaller islands to the bigger regional centres.

Due to the relatively small populations (average 500-1,500 persons) per island, the costs of providing community infrastructure (electricity, water supply, sewerage, waste collection) and communal services (health, education, local administration) is extremely high. Further, the limited depth of the islands ports and the low transport volumes, lead to high per-ton transport costs for import of food, construction materials and other goods.

In a country with high GDP growth, and a society that is rapidly modernizing, demand for better infrastructure and services will often grow at a much faster pace than even GDP growth.

Both the population pressure and the high costs of communal infrastructure and provisions in the smaller islands will in time result in migration to larger islands, often to Malé.

3.2.3 Extreme weather conditions and sea-level rise

At the Maldives virtually no cyclones occur, but sometimes there are significant storm surges with up to one meter sea level rise. In April 1987 there was a storm surge at Malé, which resulted in unusually high waves. One third of Malé was inundated by about 60 cm of water. Again in 1991 a storm surge occurred near Malé. Although the damage was minimal, the experience was a forceful reminder of how vulnerable the Maldives can be to even a small rise in water level. Then of course there was the December 2004 tsunami and the resulting waves and flooding in Malé and other islands.

Climate change and predicted sea level rise are of great importance to the Maldives, due to the low elevation of the islands, making them vulnerable to even small rises in the sea level. During the past century the global temperature increased by about 0.6 degree. Climate models calculate that the global mean surface temperature of the earth could rise by about 1 to 4 degrees by 2100. During the past century the average sea level increased by about 15 to 20 cm. The estimated predicted sea level rise in the period 2000 to 2100 will be, according to the latest UN/IPCC (Intergovernmental Panel on Climate Change) report (Jan 2007), between 18 and 59 cm, average 0.4 meter. This sea-level rise combined with more frequent extreme weather occurrences makes the Maldives one of the most vulnerable countries to climate change and sea level rise.

3.3 Justification of the project

There are three main objectives of the project:

- Increase the useable land-space in the Greater Malé area, allowing extra space for industrial activities, housing, and services, including related infrastructure, which should be provided on the new island against reasonable costs.
- Build the new island as a safe-island, providing reasonable safety against the sea for at least the next 50 years.
- Provide efficient transport facilities for the new industries and services, and the people employed on the new land.

The economy of the Maldives is growing and with it the population, transportation of goods, the need for harbours, schools, hospitals, housing and wharehouses and industrial activities increase as well. The necessity of space for all these activities is extensive. In Kaafu atoll there are currently more development projects in execution or planned.

Table 3-1 Main Projects in the area

Area	Main land use
Hulhumale 1	Residential (+light industry)
Hulhumale 2	Residential
Hulhumale DP World	International shipping
Hulhule airport ext	International air traffic
Male NW port area	Shipping
Thilafushi	Heavy Industries

Gulhi Falhu is located close by Malé in the southern rim of Kaafu Atoll (see next chapter). Overall some 200 hectares of land could be developed in/on Gulhi Falhu reef and lagoon; this land will border (enclose) a large protected anchorage area, accessible virtually at all times. After its implementation the project is expected to have a huge effect on employment in the Greater Malé area. When completed GF Island will be a part of the urban corridor on the south-east side of Kaafu Atoll consisting of (west to east) Thilafushi, Gulhi Falhu, Villingili, Malé island, Hulhule' airport, and Hulhumale residential landfill.

3.4 Potential users

The key functions for the development of Gulhi Falhu include the relocation of some industrial activities from Malé, the relocation of logistics inter-island redistribution activities, and it caters for related population growth.

The Maldivian Foreign Investment Services Bureau (FISB) confirmed in its Letter of 17 October 2006 which activities could be operated on Gulhi Falhu. The Joint Developers made an assessment of these operations and concluded that the potential users as identified in Table 3-2 were to be included in the master planning for Gulhi Falhu.

Table 3-2: Potential Users for Gulhi Falhu

Potential Users
Warehousing Complex
Cool and Cold Storage
(Business) Hotel
Maritime Training College
Social Housing
Low Cost Labour Housing
Hospital
Duty Free Shopping / shopping mall
Offshore Banking, Finance and Insurance
Power Generation
Bonded Stores
International school

4 Project Description

4.1 Project Location

The project location is Gulhi Falhu Reef located on the southern rim of North Male' Atoll at approximately 4.17971687° N latitude and 73.46668371° E longitude (see Figure 4.1). With a width of about 1.6 km and roughly 2.8 km in length, Gulhi Falhu Reef is one of the largest reef system in the Male' Urban Region with a total surface area of approximately 365 ha. Gulhi Falhu is in close proximity to Viligilli Island (400 m), Thilafushi Island (300 m) and Male' (2.5 km). The nearest resorts are Giraavaru Island Resort (5 km) and Kurumba Maldives (6.7 km).

4.2 Master Plan Considerations

4.2.1 Characteristics Gulhi Falhu

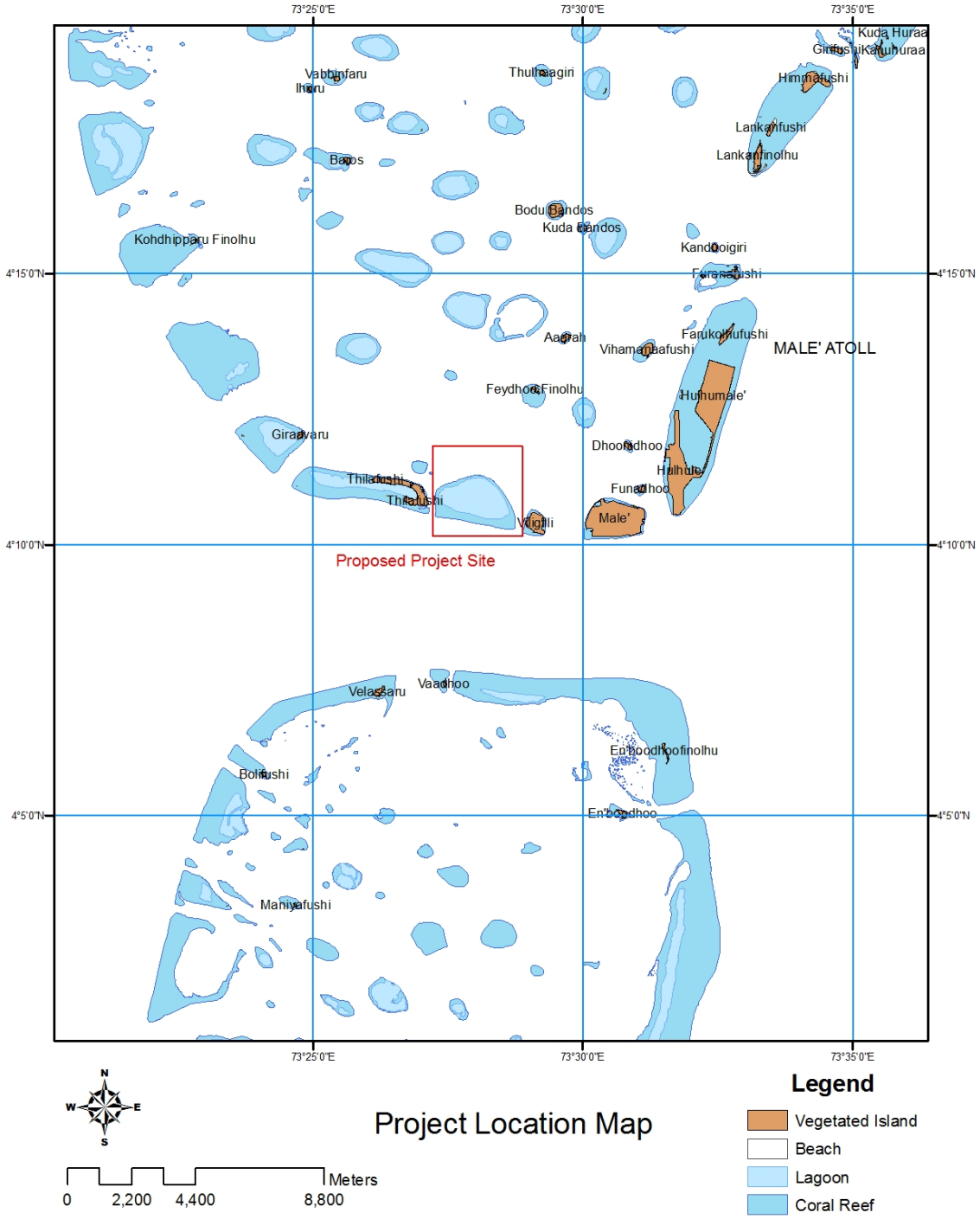
Gulhi Falhu is a ringed reef located on the southern rim of atoll. It has a central location with the artificial island of Thilafushi to the west and that of Vilingili to the east. As such it is more protected from the direct hit of the southeast swell wave than Male' or Viligili, but is also less affected by the diffraction of the swell progressing northward in the inner sea, which reaches the reefs of Thilafushi and Giraavaru with more energy. The reef is therefore lacking a number of characteristics usually present in exposed reefs and the periphery of the reef is deeper and narrower. The reef crest is virtually absent and there are no breakers except at the reef corners facing the Vaadhoo Kandu to the south. The hydrodynamic forces are not strong enough to pile up large amounts of rocks. At the corners, two small sand banks are naturally created where the reef is shallower.

On the southern side, the flat foreslope of the reef edge drops sharply at 4 meters to a wall where many overhangs are present. One of them has broken off on a whole section and is a popular dive site called "Hans Hass Place". On its shallow side, it is replaced with a rocky platform with little loose substrate where the wave influence is the strongest. It later becomes more and more like a lagoon and more sandy.

Gulhi Falhu is a typical atoll shape reef, which is at present almost entirely below water. Only a small area in the southwest corner of the reef flat emerges at low tide. A detailed bathymetric survey is provided in Annex 8. The outer edges of this reef are located just below Mean Sea Level (MSL) and have a (variable) width of 200m to 400 m. In the middle / western part of the lagoon the water depths are up to MSL − 20m.

In developing Gulhi Falhu it is therefore best to reclaim land area around the edges of the lagoon to reduce required land fill volumes. The shallow southern edge is wider than the northern one and therefore more land can be readily reclaimed on this southern side. Based on these characteristics of Gulhi Falhu lagoon, the reclaimed areas in the master plan are located around the edges, phase 1 and 2 mainly along the southern reef.

Figure 4-1 Location of proposed project site



4.2.2 Site Conditions

Maldives experiences two main seasons: the rainy SW monsoon and the dry NE monsoon. Winds are strongest during the SW monsoon and the project site will face the predominant wind and wave direction during this period. The project site will be largely protected from wind and wave activity during NE monsoon.

The proposed project site generally has shallow reef flat waters in the range of 1.0 to 1.7 m MSL. Reclamation will be done mainly in these shallow areas. It will be possible for dredge vessels to approach the project site. However, a reef entrance will have to be created. The central areas of the lagoon are deep, on average 8 m.

Lagoonal currents will be strongest during the SW monsoon and force sediments on to the reef flat during tidal flows, unless protected by adequate silt screens.

This site experiences swell waves approaching from the SE Indian Ocean. However, direct exposure is limited due to refraction around the south Male Atoll, Male' and Viligilli Island. Swell waves approaching from the SW may have a reduced energy due to refraction around the western rim atolls of Maldives. However, SW swell waves may play a significant role in year round wave activity on the southern rim of the reef.

4.2.3 Phased Development

In any master planning project, due attention is required for a phased development of the facilities and the same is the case for the development of Gulhi Falhu. Phasing is needed to best anticipate on market requirements (land areas needed) as well as developments (type of users).

At the time of writing of this Environmental Impact Assessment the Master Plan for the development of Gulhi Falhu has dedicated the land created in Phase 1 mainly for warehousing and distribution and land created in Phase 2 and 3 mainly for housing (see also the Land Use Plan in Annex 3). During the development of the phases, the following facilities will also be developed:

- Power supply
- Drinking water supply

The following phasing is proposed for the development of Gulhi Falhu (see also Figure 4-2):

- Phase 1: approximately 10ha
- Phase 2: approximately 30ha
- Phase 3: approximately 70 ha
- Phase 4: to be determined at a later stage

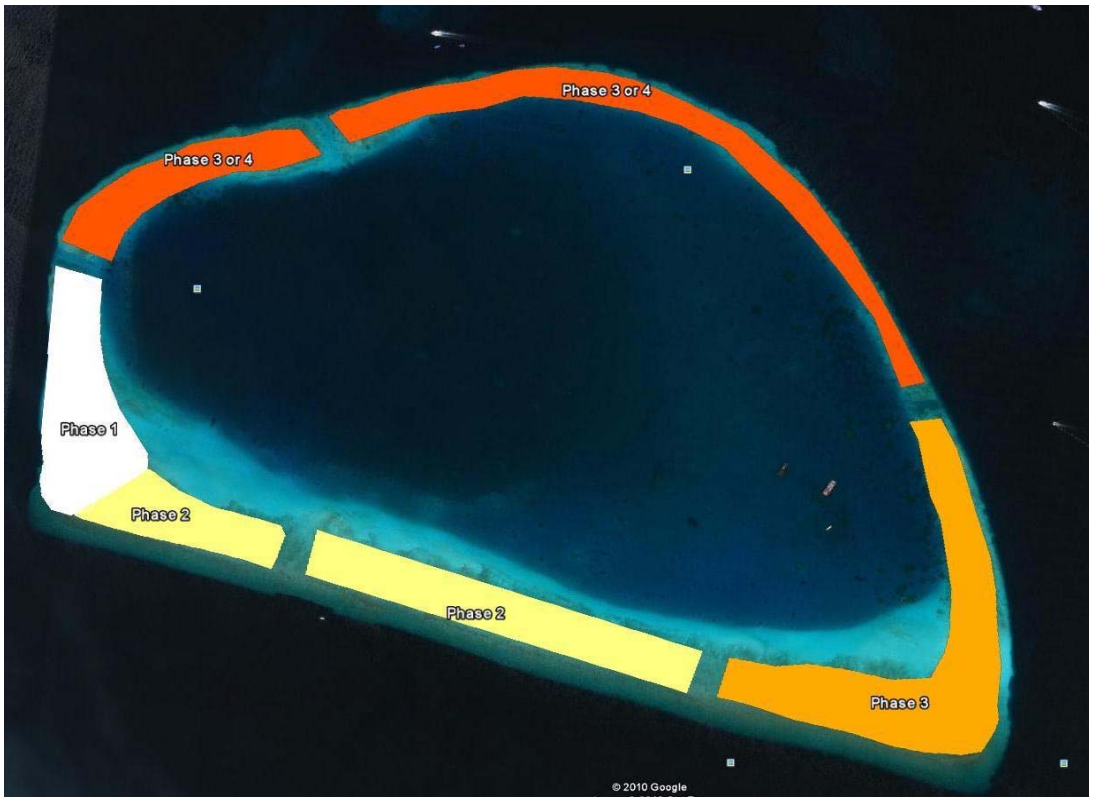


Figure 4-2 Gulhi Falhu project phasing

4.2.4 Technical Boundary Conditions

Gulhi Falhu consists of a shallow reef, enclosing an inner lagoon area. The outer dimensions of the Gulhi Falhu reef are approximately 2500 m (east-west) by 1500 m (north-south). The width of the surrounding shallow reef varies between 300 m (south side) and 100 to 150 m (north side). The water depth related to MSL over the reef varies between 1.0 and 2.0 m; there is no land in Gulhi Falhu. The enclosed inner lagoon has water depths of around -10/-12 m MSL (appr. 100 ha in the east) and around -18/-20 m MSL (appr. 100 ha in the west).

In addition, sand is proposed to be borrowed from the atoll lagoon approximately 1 km north of the reef system. The total boundary area during construction will include the borrow areas. This issue is addressed in more detail, later in this section.

The general boundary conditions for the project design will be described in chapter 6 including: location, geography, climatic conditions, hydraulic conditions, geology, soils, and marine ecology.

4.2.5 Design Considerations

The design of the reclamation and shore protection works has been based on the following main concepts and considerations:

- To make maximum use of the topography / bathymetry as presently exists at Gulhi Falhu on the one hand and using least-cost considerations on the other hand:
    - The phase 1 and 2 reclamation takes as much as possible place in areas with present water depths of 1 to 2 meters.
    - The phase 3 and further reclamation may take place in areas with present water depths of 1 to 10 meters.
- The newly reclaimed areas of the Gulhi Falhu Island must be protected against flooding, wave action and erosion.
- The existing currents (mainly tidal) around the Gulhi Falhu reef should be affected as little as possible by the project.
- The existing natural values on the outside of Gulhi Falhu reef must be preserved as much as possible.

4.3 Project Outline

The proposed overall project involves the reclamation of over 110 ha over Gulhi Falhu and the construction of revetments over a length of approximately 2500 m along the reclaimed land.

The main components of the project are:

- Dredging of approximately 300,000 m3 of coral sand in Phase 1; 700,000 m3 of coral sand in Phase 2 and an amount to be determined in Phase 3 and Phase 4 from a nearby borrow area and pumping the material into the reclamation area.
- Finishing the reclaimed area to the required levels.
- Construction of revetment over a length of approximately 2500 m.
- The project is expected to be carried out in four phases as shown in Table 4-3.

Table 4-1 Summary of four phases of development

Development phase	**Reclamation Area**	**Volume of dredged material req.**	**Proposed borrow area**	**Dredging method**	**Planned land use**
Phase 1	10 ha	300,000 m^3	Within atoll lagoon just north of Gulhi Falhu	Trailing Suction Hopper Dredger (TSHD)	Warehousing and distribution
Phase 2	30 ha	700,000 m^3	Within atoll lagoon just north of Gulhi Falhu	TSHD	Housing
Phase 3	70 ha	To be determined	To be determined	To be determined	To be determined
Phase 4	TBD	TBD	TBD	TBD	TBD

At present this project is mainly concerned with the first phase of the development. The activities of Phase 2, 3 and 4 have not been scheduled yet and are not clear when it would be implemented. Detailed plans for the operations stage of the phase 1 has also not been finalized yet. Hence, for all practical purposes this report will have to mainly look into the construction stage activities of phase 1. A separate assessment is required to assess the implications of the operations stage of phase 1 and remaining phases.

The key activities of the first phase of the development are:

1. Dredging
2. Land reclamation
3. Coastal protection

4.3.1 Project Activity Zone

Figure 4-3 shows the activity zone of the proposed project. The project area comprise of a borrow area, reclamation zone and dredger activity zone. The borrow area and dredger activity zone will be used only during the dredging activities, namely for a week. Rest of the work will be undertaken in the reclamation site – a 10 ha area on the southwestern corner of Gulhi Falhu Reef.

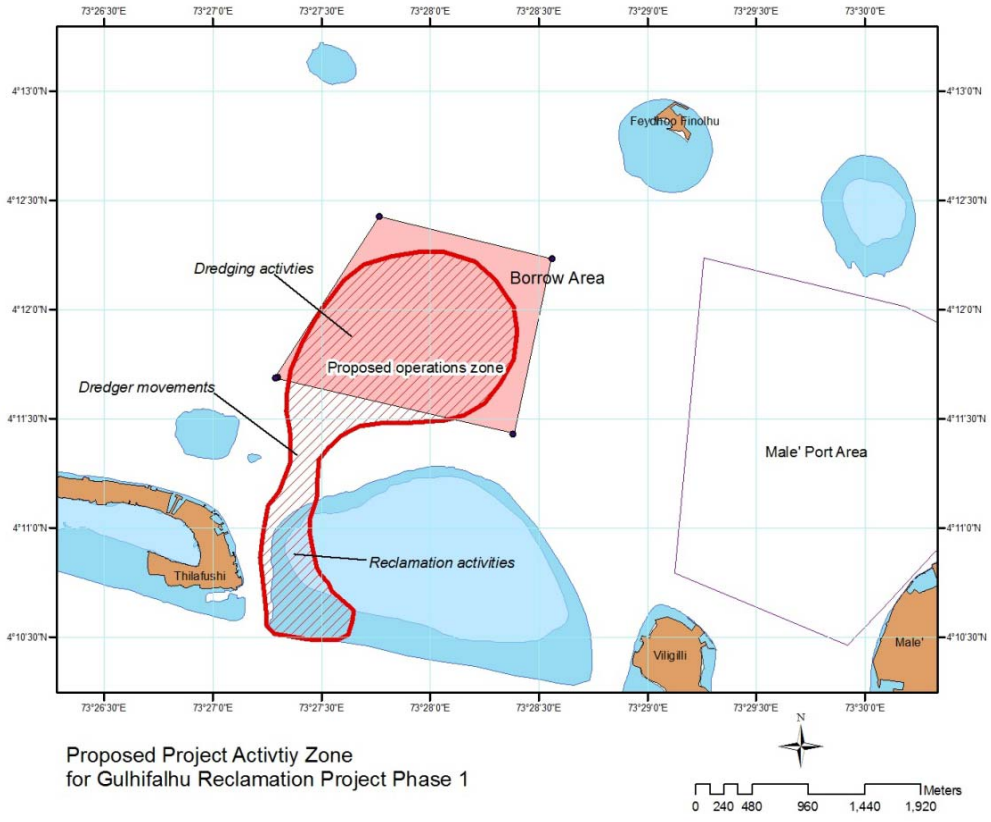


Figure 4-3 Proposed project activity zone for Gulhi Falhu reclamation project Phase 1

The subsequent sections provide detailed descriptions of the major components of the project.

4.4 Detailed Description: Dredging

4.4.1 Method and Equipment Used for Dredging

The method proposed is sourcing sand from the bed of the atoll lagoon using a Trailing Suction Hopper Dredger (TSHD).

A TSHD is a normal sea-going ship equipped with one or two suction pipes. At the end of each suction pipe is a draghead, which can be lowered onto the seabed while the TSHD navigates at a reduced speed. The material loosened by the draghead, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump, and subsequently placed in the hopper of the dredger. The TSHD will transport the sediments to the reclamation where they will be brought to shore.

Most of the turbidity generated by a trailer suction hopper dredge is caused by the overflow of turbid water during the hopper filling operations. Overflow is the flowing overboard of excessive process water, together with a large part of the finest material. Overflow is used to maximise the load of sand inside the hopper. When dredging pure sandy sediments the amount of overflow of particles is mainly determined by the grain size distribution of the dredged sediment. It is to be noted that the overflow process will not be a continuous activity, since its duration will be limited to operational dredging time, which is usually less than half the total cycle time.

The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas.

The proposed dredge vessel is The Queen of the Netherlands built by Verolme Shipyard Heusden B.V.and Keppel Shipyard Singapore. The hopper capacity of this model is 35,500 m^3. Details of the dredge vessel are provided in Annex 9

4.4.2 Dredging Fleet and Equipment

- One trailing suction hopper dredger
- One general purpose mechanized vessel for transport
- One wheel loader

4.4.3 Analysis of Options

The options including sources of fill material and type of dredger that can be used in the project are as follows:

Option 1 sand and coral material from the shallow reef flat and the lagoon area within the reef, to be dredged by cutter suction dredge (CSD);

A CSD is a stationary dredger, which dislodges the material with a rotating cutterhead mounted on a ladder. The cutterhead is equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of a centrifugal pump, which is installed on the dredge pontoon or on the ladder of the

dredger. The amount of material not entering the suction mouth may be as much as 30% of the total dislodged material. Much of this material will fall immediately to the seabed and will be dredged on the next cut. Only the finer particles will stay in suspension and will be distributed throughout the water column by the local currents. With a CSD, the creation of turbidity is a more or less a continuous process.

Due to the fact that a rather deep basin will be created by the CSD of about 6 − 7 meters depth, the majority of the suspended sediments will stay within this created basin. As the cut material will be disposed by a discharge pipeline to the land reclamation site no additional turbidity will be created at the dredging site. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local hydrodynamic conditions.

Option 2 sand from the bed of the lagoon of the atoll (away from islands), to be dredged by a trailing suction hopper dredge (TSHD);

Option 3 sand and coral material from a reef elsewhere in the atoll, to be dredged by a CSD;

Option 4 sand imported from overseas using a large scale TSHD.

Option 1 has simple logistics, the impacts on the environment are localised (limited to an area inside the lagoon where dredging and reclamation activities take place) and manageable, although deep water access to the islands is required.

Option 2 also has relatively simple logistics. The impacts on the environment are localised (limited to the borrow area and the island where reclamation activities take place) and manageable.

Option 3 involves more complicated logistics for transportation of the dredged material from the borrow area to the reclamation area. The impacts on the environment are also more severe, due to the fact that coral reefs will be exposed to dredging and reclamation activities at two different locations. Environmental impacts are therefore more difficult to manage. Hence, Option 3 is environmentally prohibitive.

Option 4 involves very long sailing distances for the TSHD and a very long execution time of the project. Hence, Option 4 is economically prohibitive.

With both types of dredgers a sediment-water mixture will be pumped to the reclamation site from where the excess of water will flow back (return flow) to the sea and most of the sediments stay behind. The potential issue of turbidity is basically the same for both dredging methods. The main differences between the methods are that:

- Impact of the re-suspension from the CSD at the borrow area can be better controlled than from the THSD at the atoll lagoon;

- During overflowing with the TSHD a large portion of the fines will be returned to the borrow area. The dredged material arriving at the reclamation area therefore contains less fines compared to the material from the CSD;
- Option 1 will have less negative impact on the ecology of the borrow area and nearby sensitive areas compared to option 2. Option 2 has less negative impact on sensitive receivers around the reclamation area compared to option 1. Since the reclamation area is located close to a marine Protected Area option 2 would be preferred above option 1.
- CSD takes more time in operation and therefore timeframe for impact is relatively more.

In addition, a TSHD is currently available to the proponent and will help reduce costs and save time. Therefore, the chosen option is Option 2.

4.4.4 Sand Borrow Area

The proposed location for the sand borrow area is within Kaafu atoll just to the north of Gulhi Falhu. Location and size of sand borrow areas is given in Figure 4-4.

This location is preferred due to the use of a large TSH dredger and due to the presence of a protected dive site south of the reef system. The alternative available is deep areas of the Gulhi Falhu Reef itself. This location is most suitable for a Cutter-suction dredger. In addition, the quantity of fill material required for Phase 1 and future Phases can be made available from within the atoll lagoon rather than Gulhi Falhu lagoon.

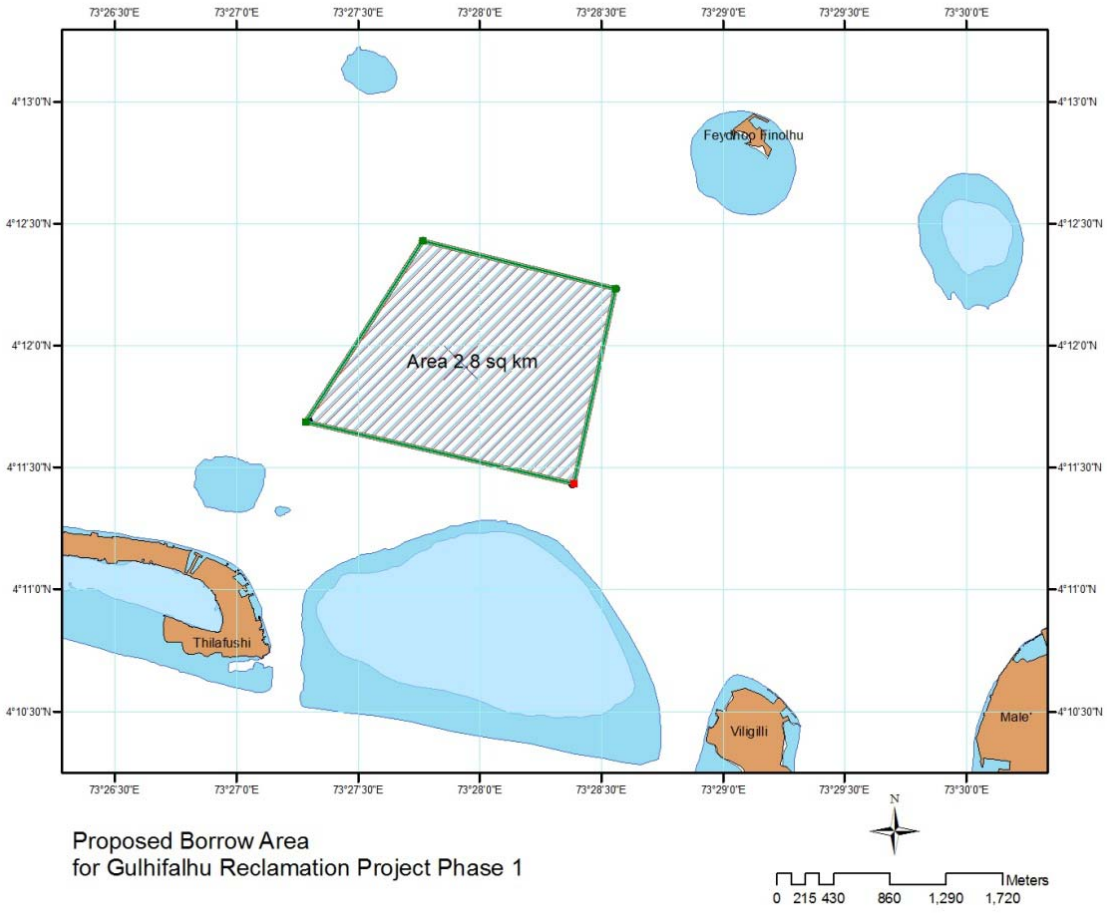


Figure 4-4 Location of proposed borrow areas

4.4.5 Quantity, quality and characteristics of fill material

The quantity of fill material for phase 1 is 300,000m^3 as indicated in the table above. This figure is based on the reclamation parameters defined in the next section below.

The dredge depth is generally up 2.0 m and on average 1-1.5m from the sea bed. However, the actual depth will depend on the quality of material at any given location.

As an indication of guarantees for sufficient availability of fill material, the proponent has carried out a survey of the proposed borrow area. The proposed borrow area is selected based on this survey. However, the contractor of the survey does not wish to disclose the details of the survey in a public document due to possible disadvantages to the business from competitors. This clause has been included in the contract between the contractor and the proponent.

In general, the fill material is expected to be moderately coarse to fine sand. The presence of large coral pieces is expected to be minimal.

All available details of the fill material characteristics are provided in the existing environment section.

4.4.6 Duration of dredging activity

Each phase is expected to take six to seven months including preliminary work and demobilisation. Given that the hopper capacity is 35,500 m^3 and approximately five trips can be made by the TSHD daily, Table 4-2 provides an estimated duration of dredging activity for Phase 1 and Phase 2. A detailed work plan is provided at the end of the chapter.

Table 4-2 Estimated duration of dredging activity for Phase 1 and Phase 2

Phase	**Volume of material**	**No. of trips required**	**Duration of actual dredging activity**[1]
Phase 1	300,000 m^3	9	3 – 4 days (maximum 1 week)
Phase 2	700,000 m^3	20	4 – 5 days (maximum 2 weeks)

4.4.7 Labour Requirements and Availability

The tentative list of labour requirements is given in Table 4-3.

Table 4-3 List of labour requirements for dredging

Activity or work group	**Specialists**	**Labourers**
Dredge fleet	5	6
Dry fill	4	5
Special equipment	2	4
Workshop	2	4
Administration	2	5
Total	15	24

Specialist labour will be required to undertake specific tasks. A total of 39 jobs may be available for the locals from the project. However, no specific quota for local or foreigners have been established. It is unlikely that the required specialists may be available from the atolls hence, the use of foreign labour at least for some jobs is inevitable. Most of these workers are currently the staff of the specialised dredge vessel. Only land based loading and profiling activities will be undertaken by workers outside the ship.

1 Additional trips may be required in each phase depending on site conditions at the time of dredging.

4.4.8 Housing of Temporary Labour

Majority of the workforce will be accommodated onboard the dredge vessel and the rest will be housed in Thilafushi.

4.4.9 Emergency Plan for Spills

Royal Boskalis Westminster NV has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.

Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OHSA and environmental requirements, and are adjusted if a client has even more stringent requirements. Dredging vessels are IMS certified and have to meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Annex 7 contains the framework that is used to make a specific Environmental Management Plan for each individual project that Royal Boskalis Westminster undertakes. Similar frameworks are applied for project specific Safety and Health Management Plans.

4.5 Detailed Description: Land Reclamation by Filling

4.5.1 Reclamation Design Levels

Taking into account the presently occurring water levels, the predicted sea-level rise, and the relatively high-value industries and services that Gulhi Falhu land-development will potentially cater for, the finished level of the reclaimed land will be +1.5 m MSL.

It is noted that most of Malé and the other inhabited islands in the Maldives are at +1.0 m MSL to +1.4 m MSL; so called “Safe Islands” are presently constructed at +1.4 m MSL.

4.5.2 Sediment Containment

As for the design of sediment containment measures area there are 3 options. These are:

Option 1: Enclosed reclamation area with bunds

Option 2: Open reclamation area without bunds

Option 3: Reclamation area with no bunds in phase 1 and 2 and with bunds for phases 3 and 4

Option 4: Silt screens around the reclamation area

Option 1 involves more complicated logistics since Gulhi Falhu reef is completely submerged and there is no material to create bunds with at the start of the development. Material needs to be imported to create the

bunds. Additionally there needs to be land reclaimed before excavators or bulldozers will be able to prepare the bunds for the revetments. Another option is to build the bunds from the water. For this, cranes on pontoons, barges or a hopper with sand will be required. The impacts on the environment are localised (limited to an area around the island and inside the lagoon where the construction of the revetment takes place) and manageable. The revetment will reduce the size of the impact area during reclamation activities by keeping the excess water containing fine sediment within the bunded area. Release of this water is manageable. The import of sand from overseas, the equipment and the long execution time make this option economically prohibitive.

Option 2 has simple logistics since no preparations need to be made prior to the reclamation. The impacts on the environment are temporary increased turbidity levels, a relatively high load of sediment which is potentially difficult to control, due to the fact that excess water will be released on all sides of the reclamation and during each phase. Environmental impacts are therefore more difficult to manage. This makes this option environmentally prohibitive.

Option 3 has moderately easy logistics. Phase 1 and 2 will be executed according to option 2. Before phase 3 and 4 will commence bunds can be set up with material stored on the reclamations from phase 1 and 2. The bunds can be set up with excavators and bulldozers from the now existing land. The impacts for the creation of the bunds on the environment are localised (limited to the area of the revetment) and manageable. The impacts of the reclamation of phase 1 and 2 such as increased turbidity and a high sediment load will however be short term. The increase in turbidity and the sediment load during the reclamation of phase 3 and 4 will be reduced, more local and much more manageable.

Option 4, placing silt screens on the eastern and the southern side of the reclamation area will contain the sediment in the area and is economically feasible.

Preferred option

Option 1 will have the least impact on the ecology of the area around the reclamation area and nearby sensitive areas. However this option is economically not feasible. Option 2 is environmentally prohibitive. Option 3 is economically feasible with the strongest impact mainly focused on phase 1 and 2. Option 4 is both economically feasible and environmentally favourable, therefore the preferred option is Option 4 i.e. to place silt screens in the reclamation area to contain the sediment.

The Figure 4-5 below shows the sediment containment deployment map.

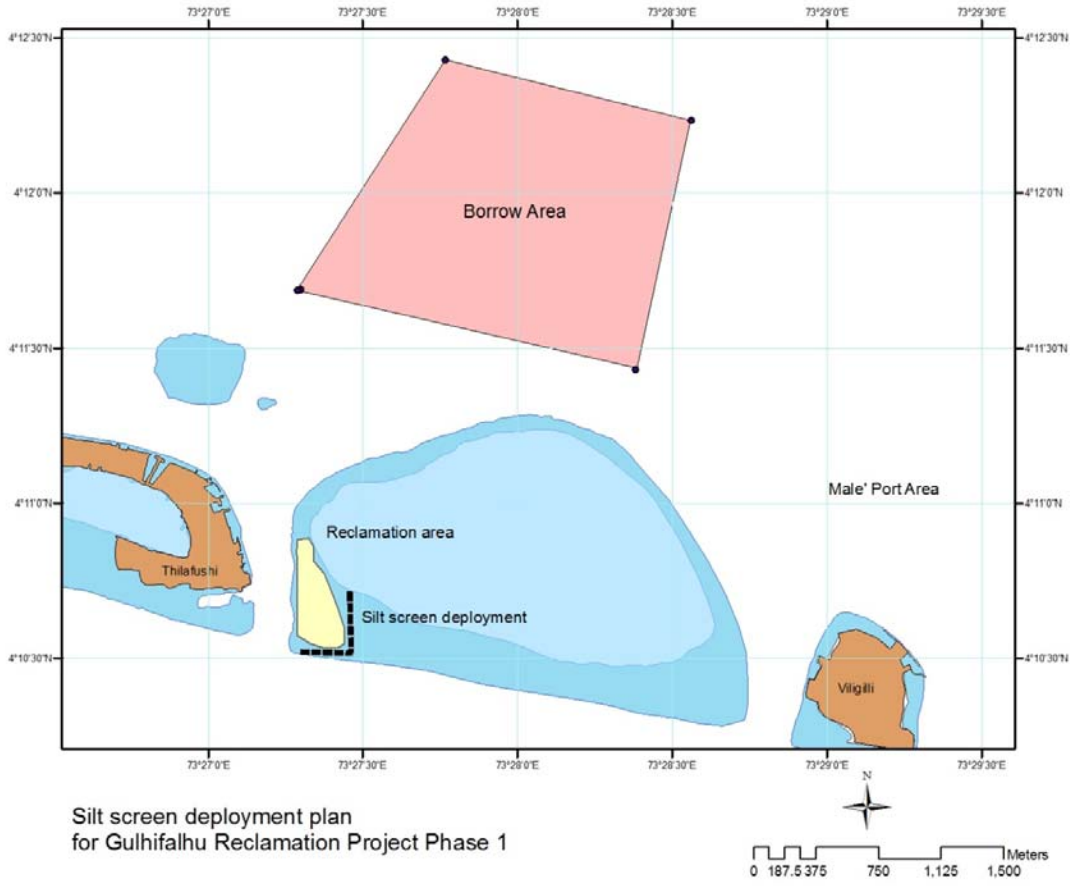


Figure 4-5 Map showing of sediment containment deployment

4.5.3 Planning and Timing

A detailed work plan is provided at the end of the chapter.

4.5.4 Method and Equipment for Transport of Fill Material

The transport of fill material for hydraulic filling will be undertaken directly by the dredge vessel. In a TSH Dredger the fill material collected from the borrow area is placed on the ship and transported to the reclamation area.

Once at the reclamation site the pipes from the ships hold is connected to floating pipe deployed near the reclamation area which transports the sediment from the ship to the designated reclamation zone. The connection of the pipes will be undertaken using a small boat.

The following equipment will be used to transport of fill material for dryfill.

- One excavator
- Two Dumpers

- Two Trucks
- Two wheel loaders.

Once sand has been pumped into the designated site, loaders will level the reclaimed area. Material from the designated pump site will also be transported to the fringes of the reclamation zone using loaders and trucks.

4.5.5 Distance of Transport

Distance of transport of fill material is approximately 1 km to 1.5 km.

4.5.6 Need for and Location of Temporary Stockpiles

TSHD stores the material onboard the ship. The dredge material is deposited through bottom flaps or doors, or by rainbowing. In the proposed reclamation the material is pumped on to the location through a pipeline.

4.5.7 Stability of Reclamation

Rate and volume of pumping sediment will be faster than the rate of erosion. Sediment will be highly mobile within the first 10 m from the shoreline and erosion will be prevalent in the zone. However, the rest of the island is expected to be stable. Erosion is predicted to be severe in the short-term.

4.5.8 Safety Measures during Construction

The contractor would ensure that Health and Safety procedures are complied with at all times. Construction activities would be carried out under the supervision of a suitably experienced person. All reasonable precautions will be taken for the safety of employees, and equipment will be operated by competent persons. Warning signs, barricades or warning devices will be provided and used. Necessary safety gear will be worn at all times.

4.5.9 Labour Requirements and Availability

See detailed description for dredging above.

4.6 Detailed Description: Shore Protection Works

4.6.1 Revetment Construction

Table 4-4 provides the details of the revetment that will be constructed.

Table 4-4 Location and length of revetment

Location	Impact of waves/ current	Length of revetment (m)
Seaside (south side of Gulhi Falhu)	Heavy (waves)	1500 – 1700
Between channels	Heavy (current)	500
Lagoon side (inner slopes)	Light – medium	1000-2000

For the south side revetment an optimization has shown that a 50-70 meter wide strip of reef area will be left untouched in order to allow wave energy dissipation and a resulting reduction of cost of the revetment; a wider strip would result in cheaper revetment but also in a loss of easily reclaimed reef area.

All shore protection works have been designed in rock placed on geo-textile; at some locations concrete blocks, X-blocks or acropods may be considered as an alternative. Rock is imported from India or Sri Lanka. Phase 1 and 2 will be attached to each other. No shore protection will therefore be placed between the reclamation sides of these phases. Figure 4-6 shows the cross-section of a typical revetment.

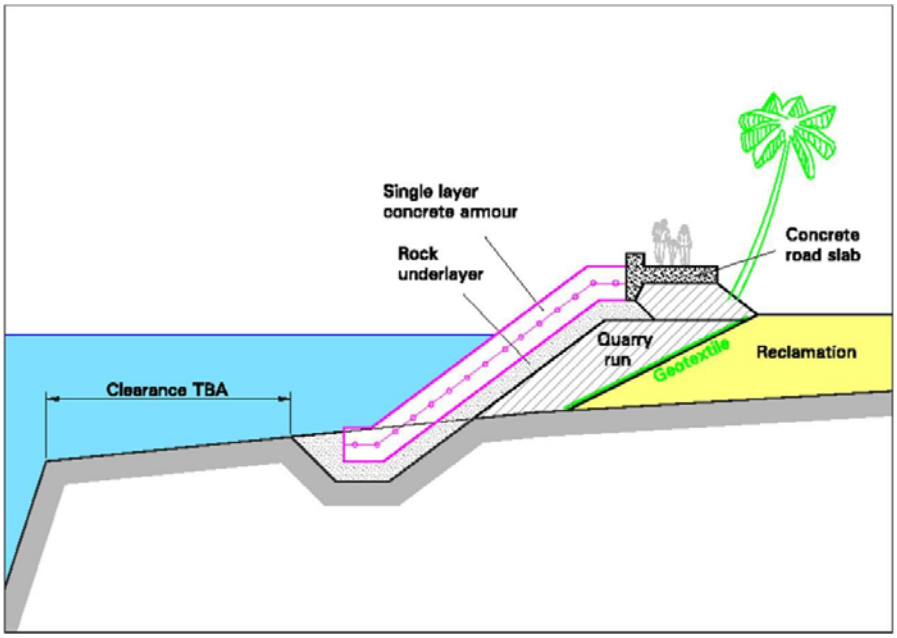


Figure 4-6 Cross-section of a typical revetment

4.6.2 Quay Wall

Quay wall length in phase 1 will be between 200 and 600 meter and will be located at the western side of Gulhi Falhu. The design vessel for the ocean-going berths has the following main characteristics:

- Length 150 m
- Beam 30 m
- Draft 10 m
- Carrying capacity 7000-10000 BRT.

The most common vessel for transport to and from the outer islands is the second generation 50- foot Dhoni with the following specifications:

- LOA 15.5m
- Beam 4.4m
- Depth 1.75m
- Draught 1.05m
- Engine power 75 hp.

Another vessel, the so called "2000 bag Dhoni" (carrying capacity 100 tons), is at present the largest transport vessel carrying food and other goods from Malé to the outer atolls.

In order to allow these vessels easy access at all times and all tides, the depth along the quay wall has been chosen at -3.6 m MSL. The crest level of the capping beam of the quay wall is +1.4 m MSL. It is proposed to construct 200- 600 m of quay wall for alongside or head-on mooring.

4.6.3 Design Criteria

- Top of quay shall be the higher of the following
    - 1.3 m above MSL
    - 0.15m above ground level.
- Access stairs shall be incorporated into the quay wall (3 sets of stairs).
- Mooring Hooks at intervals not less than 5m shall be provided.
- Unless substantiated with relevant data, soil properties shall be assumed as below.
    - Angle of friction of sand not greater than 32º.
    - Bearing capacity of sand not greater than 100 KN/m²
- All reinforced concrete shall be a minimum of grade C30 and a minimum concrete cover of 50mm shall be provided to all steel reinforcement.
- The specifications are given for different option for the material and workmanship for breakwater and quay wall. Contractor is to follow the respective specification, based on his detail design.

4.6.4 Methods and Equipment

Special equipment for construction of revetment and quay wall are

- Concreting machines
- Truck and dumper
- Excavator

4.7 Work Plan

The project is planned to be carried out in four phases. Both Phase 1 and Phase 2 are expected to take six to seven months each phase. Table 4-5 shows the work plan for one phase. The preparatory work is expected to take one month. The dredging activity is expected to take one week. Reclamation works is expected to take two months, primarily for profiling the reclaimed parts and coastline. Construction of revetment and quay walls is expected to take three months.

Table 4-5 Work plan for one phase

No	Activity Description/Months	1	2	3	4	5	6	7
	Preliminaries							
	Detailed design	X						
	Mobilisation	X						
	Dredging and reclamation works							
	Preparation of mitigation measures		X					
	Preparation of borrow area		X					
	Dredging		X					
	Reclamation works		X	X				
	Profiling		X	X				
	Construction activities							
	Revetment				X	X	X	
	Quay walls				X	X		
	Finalizing							
	All other works						X	
	Demobilisation							X

4.8 Summary of Inputs and Outputs

The types of materials that will go into the development and from where and how this will be obtained are given in Table 4-6 and the type of outputs (products and waste streams) and what is expected to happen to the outputs are given in Table 4-7.

Table 4-6 Major inputs during construction – Phase 1 reclamation, dredging and coastal protection

Input resource(s)	Source/Type	How to obtain resources
Construction workers	Local and foreign, mainly foreign	**Recruiting agencies, etc.**
Engineers and Site supervisors	Local and foreign	**Advertise in local papers, social networks, etc.**
Construction material	electrical cables and wires, PVC pipes, light weight concrete blocks, reinforcement steel bars, sand, cement, aggregates, boulders 800-1000kg, etc	**Import and purchase where locally available at competitive prices – Main Contractor's responsibility.**
Maintenance material	Similar to above	**Import or purchase locally where available**
Water supply (during construction)	Desalinated water	**50 m^3/day desalination plant existing on the dredger**
Electricity/Energy (during construction)	Diesel	**Generator existing on the vessel; 50 Kva portable generator on the project site**
Machinery	Dredger, Excavators, cranes, loaders, trucks, concrete mixers, dredger, dredge pipes	**Import or hire locally where available**
Food and Beverage	Mainly imported sources except a few locally available products.	**Import and purchase locally**
Fire fighting equipment	Fire Pumps, Fire Protection System, Smoke Detectors, Carbon Dioxide and Foam Fire Extinguishers, etc.	**Local suppliers**
Fuel, Kerosene and LPG	Light Diesel, LPG Gas, Petrol, Lubricants	**Local suppliers**

Table 4-7 Waste output management during construction stage – Phase 1 reclamation, dredging and coastal protection

Products and waste materials	Anticipated quantities	Method of disposal
Construction waste (general)	Small quantities	**Combustibles: Burnt/incinerated Others: Sent to Thilafushi**
Dredge waste	moderate quantity	**Construction and as base fill for coastal protection zones**
Waste oil	Small quantities	**incinerated**
Hazardous waste (diesel)	Small quantities	**Barrelled and sent to designated Thilafushi**

5 Policy, Planning and Legal Framework

5.1 Introduction

This Chapter will provide a summary of the legal instruments applicable to the project and demonstrate how the project conforms to these aspects.

The main legal instruments of concern are the Environmental Protection and Preservation Act (EPPA) 1993, the Environmental Impact Assessment Regulations 2007.

5.2 The Environmental Protection and Preservation Act (EPPA) 1993

The Environmental Protection and Preservation Act (EPPA) of the Maldives (Law No. 4/93) is an umbrella law that provides wide statutory powers to the Environment Ministry regarding environmental regulation and enforcement.

The EPP Act 1993 states that the natural environment and its resources are a national heritage that needs to be protected and preserved for the benefit of future generations and that the protection and preservation of the country's land and water resources, flora and fauna as well as the beaches, reefs, lagoons and all natural habitats are important for the sustainable development of the country.

The primary components of the EPP Act 1993 are:

5.2.1 Environmental Guidance

Guidelines and advice on environmental protection shall be provided by the concerned government authorities in accordance with the prevailing conditions and needs of the country. Hence, all concerned parties shall take due consideration of the guidelines provided by the government authorities.

5.2.2 Environmental Protection and Conservation

Formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions shall be carried out by the Environment Ministry.

5.2.3 Protected Areas and Natural Reserves

The Environment Ministry shall be responsible for identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.

Kiki Reef which is located south of Gulhi Falhu reef is a declared marine protected area.

5.2.4 Environmental Impact Assessment

An EIA shall be submitted to the Environment Ministry before implementing any developing project that may have a potential impact on the environment.

5.2.5 Termination of Projects

Projects that have any undesirable impact on the environment can be terminated without compensation.

5.2.6 Waste Disposal Oil and Poisonous Substances

Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government. If such waste is to be incinerated, appropriate precaution should be undertaken to avoid any harm to the health of the population.

5.2.7 Hazardous/Toxic or Nuclear Waste

Hazardous / Toxic or Nuclear Wastes shall not be disposed anywhere within the territory of the country. Permission should be obtained for any transboundary movement of such wastes through the territory of Maldives.

5.2.8 The Penalty for Breaking the Law and Damaging the Environment

The penalty for minor offenses in breach of the EPP Act 1993 or any regulations made under this Act, shall be a fine ranging between Rf. 5.00 (Five Rufiyaa) and Rf. 500.00 (Five Hundred Rufiyaa) and for all major offences a fine not exceeding Rf. 100,000,000.00 (One Hundred Million Rufiyaa). The fine shall be levied by the Environment Ministry or by any other government authority designated by that ministry and shall depend on the seriousness of the offence.

5.2.9 Compensation

The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

This EIA report will comply with the EPP Act 1993.

5.3 Environmental Impact Assessment Regulation 2007

The Environment Ministry issued the EIA Regulation in May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Maldives. This Regulation provides a comprehensive outline of the EIA process, including the application to undertake an EIA, details on the contents, format of the IEE/EIA report, the roles and responsibilities of the consultants and the proponents as well as minimum requirements for consultants undertaking the EIA.

This EIA has been undertaken in accordance with the EIA Regulations 2007 of the Maldives.

5.3.1 Post EIA Monitoring, Auditing and Evaluation

The EIA Regulations 2007 provides a guideline of the environmental monitoring programme that should be included in EIA reports as monitoring is a crucial aspect of the EIA process.

Accordingly, the monitoring programme shall outline the objectives of monitoring, the specific information to be collected, the data collection program and managing the monitoring programme. Managing the monitoring programme requires assigning institutional responsibility, enforcement capability, requirements for reporting and ensuring that adequate resources are provided in terms of funds, skilled staff and the like.

The monitoring programme outlined in the EIA report will comply with the EIA Regulations 2007.

5.4 'Aneh Dhivehi Rajje' – The Strategic Action Plan (SAP)

The Strategic Action Plan (SAP) provides the National Development Framework for the period 2009-2013. It has been compiled through consultation with multiple sectors and by reviewing development trends, emerging issues, goals, policies and interventions relevant to the five main pledges and key themes of the MDP Alliance Manifesto.

The five pledges listed below represent the vision on which the people elected this government.

5.4.1 The establishment of a nationwide transport system

Due to the lack of a public transport system in the Maldives residents of many islands are unable to travel or are forced to pay for limited and over-priced private transport services. A sustainable maritime transport network will increase accessibility and mobility of the people and will increase economic regeneration at all levels through revitalization of the urban setting and land use.

5.4.2 Ensuring affordable living costs

As the country is heavily dependent on imports (especially food and energy) and highly susceptible to external shocks, achieving price stability is a major challenge. The government therefore has initiated efforts to control inflationary pressures through prudent fiscal policies and plans including the shift to direct taxation and the introduction of expenditure reduction measures.

5.4.3 Provision of affordable housing

Over a third of the country's population resides in Malé making it one of the most densely populated cities in the world. The government aims to address the housing situation in the capital Male' and other urban centres through increasing housing delivery through public-private partnership schemes and improving affordability through housing finance schemes. It is also believed that decentralisation and improved connectivity in the provinces will support de-congestion in the capital and other urban centres.

5.4.4 Providing quality healthcare for all

In the past most Maldivians have not had any insurance plan to pay for their medical expenses. This has created a heavy burden for the government and resulted in an out of control welfare situation. Therefore, the government plans to introduce and implement a basic health insurance scheme accessible to all citizens.

5.4.5 Prevention of narcotics abuse and trafficking

The Maldives over the years has seen rampant increase in substance abuse among the youth. One study suggests that over 30% of the youth are dependent on heroin and the study found out the youngest age to use drugs was nine years. The government is taking a firm stance to reduce the supply of narcotics into the Maldives. The policies also address elimination of demand for narcotics and other illegal substances and ensure access to appropriate treatment and rehabilitation services for addicts. More broadly, it will establish a comprehensive and coordinated national response to combat narcotics and trafficking.

The project has a direct relevance to the Policy 4 of SAP which is establishing additional housing units to enable affordable housing, as this project will ease out the current congestion in Male' and enhance the economic potential of Male'. It is noteworthy that there are some contradicting policies, however, detail assessment of these policies are outside the scope of this report.

5.5 National Environmental Action Plan II (NEAP II)

The aim of NEAP II is to protect and preserve the environment of the Maldives and to sustainably manage the country's natural resources for the collective benefit and enjoyment of present and future generations.

Accordingly, the key strategies of the NEAP II are:

- Continuous assessment of the state of the environment in the Maldives, including impacts of human activities on land, atmosphere, freshwater, lagoons, reefs and the ocean; and the effects of these activities on human well-being
- Development and implementation of management methods suitable for the natural and social environment of the Maldives and maintain or enhance environmental quality and protect human health, while at the same time using resources on a sustainable basis
- Ensure stakeholder participation in the decision making process by consultation and collaboration with all relevant sectors of society
- Preparation and implementation of comprehensive national environmental legislation in order to provide for responsible and effective management of the environment
- Adhering to international and regional environmental conventions and agreements and implementation of commitments embodied in such conventions.

Furthermore, NEAP II specifies priority actions in the following areas:

- Climate change and sea level rise; coastal zone management;

- biological diversity conservation; integrated reef resources management;
- integrated water resources management;
- management of solid waste and sewerage;
- Pollution control and management of hazardous waste;
- sustainable tourism development;
- land resources management and sustainable agriculture
- Human settlement and urbanization.

5.6 National Strategy for Sustainable Development

The National Strategy for Sustainable Development is a new policy developed by the new government. Its aim is to unite all existing policies regarding environmental, social and economic development, and to provide a framework for future policies addressing these issues

5.7 Waste Management Policy

The aim of the waste management policy is to formulate and implement guidelines and means for solid waste management in order to maintain a healthy environment. Accordingly, the key elements of the policy include:

- Ensure safe disposal of solid waste and encourage recycling and reduction of waste generated;
- Develop guidelines on waste management and disposal and advocate to enforce such guidelines through inter-sectoral collaboration;
- Ensure safe disposal of chemical, hazardous and industrial waste.

5.8 Regulation on Sand and Aggregate Mining

The Regulation on Sand and Aggregate Mining was issued by the Ministry of Fisheries, Agriculture and Marine Resources on 13th March 2000. This Regulation addresses sand and aggregate mining from uninhabited islands that has been leased and from the coastal zone of other uninhabited islands. Under this Regulation, it is an offence to mine sand or aggregate from the beach, lagoon or reef of any island leased for the purpose of building a tourist resort.

Mining of aggregate or sand for the construction of resorts and associated facilities is discouraged and utilization of alternative construction material is encouraged under the policy of the Tourism Ministry of the Maldives. As an incentive, import duty is exempted for the import of cement, iron, steel, roofing sheets and timber for the construction of tourist resorts. However, sand mining is allowed for reclamation and beach replenishment projects, primarily from the immediate lagoon of the island and in the case of a lack of sand on the island, from an area that is decided by the Ministry of Fisheries, Agriculture and Marine Resources.

5.9 Ban on Coral Mining

Coral mining from the house reef and the atoll rim has been banned from 26th September 1990 through a directive from the President's Office.

5.10 Population Policy

The primary objective of the population policy of Maldives is to contribute to improve the standard of living and quality of life of each individual through socio-economic development that is sustainable and ensures a balance between population and development.

5.11 Land Act

The Land Act provides for allocation and releasing of land for different needs as well as releasing of public land for housing. The Act also states the conditions that govern the using of, owning, selling, renting and transferring of ownership of public and private land.

5.12 Fisheries Act

The Fisheries Act provides for:

- Formulation of Fisheries Regulations and Fisheries Management and Development
- Fishing Grounds most Commonly used by Maldivians
- Information and Research on Fisheries in the Maldives
- Conservation of Living Marine Resources for a Special Purpose
- Licensing
- Cancellation of License
- Fishing by Foreigners in the Exclusive Economic Zone (EEZ) of the Maldives
- Procedure for Entering the EEZ of the Maldives by Fishing Vessels without a License
- Steps to be taken in case of suspected illegal activities
- Penalties

5.13 Relevant International Conventions, Treaties and Protocols

5.13.1 United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol

The UNFCCC is an "overall framework for the intergovernmental efforts to achieve stabilization of greenhouse gas concentrations in the atmosphere at a low level enough to prevent dangerous anthropogenic interference with the climate system, recognizing that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other greenhouse gases."

The Clean Development Mechanism (CDM) of the Kyoto Protocol allows implementing project activities that reduce emissions in non-Annex I Parties, in return for certified emission reductions (CERs). Accordingly, the CERs generated by such project activities can be used by Annex I Parties to help meet their emission targets under the Kyoto Protocol.

5.13.2 United Nations Convention on Biological Diversity (UNCBD)

The objective of the UNCBD is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, taking into account all rights over those resources and to technologies and by appropriate funding."

Maldives was one of the first nations to ratify the UNCBD. In 2002, Maldives developed the National Biodiversity Strategy and Action Plan (NBSAP) through wide consultation and extensive stakeholder participation.

5.13.3 United Nations Conference on Desertification (UNCCD)

The objective of UNCCD is "to combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements, in the framework of an integrated approach which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas."

The Convention calls for improved productivity of land and the rehabilitation, conservation and sustainable management of land and water resources in order to improve the living conditions particularly at the community level.

5.13.4 United Nations Convention on the Law of the Sea (UNCLOS)

The UNCLOS provides a legal order for the seas and oceans to facilitate international communication, promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources and the study, protection and preservation of the marine environment.

Under UNCLOS, the Maldives is an archipelagic state and UNCLOS provides important provisions for the utilization of fishery resources within the territory of the Maldives and ensure that there is no serious pollution or dumping of waste by vessels that use the territory of the Maldives.

5.13.5 International Convention for the Prevention of Pollution from Ships (MARPOL)

The MARPOL is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in

1973 and 1978. MARPOL includes regulations aimed at preventing and minimising pollution from ships either by accidental or from routine operations.

The Convention currently includes:

- Prevention of Pollution by Oil,
- Control of Pollution by Noxious Liquid Substances in Bulk,
- Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form,
- Prevention of Pollution by Sewage from Ship,
- Prevention of Pollution by Garbage from Ships, and
- Prevention of Air Pollution from Ships

5.13.6 Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia

The objectives of Male' Declaration includes:

- Assessing and analysing the origin and causes, nature, extent and effects of local and regional air pollution,
- Developing and/or adopting strategies to prevent and minimise air pollution
- Setting up monitoring arrangements beginning with the study of sulphur and nitrogen and volatile organic compounds emissions, concentrations and deposition.

5.14 Responsible Ministries and Institutions in the Maldives

The main governmental institutions, involved in the development of Gulhi Falhu are described below.

The act 4/93 names the (then) Ministry of Planning and Environment as the main responsible ministry for safeguarding the environment. Some years later this responsibility went to the (then) Ministry of Home Affairs, Housing and Environment; whereas in 2004 the responsibility went to the Ministry of Environment and Construction (MEC), and more recently to a new Ministry of Environment, Energy and Water. Under the new government of President Nasheed, who was elected president in 2008, the Ministry of Housing, Transport and Environment (MHTE) is responsible for safeguarding the environment.

At present, the MHTE is the authoritative and responsible body for the effective implementation of the Environmental Protection and Preservation Act in the Country and has the statutory power over various issues related to the environment. The MHTE plays the main role within the government system with regard to environmental matters. It has the central control over environmental protection, conservation, management and related matters. This is mainly manifested at the policy level. The ministry is also responsible for developing, advising and undertaking environmental policies and government positions in national and international context as well as undertaking monitoring and research related to the environment.

In May 2004 the Environment Section of the (at that time) MEC published the so-called "Information Handbook for Proponents for EIA" (draft), which describes and clarifies the EIA process to be followed. In 2007,an updated version, Environmental Impact Assessment Regulations 2007, was published by the Ministry of Environment, Energy and Water.

The MHTE will, in case of project approvals, normally seek the advice of the National Commission for the Protection of the Environment (NCPE). The NCPE was appointed by the President in 1989 and restructured in 1993 at the time of the Environmental Act (Law No 4/93). The Commission was again restructured in 1999 to broaden the consultative process on environmental protection among the government concerned agencies. The mandate of the NCPE is to advice the Minister of Environment on environmental matters such as environmental assessment, planning and management and political decisions with regard to protection of the environment. A number of government agencies and ministries (Ministry of Tourism, Arts and Culture, Ministry of Fisheries and Agriculture) have environment-related mandates, sometimes these overlap with the mandate of the MHTE.

In the case of the development of Gulhi Falhu Industrial Zone Limited is the project proponent and client (employer) for the construction contract execution. The Ministry of Housing, Transport and Environment will act as Licensing Agency.

A Concession Agreement was signed with Gulhi Falhu Industrial Zone Limited (State owned company in Maldives) followed by a Foreign Investment agreement with the Ministry of Economic Development. The project has been approved by the Ministry of Finance and Treasury. In the former government the project was also approved by Presidential Decree in 2007. Both approval letters can be found in annex 2.

6 Description of the Natural Environment

6.1 General

Gulhi Falhu is a submerged reef, located in the southern part of the Kaafu Atoll between 4° 10‟ 20” N, 73° 28‟ 45” E and 4° 10‟ 59 N, 73° 27‟ 17” E (see Figure 6-1). The size of the reef structure is about 2800m by 1600m and has no land surface above MSL.

Kaafu atoll is located approximately 400 km north of the equator. Its diameter is approximately 40-50km. The water depth in the semi-enclosed lagoon ranges from 40m to 80m. Gulhi Falhu is located in the south-east of Kaafu Atoll, close to the capital city of Malé.

The tidal cycle is diurnal with an irregular high and a low peak. High tide and ebb tide levels vary between plus or minus 50 cm related to MSL.

6.2 Methodology

In June 2010 ecological surveys were conducted on Gulhi Falhu. The objective of the site visit was to collect data and information about the local ecosystems. Dive and snorkel surveys at various depths have been carried out to determine the distribution of habitats in the marine waters around Gulhi Falhu. The collected information is described in this chapter and has been used to determine the sensitivity and vulnerability of the marine flora and fauna with respect to the proposed dredging and reclamation works at Gulhi Falhu.

The consultancy team for the dive surveys was composed of 2 divers and one snorkeler from Marine Multi Services Pvt. Ltd. in charge of the underwater photography and dive safety and for the survey in 2010 with 1 marine biologist from Seamarc Pvt. Ltd. to organize the survey layout together with the Hydronamic environmental engineer.

For the analysis of the results of the dive and snorkel survey the software programme CPCe was used to determine the percentages live coral cover.

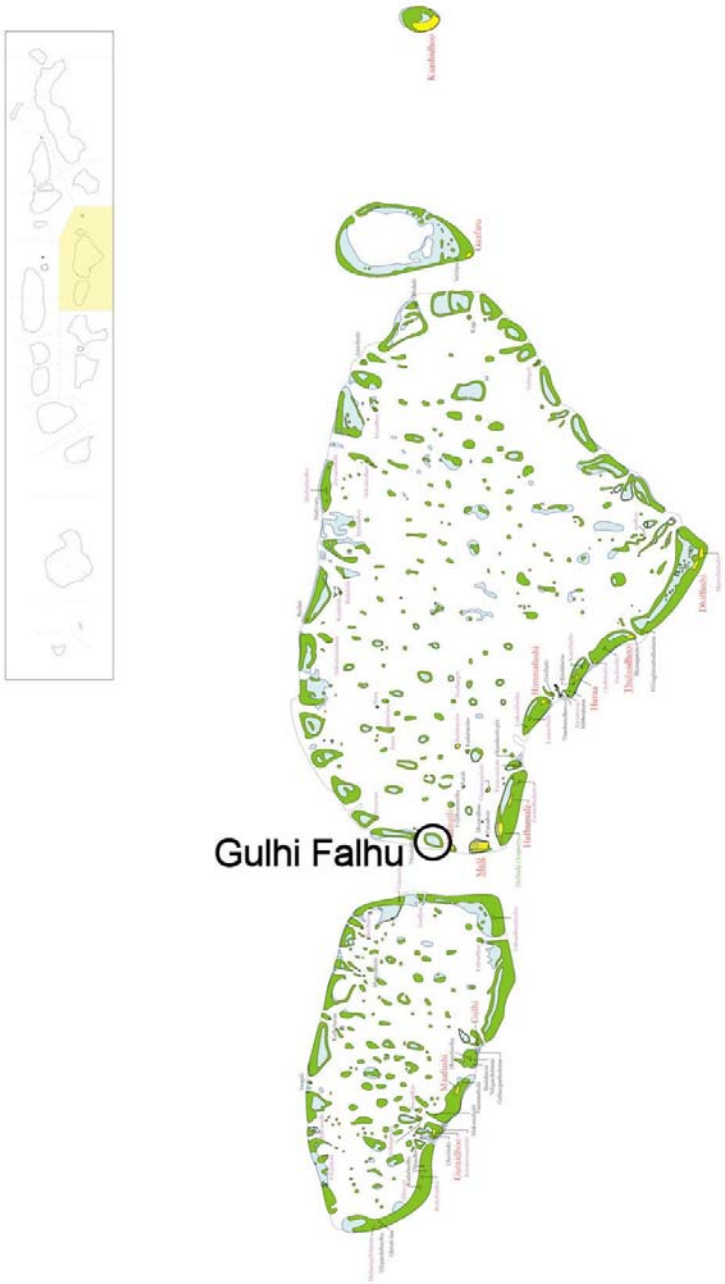


Figure 6-1 - Location of Gulhi Falhu in Kaafu Atoll

6.3 Physical Environment

6.3.1 Geology

Figure 6-2 shows the aerial photography of Gulhi falhu. Gulhi falhu is located on the southern rim of the north Male' atoll. The islands owe their origin to the deposition of shingle or coral debris during storms. The islands are made up of coralline sand, partly covered with a thin layer of soil consisting of a mixture of sand and organic matter.

The reef at Gulhi Falhu evolved in a similar manner, but was never raised above sea level through natural processes. Gulhi Falhu has no top soil.

The reef flat is wider on the south side of the reef system and very narrow on north, east and west side of the reef system. The water depth over the reef flat varies between 1.0 and 2.0m. Apart from a natural reef entrance on the eastern side, a reef entrance was made on the western side with the width of about 38 m.

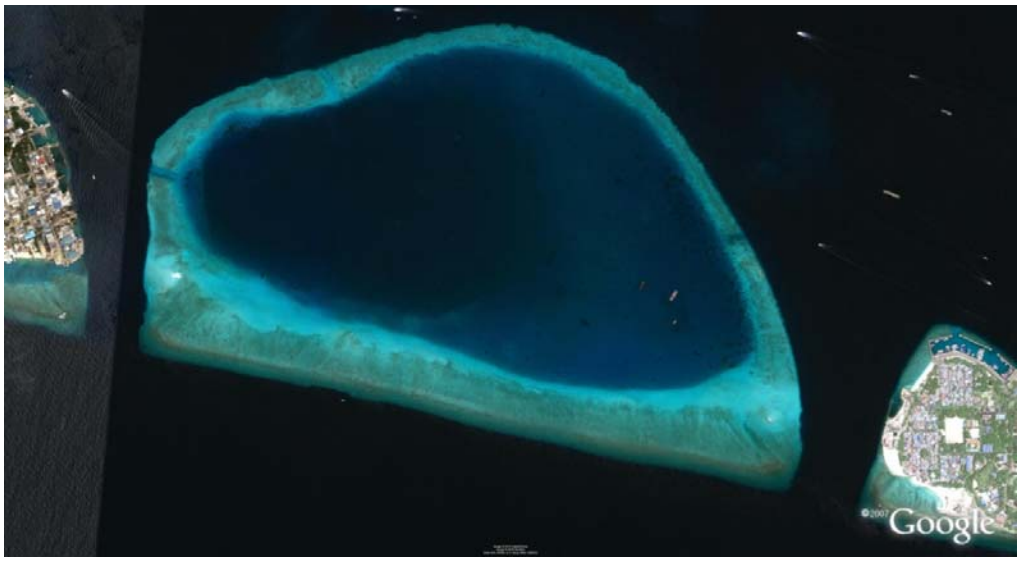


Figure 6-2 - Satellite Image of Gulhi Falhu

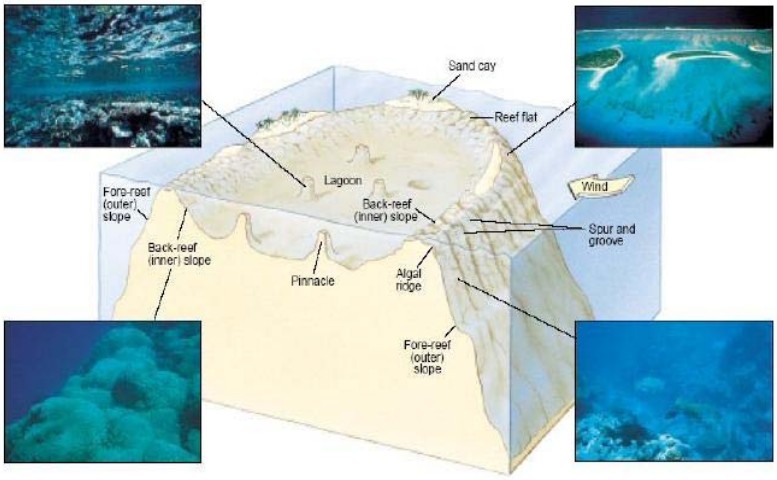


Figure 6-3 - Typical structure of an Atoll.

Based on similar projects and proponent's experience, the material of the borrow area can in general terms be described as "loosely packed, silty, coral sand and shells". The grain size envelope is expected to be as in figure 6-4.

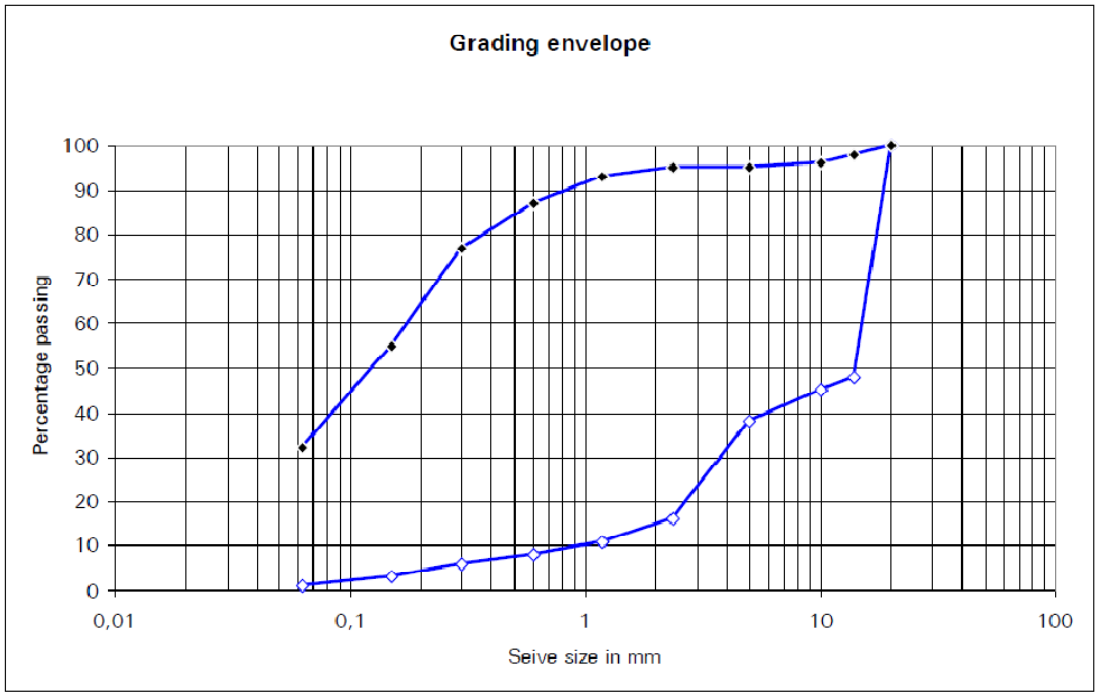


Figure 6-4 Gulhi Falhu assumed grading envelop.

One vibro-core sample was taken in the area north of Gulhi Falhu in January 2010. The results of the analysis of this sample are shown in Table 5-1 Characteristics of vibro-core sample taken near Gulhi Falhu.

Water depth	25 – 50m
Type of environment	Inside atoll lagoon, sandy seabed, coral reef formations such as farus, thilas and giris are located outside the perimeter of this area
Typical D50	625
Typical D10	60
Typical D90	1900
Percentage fines	11
Percentage coarse material	40
Percentage sand	49

Table 6-1 Characteristics of vibro-core sample taken near Gulhi Falhu

6.3.2 Climatic setting

The Maldives, in general, has a warm and humid tropical climate with average temperatures ranging between 25°C to 30°C (MHAHE, 2001) 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.

Monsoon

The Maldives lie in the Monsoonal Belt in the northern Indian Ocean and consequently the Maldives have a rather complex climate. The climate in the Maldives is dominated by southwestern (Hulhangu) and northeastern (Iruvai) monsoons. 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 the southwest monsoon occurs between March and April while that of the northeast monsoon occurs from October to November. Gales are uncommon, and cyclones are very rare in the Maldives.

Wind

The monsoons are relatively mild due to the country's location near the equator and strong winds and gales are infrequent in the Maldives. However, storms and line squalls can occur, typically in the period May to July. The winds usually get stronger in the southwest monsoon especially during June and July. During storms the impact is greater on the northern atolls than on the southern atolls.

The northeast and southwest monsoons have a dominant influence on the winds experienced in the Kaafu atoll. The southwest monsoon, with winds predominantly between SW and NW, lasts from May to October. In May and June, winds are mainly from WSW to WNW, and in July to October, winds between W and NW predominate. The northeast monsoon, with winds predominantly from NE to E, lasts from December to February. During March and April, winds are variable. During November, winds are W, becoming variable.

Wind measurements taken on Malé airport in the period January 1986 to December 1990 indicate that during the northeast monsoon, winds can occasionally exceed 30 knots (force 7 Bf) from the NE sector. During the southwest monsoon, winds have on one occasion during the period described above exceeded 40 knots (force 8-9 Bf) from the W sector. Generally, however, winds during the northeast and southwest monsoons are around 10-15 knots (force 5 Bf).

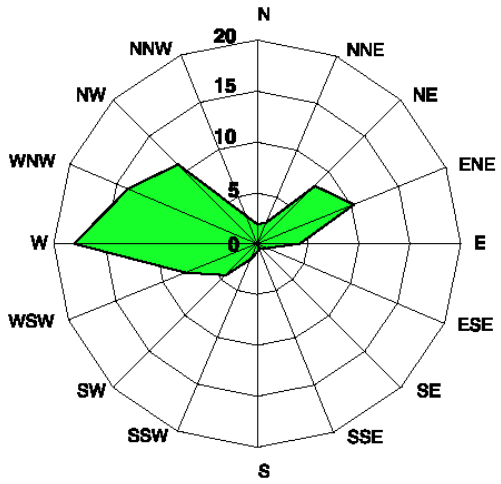


Figure 6-6: Percentage of wind direction for Malé International Airport (1980-1999)

Figure 5-4 shows the wind direction pattern for Malé International Airport. Winds from the north- east and the east-north-east are predominant during December and February. During March to April the direction varies with the general direction being westerly. Strong winds are associated with the southwest monsoon season. Strong winds and gales are infrequent, and cyclones reach only occasionally as far south as the Kaafu Atoll. Storms and line squalls can occur, typically in the period May to July. Gusts up to 50-60 knots (force 10-11 Bf) have been recorded at Malé during these storms.

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.

Rain fall

The average annual rainfall amounts to 1900mm, and there is an increase in the rainfall from north to south. The average annual rainfall for north is 1977mm and for south, it is 2470mm. The wettest months are May, August, September and December; and the driest are January to April. The northeast monsoon is

known as the dry monsoon, with an average monthly precipitation of 50-75mm. On average, the NE monsoon months have 5 days a month with rainfall exceeding

1mm. The southwest monsoon is the wet season, with monthly average rainfall ranging from 125mm to 250mm. During the SW monsoon months, each month will on average have 10 to 15days with rainfall exceeding 1mm. Open water evaporation rates are in the range of 6mm per day and transpiration from plants is also high. The relative humidity generally ranges between 75 to 80%.

6.3.3 Tides and Waves

Tides

During spring tides, the tidal range is between about 90-110 cm and during neap tides the range can be as little as a few centimeters. The height of the tide is also affected by the weather. Winds from different directions influence the raising and lowering of the water level and situations of high sea levels on the outside of the atolls are caused by storm surges and wave set-up. The water also stands higher with a low barometer, to what extent is uncertain. Maximum water levels are estimated to be in order of MSL+1m.

The tides observed in the country are twice daily (semidiurnal), and typical spring and neap tidal ranges are approximately 1.0m and 0.3m respectively. 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 – April and decrease of 0.1m during September – November. Table 6-2 shows tidal variations for Malé Airport.

Tide level	Reference to Mean Sea Level
Highest Astronomical Tide (HAT)	0.64 m
Mean Higher High Water (MHHW)	0.34 m
Mean Lower High Water (MLHW)	0.14 m
Mean Sea Level (MSL)	0.00 m
Mean Higher Low Water (MHLW)	-0.16 m
Mean Lower Low Water (MLLW)	-0.36 m
Lowest Astronomical Tide (LAT)	-0.56 m

Table 6-2: Water levels

Currents

Currents which affect the sea area around the Maldives and within the Thaa atoll are caused by one or more of the following systems: oceanic currents, tidal currents, wind-induced currents, and wave-induced currents.

The oceanic currents flowing „across the Maldives are notorious for their strength. The exposure of the Maldives to the vast Indian Ocean ensures that an immense body of water is constantly flowing across the plateau on which the atolls are built. In the Arabian Sea, as you get closer to the equator, the prevailing winds become more and more indicative of the oceanic surface current. Thus, wind (especially during monsoons) can be a major factor affecting current velocity and direction, and currents can be of great

strength (wind-induced currents). For example: currents in the channels near Malé have been recorded at 4 knots or more. Inside an atoll, current speeds are more settled.

Oceanographic currents are driven by two monsoonal winds, namely the westerly and easterly wind. The westerly flowing currents tend to dominate from January to March while the easterly currents dominate from May to November. The changes in current flow patterns occur in April and December. The current velocities are about 0.5 m/s, only in May values may increase to 0.8 m/s.

The vertical water movements associated with the rise and fall of the tide are accompanied by horizontal water motion termed tidal currents. These tidal currents have the same periodicities as the vertical oscillations, but tend to follow an elliptical path and do not normally involve simple to- and-from motion. Generally the tidal currents are eastward in flood and westward in ebb. Tidal currents, which flow according to the height of the tide, are generally not strong. There is a strong diurnal influence which governs the tides in the Maldives, but in general the tidal range is less than 1m.

On a more local scale, especially on the reef flats, wave-induced currents (cross-shore and/or long-shore) also form an important factor affecting the current regime.

Waves

The swell and wind waves experienced on the Maldives are governed mainly by the two monsoon periods. Swell caused by cyclonic storms in the area west of Australia may also reach the southern atolls of the Maldives on occasion.

The swells and wind waves experienced by the Maldives are conditioned by the prevailing biannual monsoon wind directions, and are typically strongest during April – July in the south-west monsoon period. During this season, swells generated north of the equator with heights of2-3m with periods of 18-20 seconds have been reported in the region.

The Maldives also experiences swells originating from cyclones and storm events occurring well south of the equator. It is reported that the swell waves from southeast to south-south-east occur due to strong storms in the southern hemisphere in the area west of Australia with direction towards the Maldives. The swell waves that reached Malé and Hulhule in 1987 had significant wave heights in the order of 3 meters. Local wave periods are generally in the range 2-4 seconds and are easily distinguished from the swell waves.

Due to the shallow depths on the reef flat, significant wave breaking (energy dissipation) will take place at the reef's edge, reducing the wave height of waves which pass over the reef flat.

Tsunami and waves

Although records are inexact, it would appear that earthquake-generated tsunamis of greater than 1.0m in height have occurred on three occasions in the Indian Ocean since 1883. A tsunami of the magnitude experienced on 26th December 2004, which was approximately 4.0m in height, is an extremely rare event.

In the morning of 26th December, three hours and 18 minutes after the Sumatran earthquake, the tsunami reached the shores of Maldives islands. Sea-level station records show a southward decrease in the amplitude of the tsunami tidal-record signal from ~1.8m above mean sea level (MSL) at Hanimaadho in the north, ~1.5m for Hulhule, Malé in the central region, and ~0.8m for Gan in the south. The sea-level station data are filtered and do not show absolute heights of the tsunami. Uncorrected tsunami water levels measured by UNEP showed a range from barely measurable to 3.25m, with most measurements in the 2.0 to 2.6m range. Tsunami inundation heights ranged from 0.65m in south Malé to 3.20m in L. Fonadhoo.

The tsunami's height typically decreased from east to west as it travelled across islands. Many islands reported the tsunami approaching from the west, quite probably because it refracted around the ends of the islands. Eyewitness accounts often referred to several (usually three) waves approaching in rapid succession (30 seconds to minutes) with minimal draining of water between waves. Wave effects were most pronounced on eastern shores, but flooding and damage to coastal infrastructure was widespread among the islands. The tsunami arrived in Maldives during daylight hours near low tide.

6.4 Marine environment

6.4.1 Biodiversity

The Maldives is well known for its rich marine biodiversity found along the reefs. More than 250 species of coral, 1,200 reef fish species, 5,000 species of shells, 100 − 200 species of sponges, over 1,000 species of marine crustaceans and more than 100 species of echinoderms have been recorded at the waters surrounding the islands.

The coral reefs are the most important ecosystems in the Maldives. Up until 1998 the extensive coral reefs throughout the Maldives were found to be in good condition. In 1998 an extensive bleaching event occurred due to the increase in sea surface temperatures and destroyed large areas of shallow-water coral reefs. As a result, in several areas about nearly 90% of the corals died. Although new recruitment has been noticed at numerous sites, the cover of live coral is not nearly as extensive as before the bleaching event.

The dominant species on the reefs are corals and fishes. The top ten families of fishes in the Maldives are: gobies, wrasses, groupers, damsel fishes, snappers, cardinal fishes, moray eels, blennies, butterfly fishes and surgeon fishes. 37 species of sharks can be spotted in the Maldives. The only protected shark specie, by law, is the whale shark. Some species can be found close to the edge of the reef, but most can only be found in deep waters. Stingrays are bottom feeders, they dig out clams and other animals which are covered in the seabed and can be spotted on the shallow reef flats close to shore.

The most popular fishes for divers are sharks (especially the whale shark) and rays. The whale shark is the largest fish in the world; the manta ray is very popular and can have a width of about 3m; both fishes are plankton feeders.

Five species of sea turtles can be spotted in the waters of the Maldives, being: the Hawksbill turtle, the Loggerhead turtle, the Green turtle, the Olive Ridley turtle and the Leatherback turtle. The Green turtle (Chelonia mydas) and the Hawksbill (Eretmochelys imbricata) are the most common two species that breed in the Maldives. During the ecological survey green turtles were observed on the lagoon side of the island at the slope of the reef flat.

Seven species of dolphins can be seen in the Maldives. The most common specie is the spinner dolphin - *Stenella longirostris*. Large groups of dolphins can be found at the ocean side as well as at the atoll side of the island. These dolphins roam from area to area.

Several components of the marine environment of the atoll islands can be distinguished. A cross section of a typical atoll reef in the Maldives is given in Figure 6-5

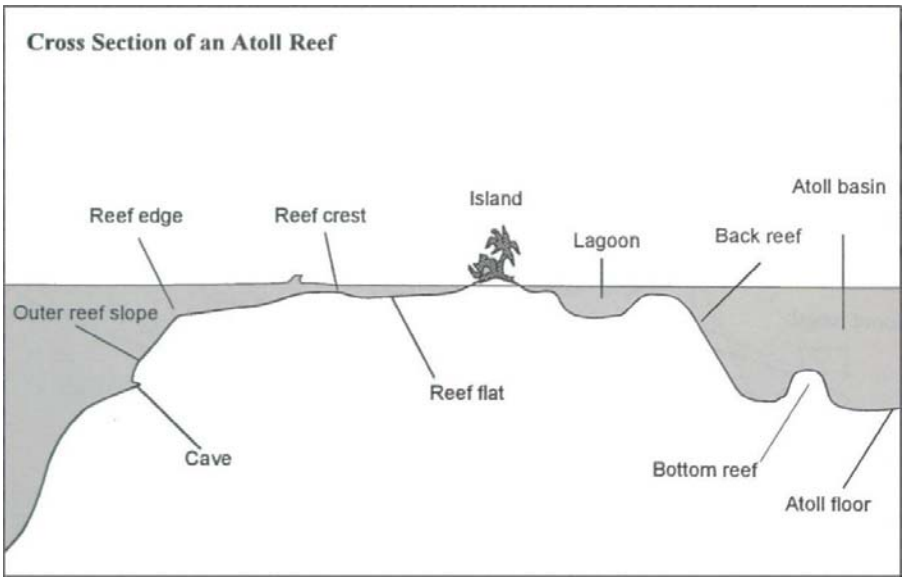


Figure 6-5: Typical cross section of an atoll reef

6.4.2 Coral survey

In June 2010 a coral survey was conducted at 6 locations on the Gulhi Falhu reef. Six sites were surveyed, sites 1, 2 and 3 are on the northern side of the reef, which is also the lee side. Site 4, 5 and 6 are located on the southern or exposed side of the reef.

Figure 6-6 shows these locations. The GPS coordinates of the locations are given in Table 6-3.

Figure 6-6: Coral survey locations of Gulhi Falhu

Table 6-3: Survey Site Location and geo-coordinates

Transect	Location	Geographical coordinates in degrees/min		UTM coordinates in meters	
		N	E	N	E
Site 1	North West side	04° 11.21"	73° 27.67"	461.950	329.200
Site 2	Middle North side	04° 11.27"	73° 27.99"	463.050	329.800
Site 3	North East side	04° 11.21"	73° 28.32"	462.950	330.400
Site 4	Centre Hans Hass	04° 10.45"	73° 27.68"	461.550	329.215
Site 5	Middle South side	04° 10.35"	73° 28.00"	461.370	329.800
Site 6	South East side	04° 10.32"	73° 28.32"	461.300	330.400

At each site, one or two transects were carried out depending on whether or not the slope was not too steep to carry out a meaningful transect. Usually, one transect is taken on the reef top near the edge, and referred as being at 5 meters, even though it is sometimes shallower. The deeper transect is usually taken at a depth of 10 m. At site 4, an additional transect was carried out to characterize the top of the rocky platform, which is the equivalent of the reef crest in this instance. 5 high resolution pictures were selected to assess the benthic cover of each site. Each picture is analyzed using 25 points grids to characterize the substrate composition at each site with a sample of 125 points per transect. Quantitative substrate cover data of the morphological characteristics of the reef community was obtained using this method and could be repeated over time to assess variations.

6.4.3 Reef atoll side

Given that the coral community is little developed, the site discussion will present the main categories with a focus on the structure of the abiotic substrate, which components, pavement, rubble sand and silt are shown separately. This enables a discussion on sediment and hydrodynamic regimes and an assessment of recovery process at each site.

6.4.3.1 Site 1

The top of the reef is flat and relatively deep for a reef edge, at a depth of 2.5 to 3 m. The substrate is composed of loose stones which may move when wave action is strong (Figure 6-7). This seems to happen rarely on this side sheltered from the oceanic swell and the sand component is quite important (12 %). In this place a small channel had been previously in use to enter the reef lagoon. Figure 6-8 gives the composition of the substrate at the site. The coral cover is virtually nil and most of the living substrate (17 %) is comprised of turf algae (13 %) and ascidians (4 %).

Figure 6-7: Substrate appearance on the reef top at site 1

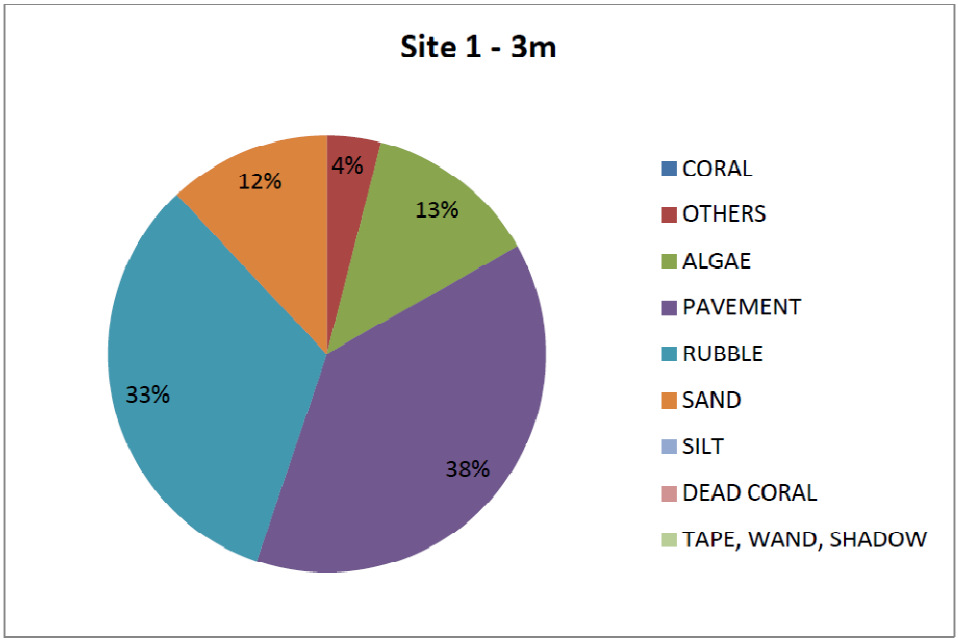


Figure 6-8: Substrate composition with separation of the abiotic components on the reef top at site 1

Some of the rocks seems to be moving to the northern reef slope which appears to be made from the rubbles accumulated over time (Figure 6-9). Therefore the substrate is not very stable and coral growth is limited. The substrate composition is given in Figure 6-10. Live coral mostly comprise of small colonies of acropridae, with the digitate and tabular forms totalling 53 % of the coral cover. It is not clear if this could be due to a late recruitment following the 1998 bleaching event or if the bigger colonies invariably are toppled over under their weight.

Figure 6-9: The outer reef slope at site 1

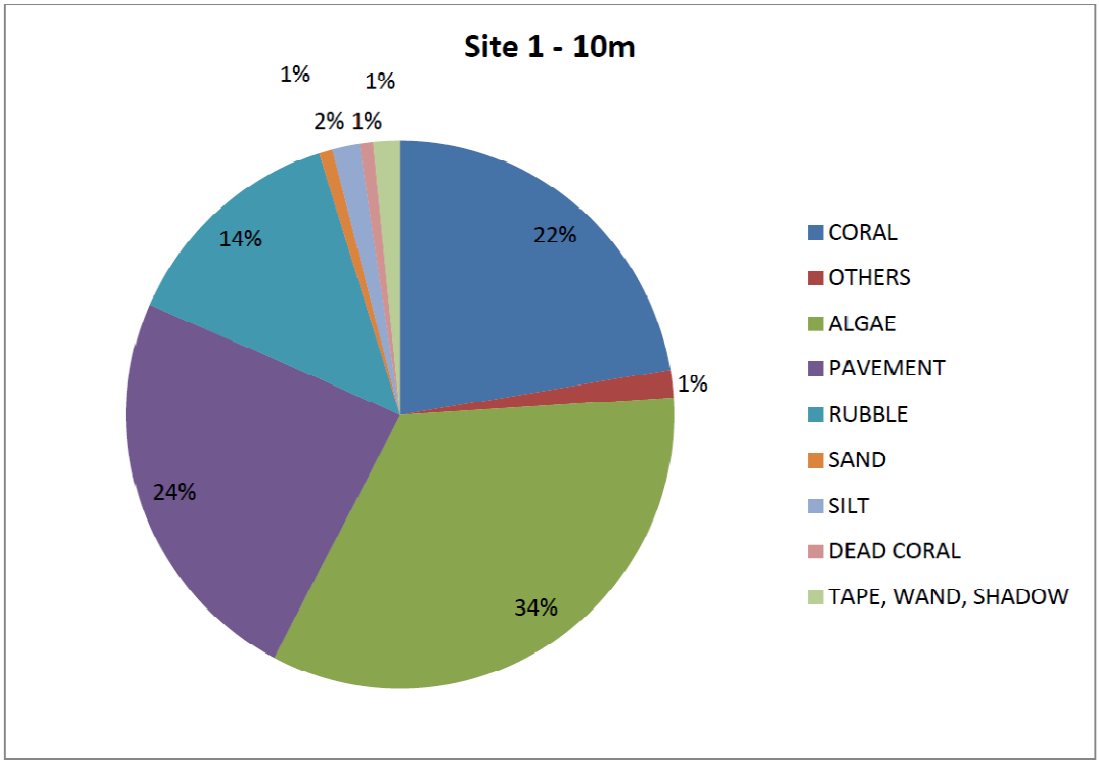


Figure 6-10: substrate composition on the reef slope at site 1

Figure 6-11: yellow sweepers gather around the few coral heads present down the slope.

6.4.3.2 Site 2

Site 2 is located at the northern most point of the reef, a point which is indicated by a navigation light. The reef top is similar to site 1 but the coral cover is more important, maybe owing to better water quality and less sediment movement over the reef flat. Even though this is not obvious from the substrate composition, it is clear that the current is stronger and that the size of the rocks is smaller, and this could have enabled a better coral growth. The midnight coral, Tubastrea micrantha, fragile, but living in areas exposed to currents is present indicating a good water movement. The substrate on site 2 is given in Figure 6-12. The composition is given in Figure 6-13

Figure 6-12: Substrate on site 2

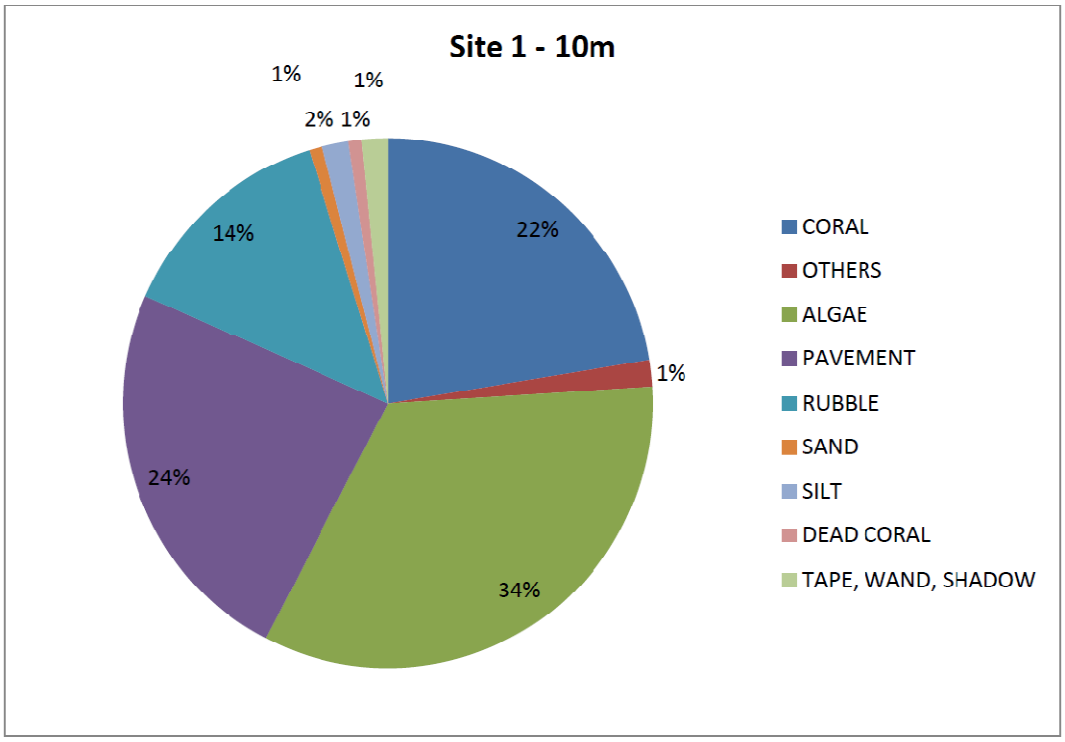


Figure 6-13: substrate composition on the reef top at site 2

The slope is also not comprised of rocks being transported over the edge but exhibits a steep wall heavily colonized by coralline algae (Figure 6-14).

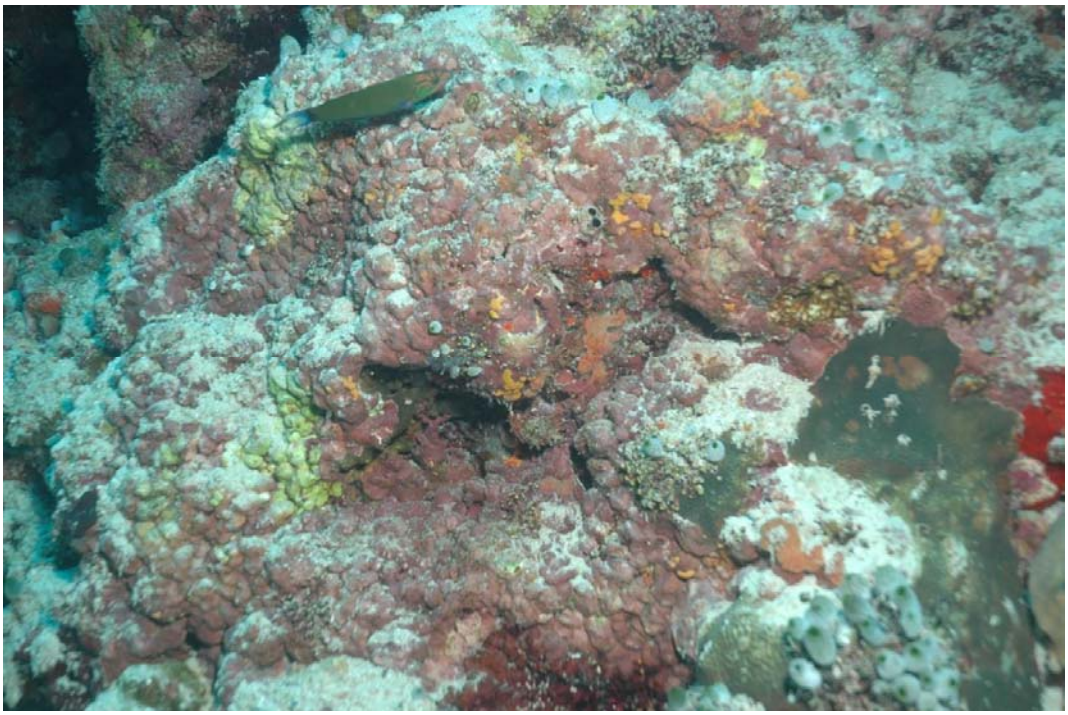


Figure 6-14: coralline algae have heavily colonized the steep wall at site 2.

Despite this apparent consolidation of the reef structure, it seems that the reef wall is subject to collapsed and the reef edge is very jiggered, with on such collapse present just in front of the navigation light (Figure 5-15).

Figure 6-15: some parts of the reef have collapsed creating a jaggered appearance of the reef edge.

The fish life is comprised mostly of planctonivores such as the blue trigger fishes, sea basslets and moon wrasses, but a number of moray eels are present.

6.4.3.3 Site 3

The reef top at site three is similar to that at site 2, but the coral cover is lower. No transect was done at the site, but the whole width of the reef flat was explored and very little coral was present throughout. A few hard slabs enable some colonies to settle in an otherwise empty substrate (Figure 6-16).

Figure 6-16: hard slabs on the reef flat enable colonies to settle sparsely.

The transect was carried out at a depth of 5 m, on the upper part of the reef slope. In this area, the erosion and breaking off of the reef crest is even more important than at site 2, and the slope is even more uneven, with steep walls alternating with gullies.

The composition of the substrate is given in Figure 6-17.

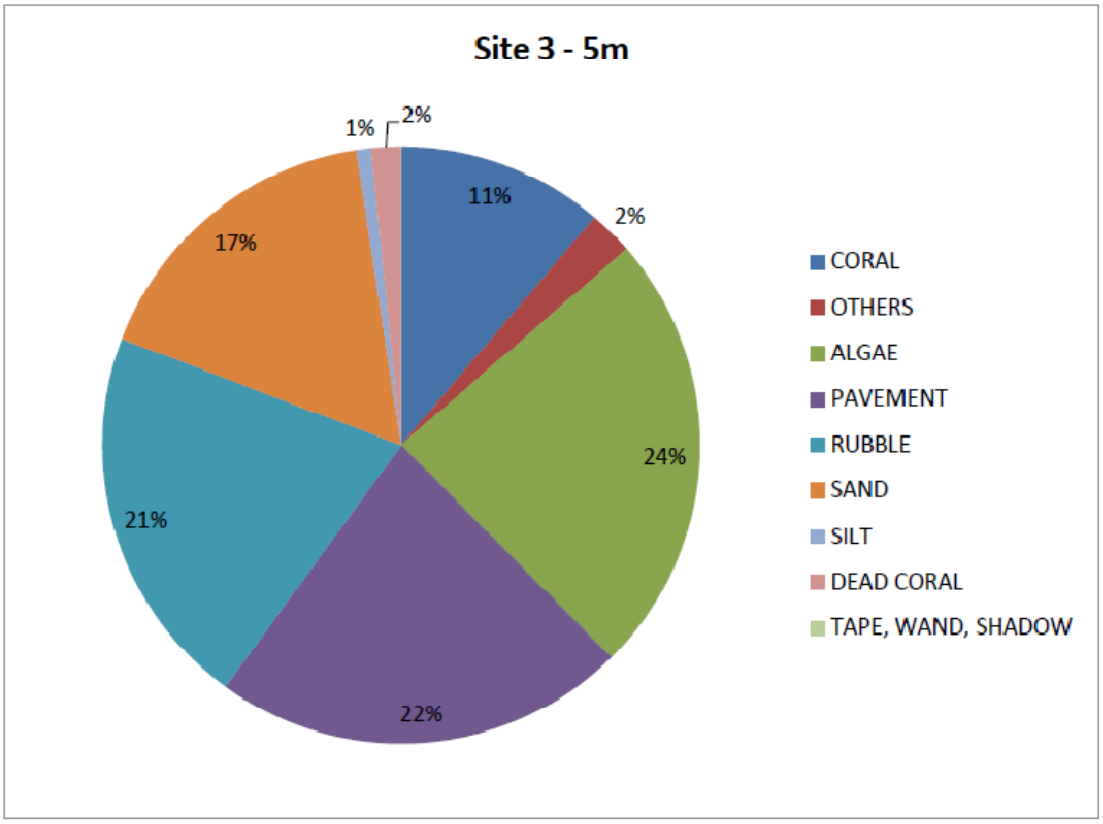


Figure 6-17: Substrate composition at 5 m at site 3

The live coral cover is relatively low for the reef slope and well below the average at depth encountered around the reef (20 % at 10 m). Algae are an important component which is dominated by turf algae over coralline algae. As the substrate is quite loose, the abiotic component is also predominant with equal parts of pavement, rubble and sand.

Whether at the bottom of the outer slope or inside the lagoon, there is a high number of garden eel of different species. These also are planctonivores, as the species mentioned above.

6.4.4 Reef Vaadhoo Kandu side

6.4.4.1 Site 4

Site 4 is a popular dive site, Hans Hass Place. It consists in a reef slope exposed to the Vaadhoo Kandu. The reef edge has collapsed on a distance of over 150 m and this gives some interesting reef formation, with a number of caves. The reef is steep past the reef edge but evolves into a slope at around 15 m depth. This is continuous until it meets with another terrace at around 40 m.

On the reef top, the coral cover is quite good, especially on the edge. The substrate composition is given in Figure 5-18 .

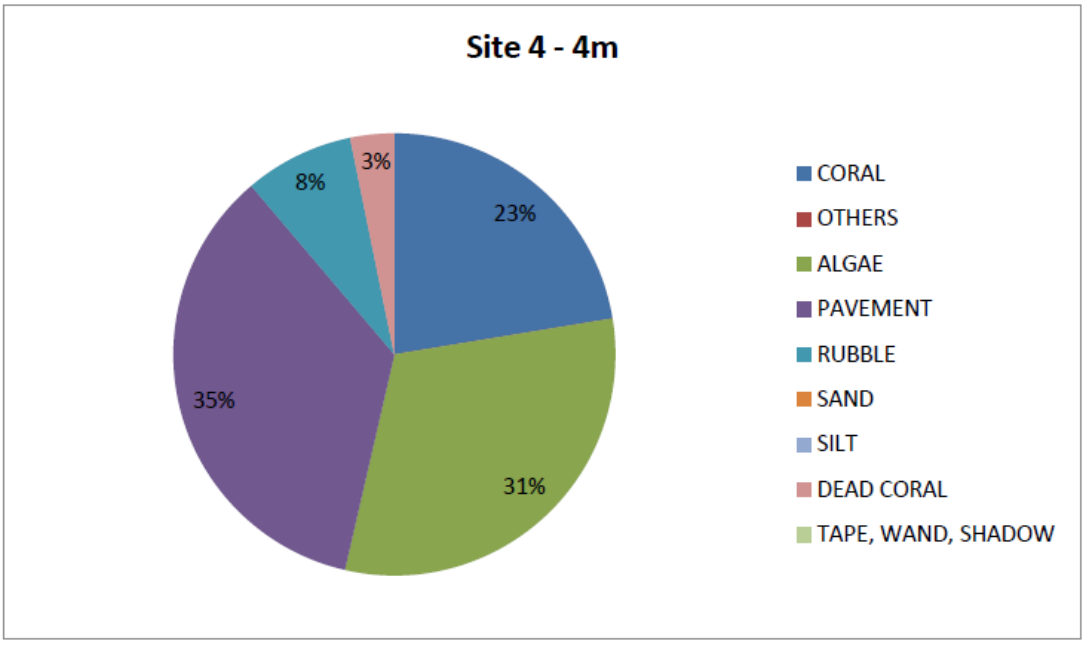


Figure 6-18: Substrate composition on the reef edge at site 4

As the wave action is quite important in the area, the component of loose rubble and sand is not important. The corals represent 23 %, and most of it is comprised of massive species with a few encrusting and sub massive life forms. Algae are also important with a high proportion of turf algae (28 %) and little coralline algae. There is still a fair amount of bare substrate and coral cover can still increase.

On the shallow part of the reef edge, the loose substrate is also little where the reef crest and algal ridge is usually present (Figure 6-19).

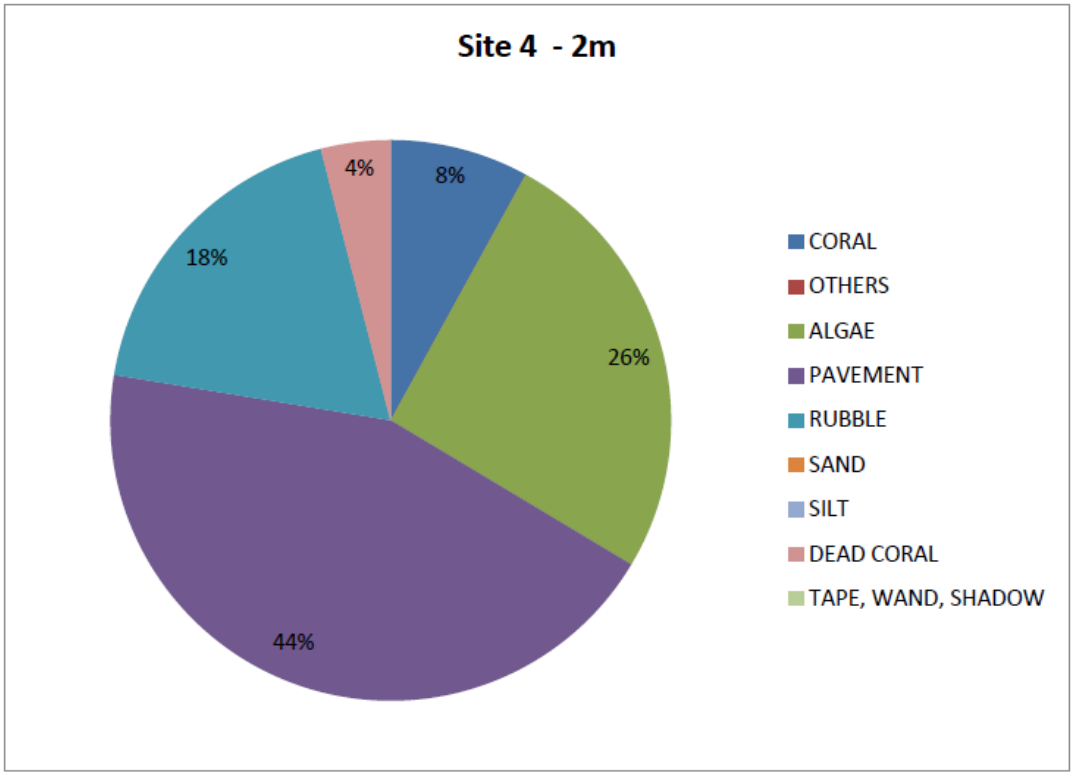


Figure 6-19: Substrate composition with separation of the abiotic components on the reef top at site 4

Here the substrate is rocky with a lot of turf algae. Most of the coral colonies present are from the Pocillopora genus. A large number (50 %) of them were bleached (Figure 6-20).

Figure 6-20: pocillopora colonies on the shallower part of the reef flat near site 4.

At depth, the coral cover remains quite satisfactory for an exposed reef slope, with a live coral cover of 16 % (Figure 5-21). The abiotic substrate remains dominant and coralline algae (16 %) also occupies a large proportion of the substrate.

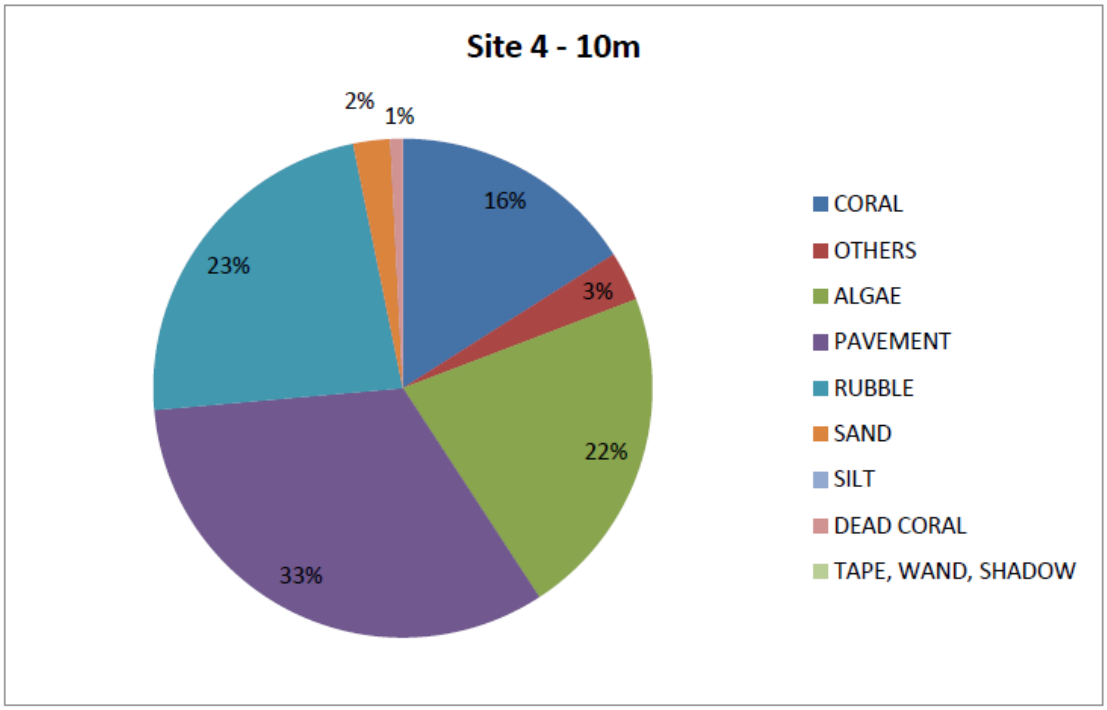


Figure 6-21: Benthic substrate at 10 m at site 4

The current in that area is important, and sand does not settle. To attest of this good current flow, many gorgonians sea fans are present on the slope and under the overhangs (Figure 6-23).

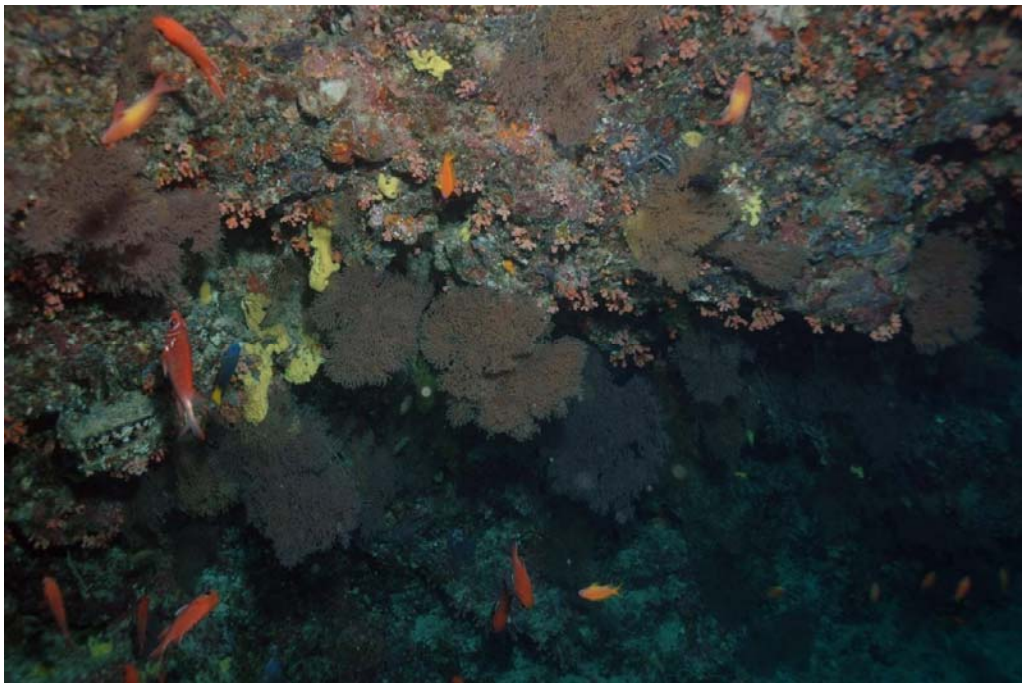


Figure 6-22: Gorgonian sea fans are present under the ledges at Hans Hass place.

6.4.4.2 Site 5

Site 5 is located very close to the middle of the southern side. The reef slope differs in that it is more regular and do not shot the so many ledges and caves as at site 4 (Figure 6-23). The gradation from a reef edge with good coral cover (Figure 6-24), mostly massifs, to the shallower platform with Pocillopora is a common feature with site 4 and site 6.

Figure 6-23: the regular transition between the reef top and the regular slope below

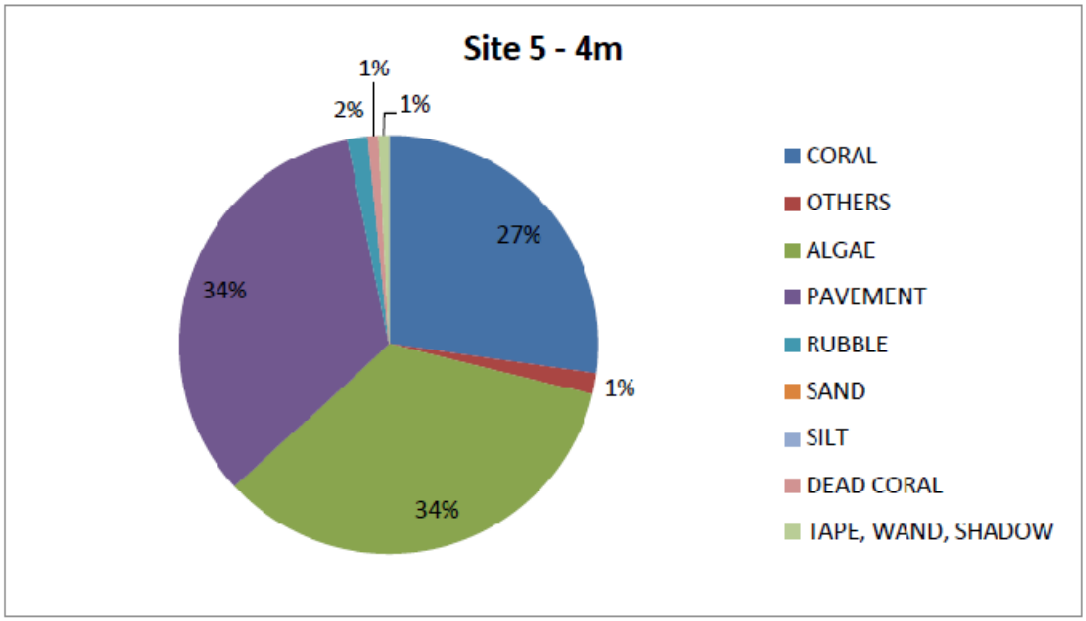


Figure 6-24: Substrate composition on the reef edge at site 5

There is little loose material on the reef top and coralline algae are more important than at site 4 (16 %), probably cementing the structure more efficiently. The coral cover is high, and mostly comprised of massives and encrusting.

At depth the coral cover is still good and mostly comprises of massive species (15 %). Coralline algae dominate over the turf algae and consolidate the structure. Some of the sand and rubble originating from the reef top trickles down the slope.

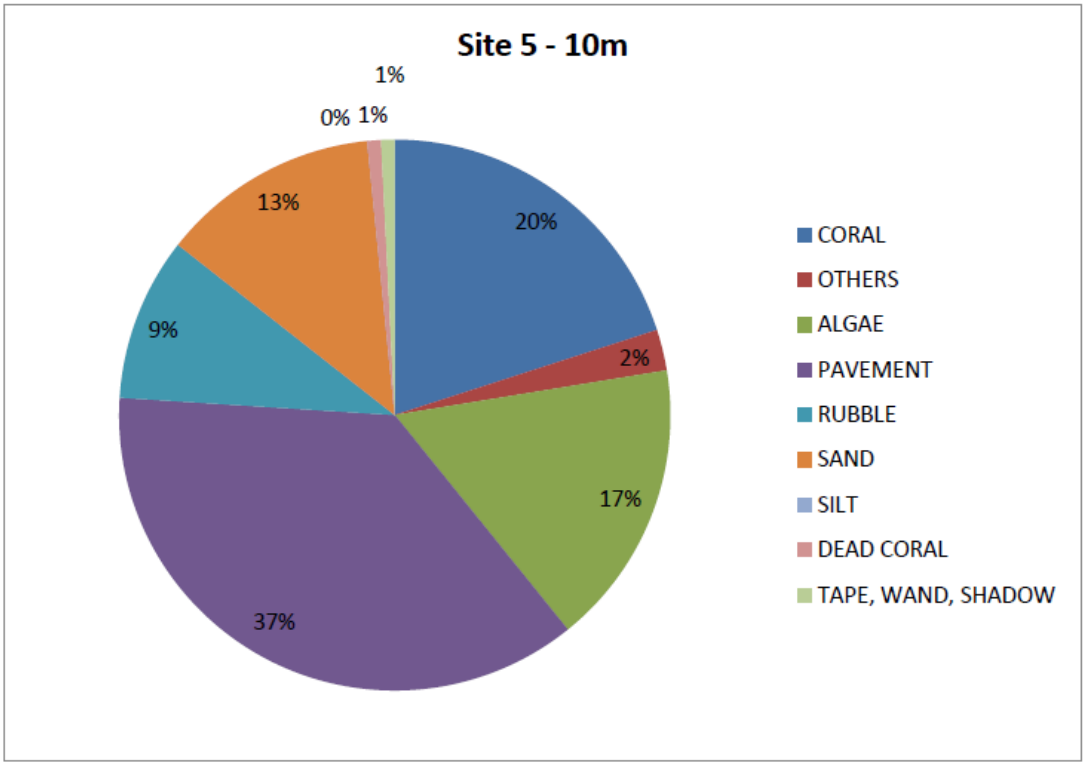


Figure 6-25: Substrate composition at 10 m at site 5

6.4.4.3 Site 6

Site 6 is very similar in all respects to site 5, with an even healthier reef edge (Figure 6-26)

Figure 6-26: Healthy reef edge at site 6.

With a live coral cover of 34 % (Figure 6-27), the site has the highest coral cover among all the sites surveyed. Again coralline algae dominates over turf and there is little loose sediment. Fish life is abundant with a large number of grazers such as the surgeon fishes and planctonivores such as sergeant fishes.

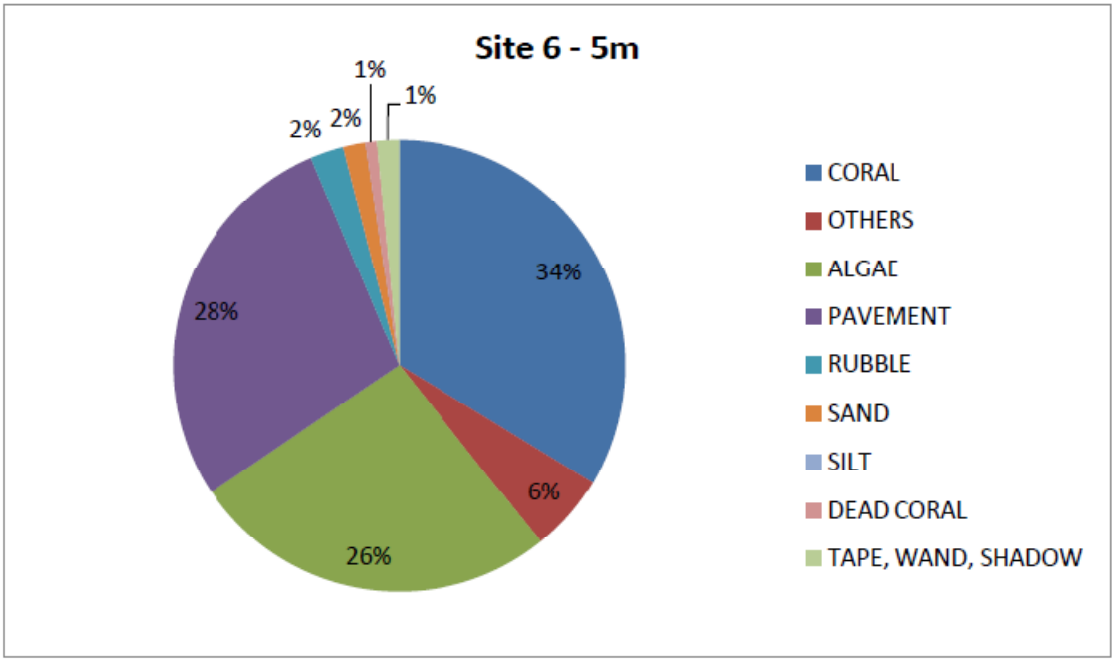


Figure 6-27: Substrate composition on the reef edge at site 6

At depth, the coral cover diminishes (Figure 6-28) and many ascidians are present, accounting for 13 %.

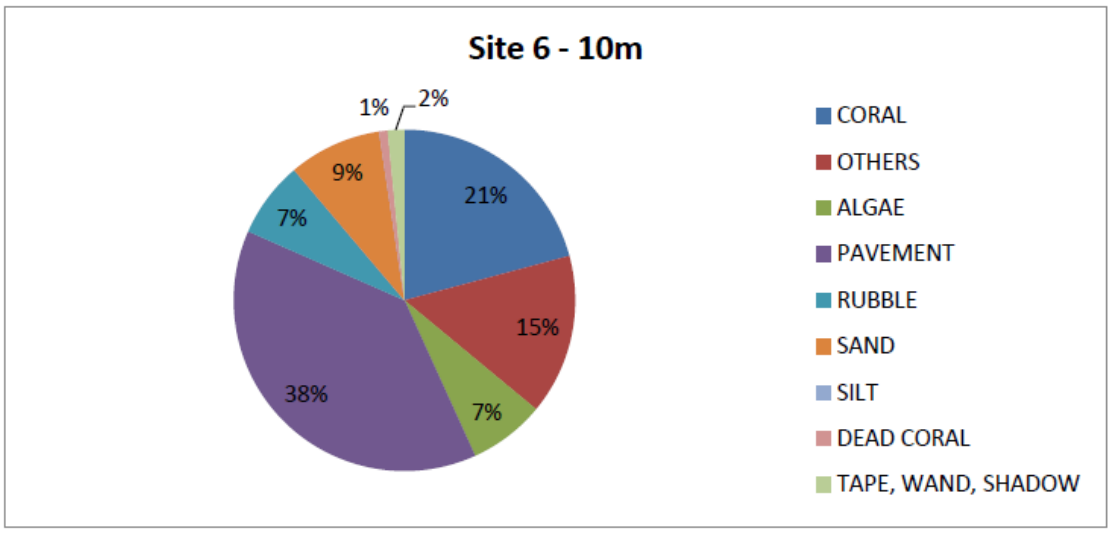


Figure 6-28: Substrate composition on the reef slope at site 6

The surface is quite rugged causing a lot of shadows to increase the unidentifiable points in the survey. Similarly as at site 5, rubbles and sand falls down the slope.

6.4.5 Summary results ecological survey 2010

The results from the photographic transects carried out on the 28th of June 2010, are given in table form (Table 6-4) and bar chart form below (Figure 6-29).

Overall, the live coral cover is not great, averaging 18 % on all transects. The massive and encrusting life forms represent the bulk of the coral cover. The reef top on the northern side (site 1 to 3) is rather bare and consists of a flat rocky substrate in the 2.5 to 3 m depth range. This seems due to a poor recovery from the 1998 bleaching event rather than a mass mortality during the recent bleaching event. As a general rule, the coral cover was quite better on the reef edges and poor on the lagoon side, with the exception of the Pocilloporids present on the platform crest on the southern side (Site 4 2 m). At depth the coral cover seems to be quite even all around the reef with a cover in the range of 20 %.

Table 6-4 Main substrate statistics for the different transects (transect names indicate the site and depth where appropriate, cover in %)

TRANSECT NAME	Site 1 3m	Site 1 10m	Site 2 3m	Site 3 5m	Site 4 2m	Site 4 4m
CORAL	0.00	22.76	15.20	11.20	8.00	22.40
OTHERS	4.00	1.63	4.80	2.40	0.00	0.00
ALGAE	12.80	34.15	8.80	24.00	25.60	31.20
SAND, PAVEMENT, RUBBLE	83.20	40.65	71.20	60.80	62.40	43.20
DEAD CORAL	0.00	0.81	0.00	1.60	4.00	3.20
TAPE, WAND, SHADOW	0.00	1.60	0.00	0.00	0.00	0.00

Table 6.5: Main substrate categories for the different transects

TRANSECT NAME	Site 4 10m	Site 5 4m	Site 5 10m	Site 6 5m	Site 6 10m	MEAN
CORAL	16.00	27.42	20.16	34.15	21.14	18.04
OTHERS	3.20	1.61	2.42	5.69	15.45	3.75
ALGAE	21.60	34.68	16.94	26.83	7.32	22.17
SAND, PAVEMENT, RUBBLE	58.40	35.48	59.68	32.52	55.28	54.80
DEAD CORAL	0.80	0.81	0.81	0.81	0.81	1.24
TAPE, WAND, SHADOW	0.00	0.80	0.80	1.60	1.60	0.58

The fish life even though abundant was comprised of the smaller species of reef associated fish and only few larger predators were encountered. The blue trigger fish is particularly abundant with different size cohorts quite obvious. There were a number of quite not so commonly encountered species such as this triggerfish tentatively identified as a juvenile of Suflamen fraenatum (Figure 6-30), an electric ray, and three napoleon fish.

Figure 6-30: A juvenile of Suflamen fraenatum

6.5 Protected areas and species

In the Maldives there are 33 marine protected Areas (MPA) of which 8 are located in the North Male Atoll and 2 in the South male atoll. The closest marine protected area to Gulhi Falhu is Hans Hass place (04° 10.5□ N 73° 28□ E) located just south of the GF reef (Figure 6-31).

Figure 6-31 location of MPA Hans Hass Place

The MPA□s in the North and South Male atoll are:

North

- Gulhifalhu Medhuga / Hans Hass Place
- Dhekunu Thilafalhuge Miyaru vani / Lions Head
- Giravaru Kuda Haa
- Gaathugiri / Banana reef
- Lankan Thila/ Nassimo Thila
- Thamburudhoo Thila / Girufushi Thila / HP Reef
- Rasfari Island
- Makunudhoo kandu
- Huraa Mangrove Area

South

- Embudhoo kandu
- Guraidhoo kandu

The areas have been chosen for a number of reasons such as their underwater beauty, fragility and their unique biodiversity.

A number of species have been protected in relation to the biological diversity convention. The marine protected species are:

- Napoleon wrasse (*Cheilinus undulates*)
- Lobsters (of the family Palinuridae)
- All marine sea turtles: Hawksbill (*Eretmochelys imbricate*) and Green turtles (*Chelonia mydas*) are the most common species in the Maldives.
- Conch (triton) shell (Charonia spp.)
- Black coral (*Antipathes aperta*)
- Giant clams (of the family Triacnidae)
- Whale shark (*Rhincodon typus*)
- Dolphins (of the family Delphinidae)
- Whales (of the order Cetacean)

Some of the protected species were observed in the waters around Gulhi Falhu reef. This was the Napoleon wrasse, giant clams and conchs. Spinner dolphins were observed south of the GF reef.

In addition, 70 bird species (including5 species which are native to the Maldives) are protected under the Environment Protection and Preservation Act (Act 4/93 of the Maldives). These include Noddy□s, Terns,

Shearwaters, Frigate Birds, and the White-tailed tropic bird. The bird species living in the Maldives are Herons, Maldivian water hen and the Asian Koel.

Gulhi Falhu is currently completely submerged and has therefore no beaches and no function as a turtle nesting area. Annex 6 gives an overview of the turtle nesting areas in the Maldives. The nearest location with recorded nesting sites lies in the Baa atoll.

6.6 Gaps in baseline information

6.6.1 Gaps in Information

The environment of Maldives is generally poorly understood. This may be due to the lack of detailed studies in the Maldives. Much of the literatures on coral islands are derived from studies done in the pacific which unfortunately has very different and climatic and geologic settings.

Detailed environmental analysis for an EIA is often required to be undertaken in a relatively short period of time. Give the seasonal climatic variations in Maldives and the differences in local geomorphologic and climate settings in individual reefs and islands such a short time frame is often too little to assess selected aspects of the environment. This problem is compounded by the absence of long-term studies in other parts of Maldives. Hence, most EIA's end up being based on an environmental snapshot of specific point in time. However, experienced EIA specialists can deliver a close match to reality based on a number of similar assessments.

In this regard, the following gaps could be identified in information.

1. Absence of long-term site specific or even regional data (at least 2 years). Most critical data include current and wave history.

2. Absence of historical and long-term records on reef and lagoon environment.

3. Lack of detailed data on geology of the reef structure due to time limitation in EIA submission.

These gaps are seriously considered in the assessment and care has been taken to address the issue in designing mitigation measures and the monitoring programme.

6.6.2 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, geomorphological or social conditions in a particular place. As noted earlier, there is also no long term data and information regarding the particular site under consideration, which makes it difficult to predict impacts. However, the level of uncertainty is partially minimised due to the experience of land reclamation activities in similar settings in the Maldives. For example, Hulhumale', Maamigil, VIlufushi

and GA. Viligilli. Nevertheless, it is important to consider that there will be uncertainties hence voluntary monitoring of natural processes as described in the monitoring programme is absolutely essential.

6.6.3 Additional Studies

A detailed study of the currents around Gulhi Fahlu has not been executed during this ecological survey. A better understanding of the complex current system is needed in order to:

- predict plume dispersion during the dredging and reclamation works
- create an optimal design for the revetments and the need for groynes

Hence, a systematic monitoring programme for currents as outlined in the monitoring programme is required in the future. These data should be used for the preparation of the EIAs for remaining phases.

7 Description of Economic and Social Environment

The present socio-economic environment of Gulhi Falhu is outlined in relation to Male', Villingili, Thilafushi and nearby resorts assuming their maybe implications from the project. Socio-economic changes caused by the establishment of Gulhi Falhu island cannot be evaluated at this stage because details of land leasing, types of industries and such information are unknown. Following sections provide a summary of the proximate socio-economic environment.

It is recommended in Chapter 1 Introduction to undertake a separate EIA to assess the impacts of development on the reclaimed land of Gulhi Falhu. A detailed description and evaluation of the socio-economic environment of nearby islands, resorts and facilities should be provided as part of the EIA on the development of Gulhi Falhu.

7.1 Villingili

Villingili is situated west of Malé, and east of Gulhi Falhu, separated by narrow channels. Villingili, once a resort, is now a residential area with about 500 houses, catering for the increasing demand for space on Malé itself.

As for the number of inhabitants, the official figure is about 15.000, however the real figure is probably something like 9000/10.000; as the island is administratively a ward of Malé municipality, detailed statistics for the Island as such are not available.

As for the economy, the government (in the broad sense including services such as electricity) employs up to 250 people; a further 200 people are employed or have business in Malé, and shop keeping on Villingili with 3 bigger shops and about 40 small general purpose shops and other such activities as sewing, employs another 100 people. Three fishing dhonis provide for the local market.

The island has a complete range of services comparable to Malé with electricity (local generation) and desalination water plant, a school up to 7th grade with some 600 pupils, and medical facilities and the like. There are two restaurants that cater for residents.

7.1.1 Public Consultation at Villingili

See public consultations chapter.

7.2 Male'

Male' being the capital has a population of over 100,000 representing one third of the population of the country. This increase in population is Male' is due to heavy migration from the atolls. Male' is considered

as the main gateway of the country. All the service related industries within the community include civil service, construction activities, retail and whole sale trade and cargo transport to other major international hubs. The main economic infrastructure include Male' International Airport and the Male' port. The key social infrastructure are 19 schools including two international schools, one power house operated by state-owned STELCO, and two hospitals, one government and one private. Two Schools teach up to grade-12. There are health clinics in the island operating privately. Male' also has the major dive schools of Maldives with the exception of dive schools in resorts.

7.3 Thilafushi

Thilafushi is located approximately 400 m from Gulhi Falhu and 6.85 km from Male'. Although originally Thilafushi was a lagoon of about 3.5 km in length, currently it has a landmass of approximately 0.5 km^2. The primary purpose of reclaiming Thilafushi was to resolve the issue of waste on Male' and has been in use for landfilling for the last 18 years or so. Since 1997 the reclaimed land of Thilafushi is being utilized for industrial purposes. Current land use of Thilafushi includes cement packing, LPG bottling, boat manufacturing and warehousing.

As part of the waste management operations, the barge carrying waste travels between Male' and Thilafushi five times a day on average. During dredging and reclamation the transportation route of the barge will have to be detoured (see Public Consultations chapter). This will have cost implications to the waste management operations of Thilafushi.

7.4 Resorts

There are two resorts located in close proximity to Gulhi Falhu. Kurumba Village is located 6.5 km north east of Gulhi Falhu and Giravaru Island Resort is 5 km to the west of Gulhi Falhu. Giraavaru has a bed capacity of 132 while Kurumba has a bed capacity of 362.

7.5 Potential for Development at Gulhi Falhu

GF□s future role follows from the above-mentioned economic conditions, in particular as related to Malé□s congestion. Following is a per sector overview of activities with their relation and importance to the future GF development.

Table 7-1 GDP development per sector in the Maldives period 1998 - 2004.

Table A.1: Gross Domestic Product by Industrial Origin in Constant 1995 Prices
(Rf million)

Sector	1998	1999	2000	2001	2002	2003	2004[a]
Primary Sector	**578.8**	**599.1**	**595.2**	**625.5**	**724.8**	**740.0**	**765.3**
Agriculture	165.5	168.8	174.7	181.4	188.6	196.3	204.6
Fisheries	373.8	388.1	381.2	402.4	494.7	498.0	512.9
Coral and Sand Mining	39.5	42.2	39.3	41.7	41.5	45.7	47.8
Secondary Sector	**801.2**	**900.5**	**914.8**	**989.0**	**1,091.7**	**1,177.7**	**1,251.5**
Manufacturing	435.4	483.3	505.1	532.4	615.1	629.8	660.9
Electricity and Water Supply	156.4	178.5	203.9	226.3	247.6	273.0	290.6
Construction	209.4	238.7	205.8	230.3	229.0	274.9	300.0
Tertiary Sector	**4,493.4**	**4,798.6**	**5,084.5**	**5,205.4**	**5,448.8**	**5,988.9**	**6,298.4**
Wholesale and Retail Trade	270.4	278.9	287.8	288.9	295.6	308.3	323.1
Tourism	1,854.2	1,982.3	2,094.0	2,093.5	2,162.6	2,482.5	2,600.1
Transport and Communication	825.4	854.2	919.1	934.2	998.0	1,078.8	1,156.5
Financial Services	194.3	208.6	215.1	220.4	235.1	259.5	273.7
Real Estate	460.6	483.9	496.7	507.4	530.7	566.9	589.3
Business Services	166.1	178.3	183.9	188.4	201.0	221.9	233.9
Government Administration	590.5	677.8	750.7	833.0	883.9	906.8	975.4
Education, Health and Social Services	131.9	134.6	137.2	139.6	141.9	144.2	146.4
FISIM	(225.2)	(241.8)	(249.3)	(255.5)	(272.5)	(300.8)	
GDP in Constant 1995 Prices	**5,648.2**	**6,056.6**	**6,345.5**	**6,564.4**	**6,992.8**	**7,585.8**	**7,997.9**
GDP at Current Prices	**6,356.9**	**6,935.4**	**7,348.4**	**7,650.8**	**8,201.0**	**9,156.7**	**9,529.6**
GDP at Current Prices ($ million)	**540.1**	**589.2**	**624.3**	**625.1**	**640.7**	**715.4**	**744.5**

FISIM = Financial services indirectly measured, GDP = gross domestic product, Rf = rufiyaa.
[a] Projection.
Source: Ministry of Planning and National Development.

As for the role of the **Primary Sector** on the GF-island to be:

Agriculture has no role, apart from some fruit trees such as coconut and mango along the roads or in the residential area.
Fisheries, important as it may be on the national level, has no particular and certainly no direct business on GF-to-be.

As for the **Secondary Sector**:

Light manufacturing primarily for the internal (Maldives) market, will have an important place on GF island. This will include probably (but is not limited to): assembly of computer hardware, laboratory activities, other research, materials testing, other assembly activities, etc.
Electricity supply: the State Electricity Company – Stelco - is to install further capacity to meet a growing demand; the Malé Power Plant presently has total capacity of 21.5 MW. With the construction of energy-intensive high-rise buildings and growing ownership of household equipment, the consumption of energy

has been growing rapidly, the demand for electricity in Malé has been growing at a rate of 12% per year. Stelco is interested to relocate part of its current activities to Gulhi Falhu and to set up new activities.

The **Tertiary Sector** provides the main reason and drive for the GF land development with transport and communication, in order to relieve the congestion at Malé port. The various projects include:

As for business services, a location for wharehouses is planned;
Services such as an international school, a shopping mall and a hospital have to be set up;
A luxury shop, to attract both tourists and residents, together with a 7-star hotel and a golf course;
Social housing and labourers quarters. Additionally luxury housing and accommodation for support staff, as far as those are not commuting from Malé is planned.

8 Stakeholder Consultation

8.1 Introduction

Stakeholder consultations were undertaken with a number of key stakeholders. One of the major issues with regard to consultations was the lack of information regarding the phases 2-4 of the project and the operations phase of phase 1. As noted in the introductions chapter, the palling stage of the phases2-3 and operations stage of phase 1 has not been completed yet. Only the construction stage of phase 1 has been planned to a level which could be used for discussion during public consultations. Moreover, this project is acting within a time restriction, since the dredger designated for the project has already been hired and transported to Maldives. It has a specific deadline to depart Maldives and once it departs the project may have to abandoned due high financial losses. Hence, the approach taken in this report is to undertake consultation with parties relevant to the first phase of the project. It is recommended to undertake a separate detailed socio-economic assessment for the operation stage and the remaining phases of this project one the planning stages are completed.

8.2 Key Stakeholders

The public consultation for this EIA was undertaken during the month of June and August 2010. The public consultation was undertaken in Viligilli and Male'. The study team visited Viligilli to seek the views of the affected public and key stakeholders. They also conducted meetings with other stakeholders in Male'.

The major stakeholders consulted are as follows:

- Villigili Island population
- Recreational fishermen
- Divers Association and Dive Schools
- Nearby resorts
- Male' Municipality waste management services.

The major stakeholders who are relevant but could not be consulted due to time restrictions are as follows:

- Fishermen (bait fishing)
- Safari boats
- Thilafushi Corporation
- Department of Planning and National Development
- Ministry of Economic Development
- Population of Male'

8.2.1 Villigilli Island

The consultation

The public consultation started with a visit to the Villingili Ward office and an interview with Mr. Mohammed Sameer, Director of the Ward Office and his Deputy. Following this, 28 interviews were carried out after asking for approval to do so (no refusals). This involved a total of 53 persons, 25 female and 28 male, with in terms of age a same number of younger and older people. No names were asked.

After a brief explanation, the first questions were whether they knew about the project, what in general was their opinion and whether there were any issues - positive of negative - to be taken into account.

When word spread about the exercise, more people came for information; these people were not interviewed.

Opinions expressed

About one quarter of those interviewed had heard about the project, mostly via the radio. The general attitude was positive, all but one ("no idea") saw the project as an opportunity in terms of employment and business (one remark: "at last something NOT in Malé"). A question asked more than a few times by the people were whether there would be a bridge from Gulhi Falhu to Villingili.

As for items for attention:

- Strong increase in traffic between Gulhi Falhu and Malé, with the additional remark that „busy" in this sense also meant „business";
- Noise from dredging during construction and whether there would be explosions;
- A small number of people worried about an increase in the currents between Gulhi Falhu and Villingili compensating for the hydraulic "barrier" the built-up island would be, with problems of increased erosion.
- Some of the men interviewed spent occasionally time at fishing near the outside of the Gulhi Falhu reef, and had questions about the situation after–the-project.

Conclusion and recommendations

Given the in general positive opinion no issues need to be addressed urgently, with exception of the current in the channel between Gulhi Falhu and Villingili. Once the project is about to be launched, a information campaign addressing the whole exercise for Villingili residents and others should be launched.

8.2.2 Recreational Fishermen

It is difficult to determine who specifically uses the Gulhifalhu site regularly for recreational fishing. A sample of 7 fishermen was interviewed to determine their patterns of usage of Gulhifalhu site and the potential impacts of reclamation.

Interviews were conducted mainly over the phone and for those who requested to see the reclamation plan, a face-to-face meeting was conducted.

In general, the areas on the oceanward side of Gulhifalhu is not regularly used as a major recreational fishing are by experienced fishers. Their preference is mainly on the opening of the channels between the Gulhifalhu and Viligilli, and Gulhifalhu and Thilafushi.

In terms, of impacts they noted potential impacts on the area between Thilafushi. However, they are not too concerned about the affects as it is not a major fishing area. They couldn't really link the decline in fishing and land reclamation. Some of them mentioned that the effects outside Hulhumale' was also minimal after reclamation.

Recreational Fishermen Consulted

Name	*Address*
Mr. Ismail Shakeel	Ma. Marujaanuge
Mr. Nooh Ali	H. Shady Villa
Adam Ali	Hulhumale 46-G02
Moosa Naeem	M. Ruhkkuri
Abdul Rasheed Yoosuf	B. Eydhafushi, Gulhazaaruge
Moosa Naseer	M. Aliveli
Hussain Fathy	M. Himmi

8.2.3 Diver Association and Dive schools

Consultations with the Divers' Association of Maldives (DAM) were held on two separate occasions: on 23 July 2010 and on 26 August 2010.

The first meeting was conducted with a number of other organizations while the latter was held specifically with the DAM senior officials.

During the first meeting Mr. Yusuf Musa (Consultant - Maldives Divers Association) stated that from local point of view this project is really beneficial and advantageous, since the end result of the project provides resolutions for wide variety of socio- economic problems. He also stated very clearly that he is convinced that the dive location "Hans Hass Place" will no longer be available after the project. The reclamation works will kill the reef. That has happened with every reclamation according to him.

Mr. Fayyaz form DAM stated that it is prime responsibility of developer to look in to measures of mitigating environmental pollution. He showed his concern on solid waste in the water as a very big problem and this might increase with the development of Gulhi Falhu.

Hence, it appeared that the DAM officials were resigned to the fact that the dive site quality would deteriorate and that it may not be usable as major site in the future.

The second meeting was held at CDE Consulting and was attended by the Vice President of DAM, Mr Azim Musthag, and Board member Mr. Yoosuf Rilwan. The following concerns were raised during the meeting:

- It is unlikely that the dive site would survive the entire Gulhifalhu Development Project. They raised examples from other reclamation projects such as Reethi Rah and Maamigili Airport Project where the oceanward reef slope was severely degraded and fish population declined drastically. They also showed the example of Male', where significant impacts were seen.
- However, they also noted that some locations have fared better like the outer rim of the Hulhumale' Reef. They also noted that places like Banana Reef were severely affected immediate after the Hulhumale' reclamation project but recovered quickly, perhaps owing ot he strong currents in the region.
- The four dive sites off Gulhifalhu were regularly used by dive schools of the resorts nearby.
- The dive schools based in Male' use the inner lagoon of Gulhifalhu for training purposes. If Gulhufalhu is closed they do not have an appropriate reef in close proximity. Their alternative is Fedhoo Finolhu Island near Male'. However, the Dive Schools are well aware that Gulhifalhu development has been coming and they were resigned to the fact that the site may not be available in the future.
- DAM member noted that they would like individual Dive Centres to be consulted, particularly the resorts closest to Gulhifalhu.

8.2.4 Nearby resort islands

In the North Male Atoll there are more than 25 resorts operational, in the South Male Atoll there are more than 15 resorts. The closest resorts to Gulhi Falhu are Giravaru Island resort, Velassaru (former Laguna Maldives) and Vadoo Island resort at a distance of less than 6km.

A consultation meeting was organised on June 23rd 2010 to inform nearby resorts, their dive centers, the Maldives Divers Association and the Maldivian Tourism Promotion Board. Other parties that were invited were the: Environmental Protection Agency, Marine Research Center, Ministry of Tourism, Ministry of Economic Development, Thilafushi Development Corporation, Ministry of Fisheries and Agriculture. The invitation letter, the invitation receipt acknowledgement, the attendance list and the minutes of this meeting can be found in annex 4.

No representatives of the resorts and their dive centers were present at this meeting. Individual consultations with the general managers of Giravaru Island resort and Vadoo Island Resort were therefore held in Male. The general manager of Velassaru and Kurumba Village was informed by email but gave no reaction.

Resorts located further than 6 km distance from Gulhi Falhu (Embudu,Taj Exotica and Club Med) were considered as too far from the reclamation site to experience direct impacts on the resort or the surrounding waters from the reclamation activities. A representative from their dive centers was contacted by phone to discuss the project.

All parties were informed on the development plans of the Gulhi Falhu project and the possible impacts on the resorts and surrounding dive sites were discussed.

In the consultation meetings the following concerns were raised:

Dive sites & coral reefs

The dive sites of Vadoo Island, Taj Exotica and Embudu Village are mainly located in the south Male atoll. Only Embudu Village uses dive locations south of Guli Falhu on a regular basis (location 2,3,4 and 5). The other dive centers do not use the MPA "Hans Hass" more than once per year.

The reason why Hans Hass Place is not used by dive centers in the South Male atoll is the travel distance and the quality of the dive site. The site is still considered "nice" but has gone done much after the development of Thilafushi. Sand on the corals, waste in the water and the bad smell have made the site less attractive. There also seems to be a lot of coral fishing that has reduced the amount of fish on the dive sites.

Navigation

A lot of suppliers take shortcuts from Male to Giravaru Island resort through the lagoon of Gulhi Falhu when the sea is rough. The concern is whether or not that is still possible.

Waste & pollution

Giravaru Island resort is facing a lot of problems from the presence of Thilafushi Island. Waste, bad odour, water pollution and flies are the main problems. This problem will also affect Gulhi Falhu since the effects have been noticed as far as Bandos Island resort. More waste is also expected when Gulhi Falhu is being developed and after completion of the island.

Currents

A shift in the currents will occur when the reclamation starts. After the reclamation of Thilafushi the current in the channel between Thilafushi and Gulhi Falhu has changed and increased. With the size of the planned reclamation all the currents around the reef and in the lagoon will change. This doesn□t have to be necessarily bad but shore protection and maybe groynes will be key issues.

Planning

Giravaru Island Resort is going to close in August for one year to do a renovation of the resort. Therefore the GM does not see any problems for the resort since there will be no guests.

Even though the reclamation might impact the environment both General Managers of Giravaru and Vaadhoo Island resort see the Development of Gulhi Falhu as a positive development for the greater Male area.

A list or a map of the current dive and snorkel sites was requested of each resort and obtained from 1 resort. This map can be found in Annex 5.

8.2.5 Male' Municipality Waste management site

A meeting was held with the Director of Male' Municipality Waste Management Site Mr. Mohamed Waheed on 26th August 2010. His comments are summarised below:

- The proposed closure of reef entrances on the western side of Gulhifalhu will force a re-routing of the waste barges (see figure below). This will increase the time of travel for each barge by 20 minutes for a return trip. About 5 return trips are undertaken every day. This will increase the fuel consumption by an extra two barrels in total at an extra Rf5000 per day. This cost will be borne by the government.
- Apart from the implications on travel for the waste management corporation does not foresee any issues with the project. They generally welcome the development and hope that it comes through.

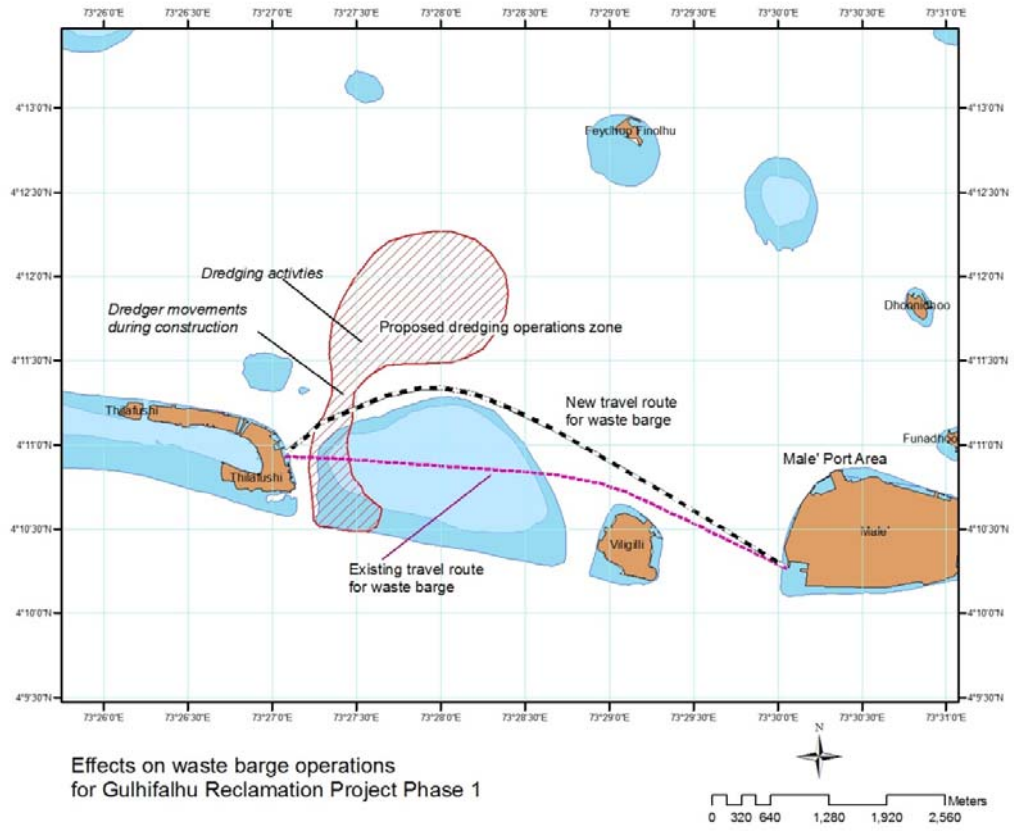


Figure 8-1: Changes to Thilafushi waste barge route

8.2.6 Other Government agencies

Representatives from the Ministry of Tourism and Thilafushi Cooperation were present in the consultation meeting. Details of the meeting are presented in the Annex.

Mr. Moosa Zameer Hassan (Director – Ministry of Tourism) stated that it is developer role to make nearby resorts aware of this project. Further he mentioned that it is advisable to allocate some budgeted amount of money for site management or waste management.

Thilafushi Cooperation generally welcomes the development.

9 Potential Impacts and Mitigation Measures

9.1 Introduction

The proposed development of Gulhi Falhu is anticipated to cause significant detrimental as well as beneficial impacts. Impact identification (environmental/social/economic impacts) and mitigation measures were primarily based on literature reviews, professional judgment and past experience from similar projects.

For the purpose of this EIA, the chain of events linking activities to specific impacts and knock-on effects are represented in flowcharts to allow for easier interpretation. This is because the cause-effect relationship between a specific activity and its potential impacts are rarely linear and in most cases, a series of casual factors linked to different activities create the conditions that cause an impact. Two separate flowcharts were developed and organized to display logically the following sequence of events:

Activity → *Casual Factor* → *Potential Impacts* → *Short Term Effects* → *Long Term Effects*

Accordingly, Figure 9.1 and 9.2 below illustrates the flowcharts. The first chart will show the potential negative impacts of the proposed development activities during construction stage (dredging and reclamation stage) and the second chart will show the potential positive impacts expected to arise once the project is complete (operation stage). It should be noted that no potential positive impacts could be identified for the construction stage of the proposed development activities.

9.2 Uncertainties in Impact Prediction

In the EIA process of the Maldives, uncertainties in impact prediction generally arise due to the lack of long term data, limited timeframes to complete EIAs and lack of standard procedures to collect data leading to inconsistent methodologies used by the various EIA consultants. Such issues are mainly linked to the lack of importance given to the EIA process in strategic planning and initial stages of development projects. Typically in the Maldives, EIAs for major development projects are only done after development activities and project locations are finalised. This gives the EIA consultants limited time frames to conduct a comprehensive impact assessment.

Accordingly, the uncertainties in impact prediction for this particular EIA are due to the time constraints in data collection and due to the limited amount and type of data available for measuring or predicting impacts.

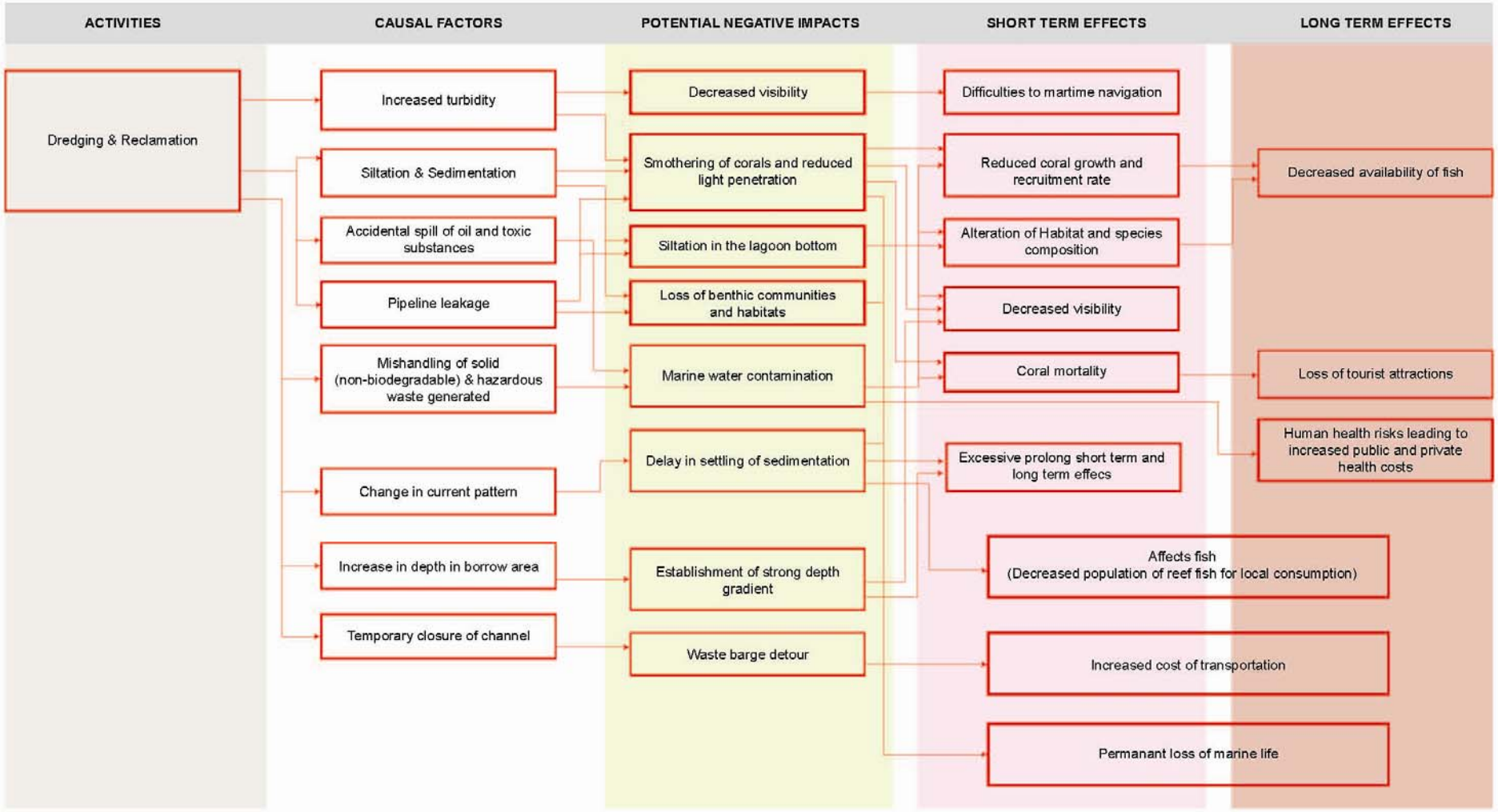


Figure 9-1 Potential negative impacts during construction stage

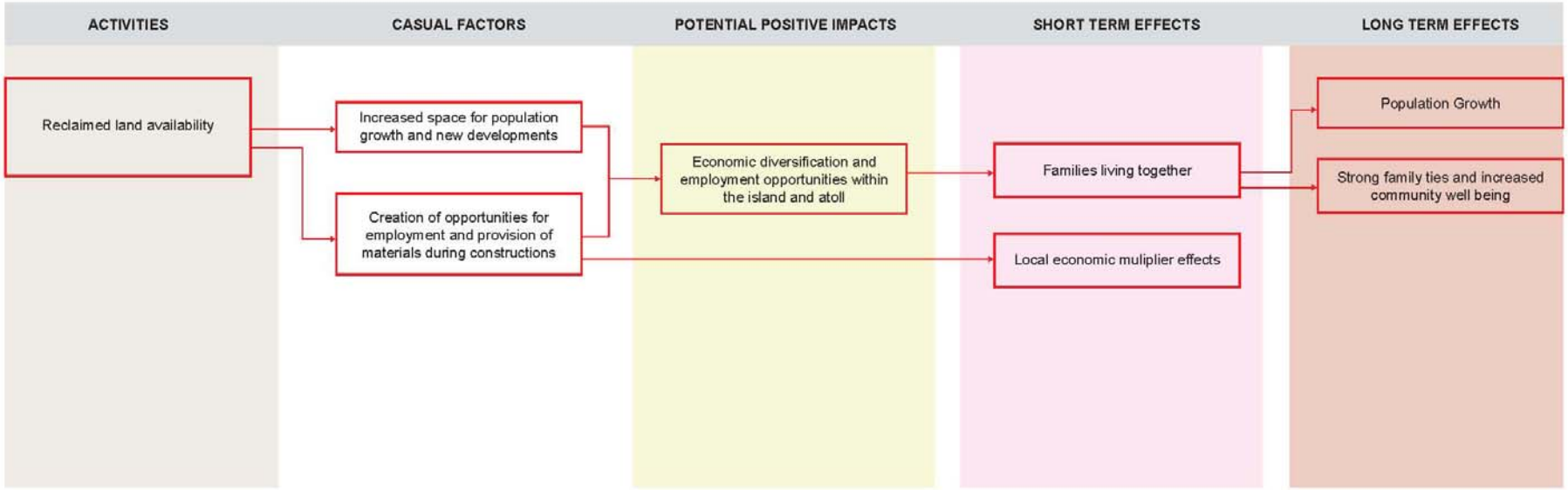


Figure 9-2 Potential positive impacts during construction stage

9.3 Brief Description of Potential Impacts and Suggested Mitigation Measures for All Adverse Impacts

This section will provide a brief description of each of the potential impacts illustrated in the flowcharts of Figure 10.1 and suggest appropriate mitigation measures for all potential adverse impacts. Similar to the flowcharts, firstly potential negative impacts and mitigation measures during the construction stage will be described. This will be followed by descriptions of the potential negative impacts during the operation stage. Finally all potential positive impacts will be discussed.

9.3.1 Potential Adverse Impacts on Natural Environment

9.3.1.1 Sedimentation

- During dredging and reclamation works as well as construction of revetments, a significant amount of siltation and sedimentation of the water column is anticipated. Also increased turbidity of the water column is expected.
- These factors will cause adverse impacts such as smothering of corals and reduced light penetration to the coral and benthic communities. As corals have a self cleansing mechanism and can withstand a certain rate of sedimentation, detrimental impacts such as reduced coral growth and recruitment rate and decreased visibility can be short term effects. However if the sedimentation exceeds the rate at which corals can self clean, then it may lead to serious detrimental impacts such as coral mortality and alteration of habitat and species composition within the Gulhi Falhu reef and the surrounding area. Figure 10.3 illustrates the possible area of direct impact of the proposed project.
- The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas.
- The proposed borrow area is located just north of Gulhi Falhu, on the side of the reef with the lowest percentages live coral cover. The closest reef structures to the north, east and west are located more than 2.5km away. To the southeast, Villingili is 1.5km away, and to the southwest, Thilafushi is 1.25km away. The nearest resorts are more than 5km away, well outside the potential area of influence.
- Depending on the monsoon season, the reef structures to the north and northeast may, under severe conditions during the southwest monsoon, be impacted by the suspended sediments generated at the TSHD borrow area. During the northeast monsoon, Villingili and Thilafushi are likely to experience some increase in suspended sediments. These impacts are temporary, and will disappear within a few days after the dredging works have ended.
- The suspended fine sediments may get caught up in the Southern currents occurring in the area. These currents would tend to carry any suspended sediments over coral reefs at the northern section of the atoll. It should be noted that the reef in this area is in a relatively poor condition when compared to the reef in the southern side of the atoll and, therefore, the possible impacts of sedimentation and turbidity would not be as severe as it would be in the case of healthier reefs.

- It must be taken into account here that the current status of the coral on Gulhi Falhu reef is not significantly high and the trend in the last years has shown a decline in quantity and diversity. According to the Divers Association Maldives, nearby resorts and local dive centers this declining autonomous trend in species abundance and biodiversity is due to the impact of Thilafushi and fishing.
- Fish population is often affected when their gills are stuck by suspended sediments. There will be loss of habitat for a large portion of the juvenile species. Most species will stay out of the harm's way by moving to safer areas of the lagoon. However, the juveniles may lose their habitats and this may affect the fish population in the short term.
- If proper mitigation measures are not in place, the impacts may cause long term detrimental effects. Therefore it is vital to take proper mitigation measures to avoid siltation, sedimentation and turbidity as much as possible.

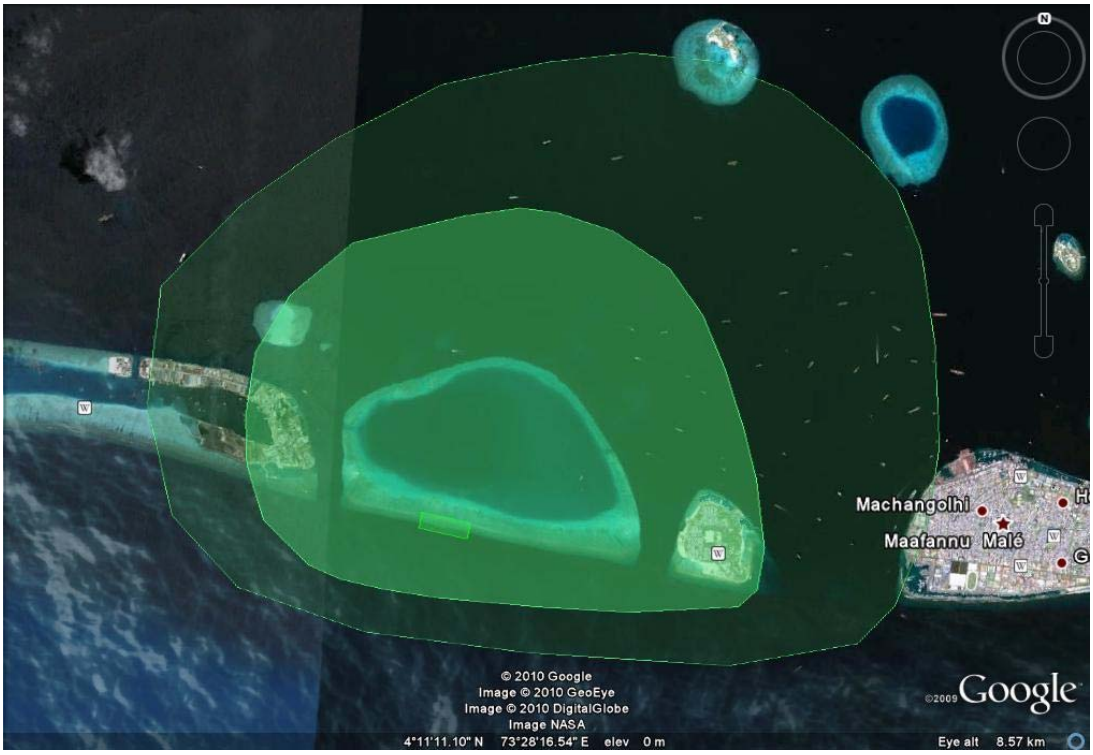


***Figure 9-3** Possible area of impact*

Possible area of direct influence (bright green, temporary increase in suspended sediment concentration during dredging and reclamation works) and less direct influence (darker green, short term reduction of visibility during storm events) of suspended solids released from the proposed borrow area and the reclamation area under worst case conditions.

Mitigation measures

- The methodology adopted by the contractor is TSHD. This method is expected to minimise turbidity at the reclaimed area as the dredged material will have less fines. This is important as sensitive areas are near the receiving area and there are no sensitive areas near the borrow area.
- Creating a temporary bundwall with multiple settlement basins around the dredge area is recommended to prevent suspended sediment outflow during dredging. However, in the first phase of Gulhi Falhu dredging and reclamation, it is impossible to deploy dry earth movement equipment necessary to create these bunds without first creating some dry land. In order to create dry land it is unavoidable that dredged sand is placed by the dredge without bunds being into place.
- It is recommended that the amount of sand that is placed without containment bunds is kept to a minimum. It is also recommended that this sand is placed during incoming tide, to ensure that excess water runs off towards the north, thereby minimising the impact on Hans Hass Place on the south side of Gulhi Falhu.
- Since it is not practicable to enclose the reclamation area with bunds in Phase 1, it is recommended to place silt screens between the reclamation area and the Hans Hass Place and if this will have an added value to the protection of the coral reef. A study of the local current pattern should therefore be studied.
- The project should be completed in a shortest period possible and it is best to carry out the work during low tide and in calm weather conditions to minimise spread of any sediment plume.
- Choice of location of the TSHD borrow area away from coral reefs, coral patches, Marine Protected Areas, resorts and dive sites.
- Use of TSHD as a dredging method avoids dredging an entrance channel for the dredger to be able to reach the reef lagoon.
- Use of limited overflowing when dredging sand from the atoll seabed by TSHD.
- The project manager, and the work force involved during the operation of the work should be briefed of environment friendly practices.
- The work should be properly supervised and monitored to minimise any adverse effect on the environment.
- The marine environment should be monitored for sedimentation and siltation stress and possible impacts on the biological aspects such as bottom benthos. This is further outlined in the monitoring programme given in this EIA report.

9.3.1.2 Loss of marine bottom organisms and habitats

- The potential impacts due to the actual dredging procedure are considered to be of high significance at borrow area. Lagoon bottom is a habitat for certain organisms such as worms, mollusks, amphipod etc. which are important food sources for bottom feeders such as certain species of fishes. For the reclamation, sand will be mined in the seabed in the atoll lagoon to a depth of 1 meter or less by a TSHD. It is estimated that an area of 1,000,000 square metres (m2) will be affected in the first phase of the dredging through direct removal of benthic communities and habitats and disturbing habitats of lagoon bottom organisms. However, it has been found elsewhere that lagoon bottom dwelling organisms re-establish within few months after such disturbances. Direct removal of hard bottom substrate for dredging can result in loss of habitats for fish, and other benthos.

- The land reclamation to enlarge the island will result in a permanent loss of marine habitats and resources. However, the land reclamation is limited to the shallow reef area and will not destroy the coral reef areas at the reef slopes at the lagoon side and the ocean side. The reef flat itself is of low ecological value.

9.3.1.3 Noise, Vibrations and Air Pollution

- Dredging and reclamation works will continue 24 hours per day.
- Experience from the projects at Viligili and Vilufushi has shown that the dredge (in those cases a CSD) cannot be heard on the island while it is working. Distance from the island to the dredge varied from 100m to 500m. A TSHD generates a similar amount of noise while pumping material ashore as a CSD, so no noise impacts are expected from the dredges.
- At the reclamation area, bulldozers, excavators etc will be working non-stop. This will generate some noise, but it is unlikely that this noise will be heard on Villingili. During north eastern and eastern winds, some noise may be heard on the east side of Thilafushi when reclamation takes place at the west site of Gulhi Falhu.
- Due to the open nature of the working areas, air pollution is assumed to be minimal. Since the dredging activities take place entirely in a wet environment dust problems will not be encountered during dredging and reclamation.
- With proper mitigation measures, it is unlikely that noise and air pollution impacts will cause long term effects such as human health risks leading to increased public and private health costs. Nevertheless, mitigation measures will be undertaken to ensure that air pollution and noise will be minimised.

Mitigation measures

- All vessels, vehicles and machinery will be tuned and well maintained to minimise air pollution and noise level.

9.3.1.4 Impact on Unique Habitats

- The proposed dredging and reclamation works is anticipated to cause significant detrimental impacts on the dive site Hans Hass Place (Kiki reef) which is located just south of the Gulhi Falhu reef. This dive site, which is a declared marine protected area, is well known for the presence of a large variety of fish species. It is reported that the dive sites around Maamigili were significantly affected due to dredging and reclamation activities carried out in Maamigili. Since Gulhi Falhu area is a similar setting, it is expected that behavior of some of the fish species will be significantly affected and might move away from the dive site and most turbid zone around the reclamation area permanently.
- Phase 2 reclamation is expected to cause irreversible detrimental effects to Hans Hass Place. Therefore, a more detailed impact assessment needs to be undertaken as part of the EIA for Phase 2.
- The impact on corals on the steep slopes is considered relatively small due to their orientation. The amount of live and healthy corals on this dive site is also relatively limited compared to other dive sites and has decreased significantly over the last years.
- The Divers Association of the Maldives has been consulted on the subject.

Mitigation measures

- As mentioned in the earlier section, it is recommended to study whether it is technically possible to place silt screens between the reclamation area and the Hans Hass Place and if this will have an added value to the protection of the coral reef by studying the local current pattern in the area.
- If it is technically possible, silt screen will be used between the reclamation area and the dive site during phase 1 and 2.
- Suspended sediment levels at the Hans Hass Place MPA and nearby dive sites will be monitored as part of the water quality monitoring program described in chapter 9.
- It is proposed that a new area is declared as a Marine Protected Area by Environmental Protection Agency to compensate for the decline of Hans Hass protected area.
- Coral transplantation on a pilot scale to compensate for coral loss as a result of the Gulhi Falhu project could be considered as a compensation measure after completion of the project. The transplantation has to add value to the location of the reception area and not cause any loss to the donor area. The transplantation pilot will be a small scale project and will have to be financially feasible.

9.3.1.5 Impact on Current Patterns

- No study has been done on the impact of dredging and reclamation on the local current patterns in the Maldives. However, experience from similar dredging and reclamation projects in the Maldives, such as Hulhumale', suggest that such activities may result in stronger current pattern in the impacted area. Based on this, it is anticipated that the local current patterns around the Gulhi Falhu area is likely to get stronger. Due to lack of baseline data of the area, the extent of this impact is not known.

Mitigation measures

- As mentioned in the previous section, it is recommended to study the local current pattern in the area to gather sufficient baseline information and undertake further studies to test the impacts of dredging and reclamation on the current pattern in the area before the second phase of the proposed dredging and reclamation commences.

9.3.1.6 Impact on Visual Amenity

- The natural character of the vicinity of the proposed development has been already affected by the presence of the waste management site in Thilafushi. The proposed project will affect the amenity value of this area by developing a natural reef area to some extent. It is considered that any adverse effects of the proposed development on natural character and visual amenity of the area are likely to be minor.

Mitigation measures

- Complete the dredging works in the shortest time possible.
- Landscape the reclaimed land to provide a feel of a coral island of Maldives

9.3.2 Impacts on the Socio-economic Environment

9.3.2.1 Impact on Fishing Activities

- No significant economic impact on commercial fisheries sector in Male' Atoll is anticipated from the proposed development.
- Gulhi Falhu reef is known to be a recreational reef fishing area for nearby islands (Vilingili and Male'). However, fishing is not allowed in the marine protected area Kiki Reef.
- Dredging and reclamation will restrict fishing activities from the area temporarily for about one week. In addition, fishing will also be affected in the short term as fish population is expected be decreased due to sedimentation and habitat loss. These effects may also continue medium term on a lesser degree of significance. The effects of increased suspended sediments will mainly be limited to within 500-1000 m from the reclamation run off point and the borrow area. Fishing for bait fish will still be possible at islands and reefs located 5 km or more away.

Mitigation measures

- See mitigation measures for sediment control.

9.3.2.2 Impact on Navigation of Boats

- Gulhi Falhu is used as a direct route by the Barge transferring waste from Male' to Thilafushi. During the dredging and reclamation of Phase 1, vessels transferring waste will need to take an alternative route which increases travel time by ten minutes each way. The current transport route through Gulhi Falhu may not be available in the long term when Phase 2 and 3 are developed.
- The waste transfer barge makes ten trips daily requiring additional two barrels (400 litres) of fuel per day for the addition travel time. This is estimated to cost an additional 5000 Rufiyaa per day. This cost will be borne by the Government as it is a municipal service.
- Marine traffic might be affected by the dredging and reclamation activities. Dredging activities in the borrow area can temporarily increase the turbidity in the water making visual navigation around the shallow reefs difficult. However, the effects will be temporary and alternate routes can be taken by vessels without significant additional costs.

Mitigation measures

- Use of navigation aids around shallow reefs when visual navigation is temporary impossible in order to prevent groundings.
- Announcements on radio and news papers giving information on temporary navigational disruptions.

9.3.2.3 Impact on Tourism

- As discussed in the previous sections, a marine protected area Kiki Reef, located less than half a kilometre from the proposed reclamation area of Phase 1, will be significantly affected during the construction activities due to sedimentation. This will be a significant impact on tourism industry as

many divers use Kiki Reef dive site. Most significant impact will be short term, however, this impact is likely to continue long term on a lesser degree of severity.

- There are two resorts located in the vicinity of Gulhi Falhu within north Kaafu atoll. Giraavaru is located approximately 5 km north west of Gulhi Falhu while Kurumba Maldives is located about 6.7 kilometres on the north east of Gulhi Falhu. In addition, Vaadhoo (5.58 km) and Velassaru (6.32km) are located to the south of Gulhi Falhu across Vaadhoo Kandu in south Kaafu atoll.
- The proposed construction works may affect aesthetics of the area which will be seen when landing aircrafts at Male' International airport and during transfer to the resort. However, the construction activities of Phase 1 will last for approximately one week.
- As discussed in the previous section, aesthetics of the area will also be affected in the long term from the developments. This impact is not likely to be significant since the urban centres of the country are already located in the close vicinity of the project site.

Mitigation measures

- See mitigation measures in visual amenity**.**

9.3.2.4 Impacts on Employment and Income, Potential for Local to have Temporary Job Opportunities

- It is expected that approximately 10-20 jobs will be available for interested locals with relevant skills. These jobs will be for a period of 6-8 weeks.

9.3.2.5 Level of Protection against Natural Hazards

- Taking into account the presently occurring water levels, the predicted sea-level rise, and the relatively high-value industries and services that Gulhi Falhu land-development will potentially cater for, the finished level of the reclaimed land will be +1.5 m MSL.
- It is noted that most of Malé and the other inhabited islands in the Maldives are at +1.0 m MSL to +1.4 m MSL; so called "Safe Islands" are presently constructed at +1.4 m MSL

9.3.2.6 Impacts on Housing, Conflicting Policies, Demographics and Transportation in the Male Urban Area

- There is not enough information on the operational stage of Phase 1 and the remaining phases (phases 2, 3 and 4) to determine the socio-economic impacts. This EIA deals only with the construction stage impacts of Phase 1. Additional EIAs are required for the operational stage of Phase 1 and the remaining phases of the project, once detailed project designs are available.

9.3.2.7 Impact of Noise, Risks and Pollution on Workers and Local Population

- The contractor, Royal Boskalis Westminster nv, has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.

- Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OHSA and environmental requirements, and are adjusted if a client has even more stringent requirements.
- Dredging vessels used for the project are IMS certified and will meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Hence, the impact of noise, accidents and pollution on workers is expected to be minor.
- Experience from the projects at Vilingili and Vilufushi has shown that the dredge (in those cases a CSD) cannot be heard on the island while it is working. Distance from the island to the dredge varied from 100m to 500m. A TSHD generates a similar amount of noise while pumping material ashore as a CSD, so no noise impacts are expected from the dredges.
- At the reclamation area, bulldozers, excavators etc will be working non-stop. This will generate some noise, but it is unlikely that this noise will be heard on Villingili. During north eastern and eastern winds, some noise may be heard on the east side of Thilafushi when reclamation takes place at the west site of Gulhi Falhu. Therefore the impact of noise on local population is temporary and is likely to be minor.

9.3.2.8 Impact on Local Population (Social Values, Norms and Beliefs) due to Presence of Workers of Dredging Company

- It is not anticipated that the social values, norms and beliefs of local population will be affected due to the presence of workers of dredging company since majority of the workers will be onboard the TSHD vessel while the rest will be housed in Thilafushi.

9.3.3 Construction related Hazards and Risks

9.3.3.1 Pollution of the Natural Environment

- During dredging and reclamation works and the construction of breakwater/revetments any accidental spill of oil and toxic substances will contaminate the marine and/or groundwater.
- Waste water, oily wastewater and solid waste that will be produced during the construction stage will contaminate the marine and/or groundwater if they are not managed properly.
- Groundwater of the newly reclaimed land will be completely saline. It is not known how much time it takes to reach the groundwater to acceptable quality. However, experience from similar projects in the Maldives has shown that the groundwater will improve to the level adequate to establish normal vegetation approximately within one year. It can be considered that it takes approximately one to two years to reach the groundwater to acceptable quality depending on the amount of rainfall. It is noteworthy that Male' region where Gulhi Falhu is not located in a high rainfall area.

Mitigation measures

- All the vessels used in construction will be equipped with wastewater and solid waste handling facilities to collect and handle the wastewater and the solid waste generated by each vessel.
- No waste or waste water will be disposed into the sea.

- Oily wastewater, oily contaminated material generated from the construction machinery during the construction activities and solid construction waste generated during offshore construction works will be collected and transferred back t o on shore for treatment/disposal, to avoid any adverse impact on the marine environment.
- Construction activities will be carried out under the supervision of a suitably experienced person.
- Vessels and machinery used for the work should be properly maintained at all times during the operation to prevent leaks.

9.4 Cost of mitigation measures

Table 9-1 Costs of mitigation measures

mitigation measure	Costs
Use of TSHD to avoid making of entrance channel	Project cost
TSHD borrow areas away from coral reefs, coral patches, Marine Protected Areas, resorts and dive sites	NA
Conduct reclamation work during low tide and in calm conditions to minimize spread of sediment plumes.	NA
All machinery will be properly tuned and maintained to minimize pollution (both air and marine environment)	US$5000
Use of limited overflowing when dredging sand from the atoll seabed by TSHD	Project Cost
Use of navigation aids around shallow reefs to prevent grounding	Project Cost
Place silt screens between the reclamation area and the Hans Hass Place	US$ 8,000
Technical studies on impacts of current patterns due to dredging and reclamation process	US$ 8,000
Coral transplantation on a pilot scale for compensate for coral loss as a result of Gulhi Falhu project.	US$ 6,000
Appointment of a new Marine Protected Area by Environmental Protection Agency (EPA) to compensate for the decline of Hans Hass ecosystem	US$8,000

10 Alternatives

10.1 Introduction

This section looks at alternative ways of undertaking the proposed project. Firstly, at the broad level there are two main options to undertake the project: (1) undertake the project or (2) not undertake the project. The environmental evaluation above has been conducted in view of the latter and this section will explore the no project option.

10.2 No Project Option

The no project option takes the following into account.

- The existing island remains as it is in its natural state.
- Light industries in Male' will remain as they are causing inconvenience to public and pollution.
- Goods will be temporarily stored in any space available, whether the space is suitable or not, leading to the risk of spillage and accident.

The advantages and disadvantages of the no project option are discussed in Table10.1 below.

Table 10-1 Advantages and Disadvantages of the No Project Option

Advantages	Disadvantages
• Environmental problems related to development can be avoided. Absence of reclamation activities keeps the lagoon and reef in good health; • Ensure the protect reef Ki ki Reef not disturbed and damaged from project activities • No development costs to the Proponent • The proponent avoids a high probability of bearing costs associated with highly probable future erosion and flooding • No economical loses to the Waste Management Centre to run Thilafushi barge	• The location remains economically stagnant and the opportunity cost on Maldivian economy is very high. • Loss of business to the Proponent • Loss of government revenue • Political and social problems due to lack of employment and economic development opportunities • Increase of ethical and social problems well within the Male' and greater Male' area. • Increase in high land cost for Male' and grater Male' region • Rise of cost of the living

Despite the environmental disadvantages of the no project option, the socio-economic benefits are too numerous for this project to be undertaken. The modern day mitigation technologies if followed properly as prescribed in this document will ensure negative impacts are managed efficiently, when implemented properly.

10.3 Alternate dredging options

The project requires up to 1 million m^3 of suitable fill sand for phase 1 and 2. The possible sources of fill material are the following:

- Option 1: Sand from the reef lagoon area to be dredged by a CSD (Cutter Suction Dredger) with a pipeline system; this option is an attractive alternative both from an economic and an environmental point of view, provided there is enough sand of sufficient quality available in the reef lagoon.
- Option 2: Sand from the seabed of the atoll lagoon just north of Gulhi Falhu, to be dredged by a TSHD (Trailing Suction Hopper Dredger); this is a realistic alternative depending on the water depth of the seabed in the atoll lagoon, and the available quantity of sand within the atoll lagoon. Sand mining in the atoll lagoon can be done by a Trailing suction hopper dredger. As the water depth is between 20 – 80m, a large TSHD is required.
- Option 3: Sand and coral material from a coral reef elsewhere in the Kaafu atoll to be dredged by a CSD; will cause considerable damage to the environment.
- Option 4: Sand imported from overseas by a jumbo trailer (very large trailer); will result in very high costs.

Dredging with a CSD at the reef lagoon area means that an access channel into the Gulhi Falhu reef lagoon needs to be dredged. Where this channel is dredged, most likely on the atoll (north, east or west) side of Gulhi Falhu where live coral cover percentage are low (between 0-10%), coral reef communities will be destroyed. On the other hand, the total area of seabed directly impacted by dredging is smaller when using a CSD than when using a TSHD.

Working with a TSHD in the atoll will generate a source of suspended sediments in a location further away from Gulhi Falhu. This will cause temporary impacts on both the environment as well as on navigation. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected. The benthic fauna will, over time, recolonise the seabed at the borrow area.

Working with a CSD elsewhere in the atoll will cause damages to the life organisms at a second reef and coral patches.

The costs of dredging overseas with a jumbo trailer will be very high.

The possible alternate methods and locations for acquiring suitable fill material for reclamation are as follows:

Options	Pros	Cons
1: Sand from the reef lagoon area to be dredged by a CSD (Cutter Suction Dredger) with a pipeline system	• Environmental impacts will be limited to the already shallow and sediment	• All impacts related to reclamation on reef flats
2: Sand from the seabed of the atoll lagoon just north of Gulhi Falhu, to be dredged by a TSHD (Trailing Suction Hopper Dredger).	• Environmental impacts related to dredging will be minimal on the lagoon and reef	• All impacts related to reclamation on reef flats • The affected area in an open lagoon will be 5-10 times higher than a shallow reef flat
3: Sand and coral material from a coral reef elsewhere in the Kaafu atoll to be dredged by a CSD	• Environmental impacts on the dredged reef • Other impacts associated with the transport, loading and unloading of sediments. • Cumulative effects high as two reef systems are disturbed.	• All impacts related to reclamation on reef flats • High costs • Social conflicts associated with other island objections
4: Sand imported from overseas by a jumbo trailer (very large trailer)	• Environmental impacts related to dredging will be minimal on the lagoon and reef	• All impacts related to reclamation on reef flats • Very high costs • Potential to introduce foreign species and diseases.

Based on these results, dredging sand from a borrow area in the atoll lagoon by TSHD is the preferred option. Dredging sand in the reef lagoon by CSD is a viable alternative option, provided the location of the access channel is chosen properly (i.e. at a location where live coral cover is lowest)

In sum, the proposed option 2 appears to be the preferable option for this project. It has lower cumulative environmental impacts and is the least costly option. This assessment only looks into the impacts of dredging. Impacts from reclamation are expected to remain constant for all four options.

10.4 Alternatives for borrow areas

There are three major alternative locations for the mining of sand for the development of Gulhi Falhu.

1. Mining sand by trailer dredger (TSHD) from the seabed in the atoll lagoon. In this case it is most likely that the dredging dept will be 1 meter or less; in that case the affected area will be some 1,000,000 m^2 during phase 1.
2. Dredging sand (by cutter dredger/ CSD) within Gulhi Falhu□s lagoon area. The area affected, will be between 350,000 and 750,000 m^2.
3. Dredging sand (by cutter dredger/ CSD) within a shallow reef or reef lagoon area nearby.

- Dredging within the reef lagoon area by a CSD (option 1) will affect an area of about 350,000 - 500,000 m^2. The created depth within the dredging area will be about 15-20 meter inside the reef lagoon, which is 8-15m deep. In case dredging is carried out within the atoll lagoon by a TSHD (option 2), it is most likely that the dredging depth will be less than 1m. In that case the affected area will be at least 1,000,000 m^2, which is 2-3 times larger than in case of dredging within the reef lagoon.
- For this project, the depth of the borrow area is directly related to the dredging method used. When a Cutter Suction Dredger (CSD) is employed, a relatively small but deep borrow area will be created in the reef lagoon. A Trailer Suction Hopper Dredger (TSHD) will create a relatively large and shallow borrow area in the seabed of the atoll lagoon at greater water depths.
- Working with a TSHD in the atoll will generate a source of suspended sediments in a location outside the Gulhi Falhu reef. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected. The process of filling the reclamation area by TSHD however will allow for more control over the release of suspended sediments from the reclamation area.
- Working with a CSD elsewhere in the atoll will cause damages to the life organisms at a second reef and coral patches and is therefore not seen as a viable alternative.
- Since benthic organisms live in the top 30 – 40 cm of the seabed and on the seabed, the damage to the benthic communities at the reef flat area will be much smaller compared to dredging the atoll lagoon area. It is expected that on the sandy reef flat area, limited benthic communities are present, due to the limited water depth and the high water temperatures. On the sandy seabed areas in the atoll lagoon, it is likely that more benthic communities will be present, due to the conditions being less extreme. However, in areas where high current speeds occur, the presence of benthic fauna will also be limited. Additionally, benthic fauna communities have the capacity to recolonize areas with disturbed seabed fairly quickly. Recovery in highly dynamic systems is quick, taking anywhere from as little as a few months up to a few years.
- Based on the above alternatives options and from an ecological point of view regarding the benthic communities, dredging at a reef lagoon or reef flat area would be preferred over dredging in the atoll lagoon area. However, given the availability of suitable dredging material in the atoll lagoon, this area is preferred above Gulhi Falhu's reef lagoon. Dredging in the atoll lagoon is also the preferred option with respect to the impact on nearby coral reefs.

10.5 Alternatives for Design of the Reclamation Area

As for the design of the reclamation area there are five options

1. Enclosed reclamation area with bunds all around in all phases of the reclamation
2. Open reclamation area without bunds in all phases
3. Reclamation area with no bunds in phase 1 and 2 and with bunds for phases 3 and 4
4. Reclamation with single or multiple settlement basins
5. Use of silt screens to filter sediment

Option 1: involves more complicated logistics since Gulhi Falhu reef is completely submerged and there is no material to create bunds with at the start of the development. Material needs to be imported to create the bunds. Additionally there needs to be land reclaimed before excavators or bulldozers will be able to prepare the bunds for the revetments. Another option is to build the bunds from the water. For this cranes on pontoons, barges or a hopper with sand. The impacts on the environment are localised (limited to an area around the island and inside the lagoon where the construction of the revetment takes place) and manageable. The revetment will reduce the size of the impact area during reclamation activities by keeping the excess water containing fine sediment within the bunded area. Release of this water is manageable. The import of sand from overseas, the equipment and the long execution time make this option economically prohibitive.

Option 2: has simple logistics since no preparations need to be made prior to the reclamation. The impacts on the environment are temporary increased turbidity levels, a relatively high load of sediment which is potentially difficult to control, due to the fact that excess water will be released on all sides of the reclamation and during each phase. Environmental impacts are therefore more difficult to manage. This makes this option environmentally prohibitive.

Option 3: has moderately easy logistics. Phase 1 and 2 will be executed according to option 2. Before phase 3 and 4 will commence bunds can be set up with material stored on the reclamations from phase 1 and 2. The bunds can be set up with excavators and bulldozers from the now existing land. The impacts for the creation of the bunds on the environment are localised (limited to the area of the revetment) and manageable. The impacts of the reclamation of phase 1 and 2 such as increased turbidity and a high sediment load will however be short term. The turbidity increase and the sediment load during the reclamation of phase 3 and 4 will be reduced, more local and much more manageable.

Option 4: involves additional dredging to create basins and will need to be supported by some sort of bund. Hence, this option is more suitable if used with enclosed reclamation. Moreover, there is not enough rom to create additional basins in the reef flat area.

Option 5: uses a simple method of lining a silt screen around the project area to prevent finer sediments from flowing into the reef system. It's effectiveness is debatable in a large project such as this and involves some

logistical issues for its place. However, if the protection of marine life is a priority, siltscreens provide a best possible option.

Table 10-2 below summarises the impacts for these five options.

Table 10-2 Comparison of impacts from reclamation options

Alternatives / Environmental impacts	**Open Reclamation**	**Closed Reclamation**	**Closed reclamation with one settling basin**	**Closed area with multiple settling basins**	**Silt screens**
Turbidity and sedimentation	Very High	High	Moderate	Low	Low
Lagoon benthos impacts (whole lagoon)	High	Low	Low	Low	Low
Lagoon benthos impacts (work area)	Very High	Very high	High	High	High
Lagoon Fish population	High	High	High	High	Moderate
Reef areas (whole reef system)	High	Low	Low	Negligible	Negligible
Reef areas (near work area)	Very High	Low	Low	Very Low	Low
Reef Fish population	High	Moderate	Low	Low	Low

Based on the analysis of the above discussed alternatives the preferred option is Option 1 will have the least impact on the ecology of the area around the reclamation area and nearby sensitive areas. However this option is economically not feasible and does not fit in the Master Plan of the development of the Gulhi Falhu project. Option 2 is environmentally prohibitive and will therefore not considered as an option. Option 3 is economically feasible with the strongest impact mainly focused on phase 1 and 2. Option 4 involves additional dredging and therefore additional costs. Option 5 is simplest most cost effective method mitigate the immediate effects on marine life. In combination with mitigating measures in order to try and reduce the influence area of the impact this is considered as the preferred option.

10.6 Alternative technologies

Given the potential for strong wave activity in the proposed Quay wall area, a concrete quay wall may not be suitable. Alternatively sheet piles could be considered which has proven highly effective in the Maldives.

11 Environmental Monitoring Plan

The monitoring program and its equipment, monitoring locations and frequencies and reporting requirements, is based on the information needs for the project. The monitoring program includes three sections:

- information needs
- the monitoring program including the equipment, the locations and frequencies
- the monitoring reports

11.1 Information needs

In this monitoring plan, which includes both the construction phase and the long term (both of which will be the responsibility of the project proponent), the most relevant information needs are:

- water quality aspects, including suspended sediments and sedimentation;
- ecological aspects related to coral;
- the re-colonization of the borrow area;
- erosion around the borrow area.
- erosion around the reclaimed island
- changes to currents and waves in proximity to Gulhi Falhu reef

11.1.1 Water quality aspects

Information need: what is the actual effect of the dredging and reclamation activities near Gulhi Falhu on the water quality?

One of the most important potential marine environmental impacts associated with dredging and reclamation works is the deterioration of water quality due to increased levels of suspended sediments and possible reduced oxygen levels.

Due to the re-suspension of the fine fraction of the coral sand, dispersion and resettling of the sediments during the dredging and the reclamation activities, a wide range of effects can be caused, including damage to coral and other organisms that cannot leave the area to escape the increased suspended solids concentrations. If the turbidity level is continuously high for a period of 3 months or more, significant damage can occur to coral.

Significant sedimentation will also cause damage to coral and other sessile organisms. In the EIA a range of mitigating measures has been selected to minimize the re-suspension and dispersion and sedimentation of suspended sediments from the borrow area and the reclamation areas.

However, because the exact effects of the dredging and reclamation works at Gulhi Falhu cannot be predicted in detail, it is necessary to monitor the actual effects of the works on water quality. In this way the scale of the

impacts as well as the duration of the impacts and the influence of the weather conditions will become clearer. The monitoring will have two purposes:

To evaluate the effectiveness of mitigating measures already in place, such as the silt screen and in later phases the bund closing off the reclamation area from the ocean, and the settling basin to signal the need for additional mitigating measures, such as adjustments in the dredging and reclamation processes.

The effects of dredging and reclamation on water quality are directly related to the working activities and the local physical characteristics, like the currents and waves. It is recommended to periodically monitor the currents along the reef to get more information on where the suspended sediments released at the borrow and reclamation areas may be transported to by the local currents.

During the construction of the reclamations at Vilufushi and Viligili, the suspended sediment plume did not disperse further than 2.5km away from the source under storm conditions. Suspended sediments settled within 2-5 days.

11.1.2 Ecological aspects related to coral

Information need: what can cause damage to coral?

At the shallow reef area around the island there is hardly any coral. After the surveys at the shallow reef areas it is estimated that the life coral is less than 1%. Even at the reef edges there is practically no live coral coverage. This is mainly due to the coral bleaching in 1998 and the tsunami in December 2004. Consequently at the shallow reef no monitoring of coral is required. At the line transects that were surveyed on the slopes around the shallow reef area, the live coral coverage varies from less than 5% to 15% at the ocean side and from 0% to more than 10% at the atoll side.

Turbidity and sedimentation

If turbidity levels are significant for several months, the light available to the coral is reduced and consequently coral colonies may die. The Sedimentation on coral is quite different. Soft corals and branching corals are less vulnerable than massive and table corals. Most coral species have a mechanism to clean very fine sediments off of their surface, but they have difficulty cleaning off coarse sediments.

11.1.3 The re-colonization of the borrow area created by a CSD

Information need: how long will it take for the borrow area to be colonised by marine organisms?

Re-colonisation of microbenthos (<1mm) is a much faster process than the recovery of the macrobenthos (>1mm). Complete restoration of the nematodes community can take place within some days. The restoration of the macrobenthos community after the sand extraction depends on the degree in which the new substrate is arranged for re-colonisation and establishment of larvae. The biological period of recovery can take place within some months to 2 or 3 years.

11.1.4 Erosion around the borrow area

Information need: what can cause damage around the borrow area?

The borrow area created by a TSHD will be located at relatively large depth (20-50m). At these depths, waves will not hit the seabed to stir up sediments.

It is expected that currents will barely influence these borrow areas, since the fastest currents run through the channels between islands and reefs where no dredging of sand will take place.

11.1.5 Erosion around the reclaimed island

Information need: How does the island re-adjust to the wave and current conditions?

The reclaimed island will undergo rapid erosion in the short to medium-term. Patterns and rates of erosion and changes to currents around the island needs to be determined to understand the adjustment patterns around the areas where the coastline is left unprotected, namely the eastern side.

11.1.6 Changes to currents in proximity to Gulhifalhu

Information need: How does the current and wave conditions changes around the near vicinity of Gulhifalhu following reclamation?

Anecdotal evidence from Hulhumale' island reclamation project suggests changes to currents and wave activity in the near vicinity due to the blockage created by a new land mass. Currents will need to be monitored between Gulhifalhu, Viligilli and Thilafushi, and immediately inside the atoll.

11.2 The monitoring program

In this section, the requirements, methodology, equipment and monitoring locations and frequency for the monitoring components are presented. Included in this section are:

- water quality monitoring;
- sedimentation monitoring;
- erosion around the borrow area;
- erosion around reclaimed land
- changes to currents in close proximity to Gulhi Falhu reef.

11.2.1 Water quality monitoring

Water quality monitoring shall be carried out by an environmental monitoring team to ensure that any deteriorating water quality is readily detected and that timely action is taken to rectify the situation. The objective of the water quality monitoring program is to determine the effectiveness of the operational controls and mitigation measures employed, and the need for supplementary mitigation measures to protect the coral.

General parameters to be recorded during sampling and measurements

- Location;
- time and date;
- weather conditions;
- sea conditions;
- tide;
- monitoring / sampling depth.

Parameters to be measured in situ

- dissolved oxygen (DO) (% saturation);
- dissolved oxygen (DO) (in mg/l);
- temperature (°C);
- turbidity (NTU);
- salinity (ppt);
- water depth (m).

Additionally, water samples will be taken periodically in conjunction with turbidity readings to determine Suspended Solids Concentration (SSC) and establish a relationship between Suspended Solids Concentration (mg/l) and turbidity (NTU). This relationship will help translate the turbidity readings that are taken at the monitoring locations into SSC so that comparison with the maximum allowed value is possible.

Parameters to be measured in the laboratory

- suspended solids (mg/l)
- heavy metals

11.2.1.1 Methodology

For marine water quality monitoring the following equipment is required:

- a survey vessel with DGPS positioning equipment;
- dissolved Oxygen and temperature measuring equipment;
- turbidity measurement equipment;
- water depth gauge;
- water sampling equipment.

11.2.1.2 Locations and frequency

A total of 8 sampling and monitoring locations (2 of these are background stations) for the water quality have been selected (see *Figure 11-1*). Prior to the start of dredging activities a baseline survey will be done.

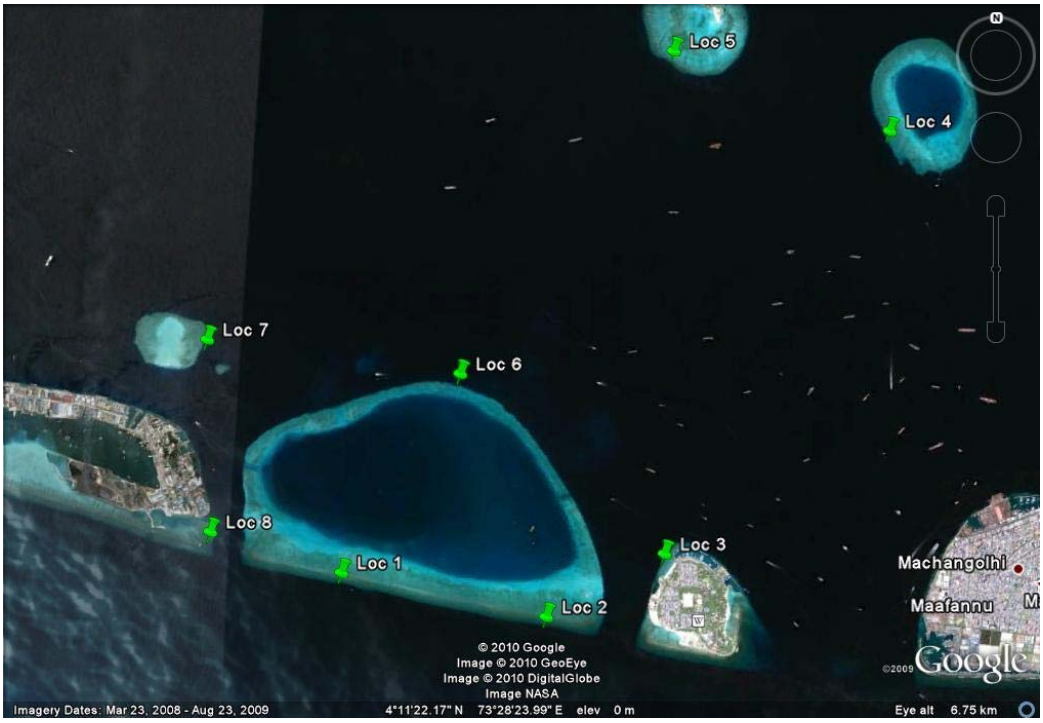


Figure 11-1 Monitoring locations around Gulhi Falhu

It is recommended that the following parameters will be monitored at the indicated frequencies:

Table 11-1 water quality sampling and monitoring

Type	Parameters	Locations	Frequency
In situ monitoring 1m below surface middle of water column 1m above seabed	Dissolved oxygen (% saturation) Dissolved oxygen (in mg/l) Temperature (°C) Turbidity (NTU); Water depth (m).	All locations	2 times per week during dredging and reclamation works + once per day during one week before the start of dredging and during the first week after the start of dredging and reclamation works and during 1 week after completion of the works
Water sampling for laboratory investigations anywhere in the water column	Suspended solids (mg/L)	In the vicinity of dredging and reclamation works	Covering a sufficient range of suspended solids concentration to establish a satisfactory correlation + monthly to update the established correlation Once before the start of the works, once a month during the execution of the works and once at completion of the works
	heavy metals	two locations near the reclamation area and two reference locations	

11.2.2 Monitoring the marine environment

Ecological change often occurs gradually over time. Therefore, long term monitoring and research programs are necessary to accurately assess environmental change. This is particularly true when the change is due to small but chronic perturbations to the environment which have a cumulative effect. It should be kept in mind that (1) many ecological processes are slow occurring over a number of years, (2) inter-annual variability is often high, (3) short term studies miss rare but important events, and (4) monitoring only reveals recent historical events. It should be noted, however, that the proposed activities involve high level turbidity and sedimentation and therefore may have faster rate of environmental change.

The objectives of this monitoring programme are to detect and document the changes occurring to the reef system due to the proposed project. The purpose will be to 1) assess the magnitude of the impacts resulting from the various phases of the project activities 2) evaluate the success of a particular management action, 3) to quantify the change in abundances of certain marine organisms, e.g. indicator species near a sewage outfall and elsewhere to compare.

Table 11-2 gives the coral reef monitoring schedule recommended for the long-term evaluation of reef system and ambient marine environment for impact assessment and mitigation of impacts.

Table 11-2 Reef monitoring schedule

Parameter/Method	Frequency of Monitoring	Purpose
Ambient Environmental Parameters Temperature, Salinity, Turbidity/light penetration, Currents	Twice a month in construction Once every month in operation	Important to the 'health' of living marine resources, reefs and fish populations and other benthos
General status of reef Manta Tow Technique	Once every year or following a significant natural event e.g. coral bleaching, COT infestation etc.	Broad scale qualitative and Semi-quantitative assessment of general status of the reef system / coral and other benthic recruitment
Marine Environmental Aesthetic Survey using Time Swim and Manta Tow Technique	Once a month in construction Once every 6 months in operation	Broad scale semi quantitative assessment of anthropogenic activities e.g. wastes disposal, amount of rubbish on the reef and general appeal of the reef system
Fish population structure / Underwater Fish Census	Once in 3 months in construction Once every 6 months in operation	Quantitative assessment of fish population of selected species
Benthic cover of reef / Permanent Photo quadrats	Once every 3 months in construction Once every 6 months in operation	Quantitative assessment of temporal changes in the reef system e.g. coral growth rates
Sedimentation / Sediment traps deployment/collection	Twice a week in construction Once every 3 months in operation	Quantitative assessment of sediment loading on the reef benthos.
Impacts from Diving and Snorkelling activities / Comparison with control sites using Visual observation	Once every 3 months in operation	Quantitative assessment of damage from these activities.

11.2.3 Erosion around the borrow area

It is expected that the erosion around the borrow area will be rather limited due to the water depth at which the borrow area will be located. Bi-annual bathymetry surveys are recommended for the borrow site. No other monitoring actions are recommended at this stage.

11.2.4 rosion around the reclaimed island

It is necessary to monitor beach profiles at monthly intervals immediately after the reclamation and quarterly thereafter.

Table 11-3 gives the monitoring requirements for the coastal zone to assess the effectiveness of the mitigation measures so that alternatives can be identified if the measures taken are in-effective.

Table 11-3 Environmental monitoring requirements for the coastal zone

Monitoring Parameter	Indicators	Baseline / Reference values	Technique	Frequency
Beachlines	Sediment distribution	Baseline to be collected immediately after the reclamation	Differential GPS	Quarterly
Beach Profiles	Rates of accretion and/or erosion	Baseline to be collected immediately after the reclamation	Beach profile surveys	Monthly for the first 6 months and Quarterly thereafter.
Currents	Nearshore currents	Baseline to be collected immediately after the reclamation	Drogue (spaghetti diagrams)	Quarterly

11.2.5 Changes to currents in close proximity to Gulhifalhu

Current surveys need to be undertaken between the Gulhifalhu and Viligilli, Gulhifalhu and Thilafushi and 1 km north of Gulhifalhu. A baseline measurement will be required before the commencement of the project and quarterly during and after reclamation.

11.2.6 Other monitoring needs

The following aspects will be monitored during the construction stage:

- Daily monitoring to ensure that the cleared areas and other construction processes are not creating any significant dust nuisance for the local environment.
- Daily monitoring of vehicle refuelling and repair to ensure that these exercises are carried out on hardstands and to ensure that they are done properly. This is to reduce the potential of soil contamination from spills. Spot checks will be conducted by the site supervisor.
- Monitor borrow areas to ensure only the designated areas are dredged.
- Regularly monitor bundwalls of silt screen lining to ensure they are intact.
- Monitor dredger activity activities to check for spills.

11.3 The monitoring reports

Weekly monitoring reports during construction.

The weekly reporting will be based on the monitoring results, site inspections and the evaluation/interpretation of the monitoring results.

Based on the weekly monitoring results the effectiveness of the operational controls, the mitigation measures employed and the need for supplementary mitigation measures will be discussed between the Engineer and the contractor on a weekly basis. In case of extreme urgent matters a meeting between the

engineer and the contractor will be arranged within 24 hours. The weekly reports shall be submitted to the engineer, the employer and the contractor.

A detailed annual environmental monitoring report is required to be compiled and submitted to the Ministry of Transport, Housing and Environment yearly based on the data collected for monitoring the parameters included in the monitoring programme given in this Chapter. This report may be submitted to the relevant Government agencies in order to demonstrate compliance. If required, however, a monitoring report for the proposed work phase may be prepared and submitted to the Ministry of Transport, Housing and Environment. 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 contractors and supervisors to ensure possible negative impacts are mitigated appropriately during and after the project.

11.4 Cost of monitoring

The cost of monitoring is estimated to be US$ 15,000 annually. Professional consultants will be hired to undertake the monitoring and the necessary equipment for monitoring will be procured.

11.5 Commitment to monitoring

The proponent is fully committed to undertake the monitoring programme given in this Chapter. An arrangement has been made with a consultancy firm to conduct construction phase monitoring programme.

12 Conclusions

12.1 Environmental

The following conclusions are drawn, based on the gathered information:

- The reclamation of Gulhi Falhu with revetments on the exposed sides can be done with medium impacts on the environment in phase 1 if preventative measures (silt screens, closed reclamation or use of siltation basins) are implemented during construction and further mitigating measures are implemented when necessary.
- A closed reclamation with siltation basins is not possible in phase 1 but partial protection could be provided and is the most suitable option for the time being.
- During the dredging and reclamation activities, good care should be taken to allow only a pre-determined minimum of suspended sediments to escape from the working areas.
- Preventative measures will be in place to ensure minimal loss of suspended sediments, and additional mitigating measures will be available for implementation should the need arise. Monitoring should concentrate upon these aspects.
- Some coral reef will be impacted at locations near dredging and reclamation works. All feasible measures will be taken to minimise the amount of coral damage by dredging the absolute minimum required volume of sand needed to fill the reclamation area.
- Monitoring activities are essential. In particular, monitoring of damage to coral reefs, their recovery, changes to currents and wave activity around the Gulhi Falhu is essential.

12.2 Socio-economic

The socio-economic impacts from the construction stage of phase 1 of the project will mainly be on the following groups:

- Dive schools around the area: they anticipate a loss of dive sites around Gulhi Falhu once the project is completed.
- Waste management services section: changes to travel routes and increase in time and costs for waste transfer is anticipated
- Recreational fishermen: temporary disruptions are anticipated.

Impacts to these groups may not be fully mitigated and they understand that the socio-economic benefits outweigh the environmental costs associated with the development.

There is not enough information on the operational stage of phase one and the remaining phases (phases 2, 3 and 4) to determine the socio-economic impacts. This EIA deals only with the construction stage impacts of phase 1. Additional EIAs are required for the operational stage of phase 1 and the remaining phases of the project, once detailed project designs are available.

13 References

1. *Environmental Impact Assessment Regulations*, Ministry of Environment, Energy and Water, Government of the Maldives, 2007
2. *EIA for the Post-tsunami Reconstruction of Safe Island Vilufushi, Thaa Atoll*, EDC, 2005
3. *EIA for the Construction of Safe Island Viligili*, EDC, 2006
4. *Environmental Impact Assessment for the Three Islands Project – Thulhaadhoo, Baa Atoll*, Hydronamic, 2009-2010
5. *Environmental Impact Assessment for the Three Islands Project – Hinnavaru, Lhaviyani Atoll*, Hydronamic, 2009-2010

14 Annexes

1. Terms of Reference approved by GoM

2. Presidential Degree (2007) and approval letter from Ministry of Finance and Treasury

(May 2010)

3. Gulhi Falhu Land use Master Plan

4. Consultation meeting 23rd June 2010: invitation letter, attendance list, minutes of meeting

5. Dive sites & resorts in the North and South Male atoll

6. Turtle nesting sites in the Maldives

7. Environmental Management Framework (Boskalis SHE-Q)

8. Bathymetry Survey

9. Queen of the Netherlands Specification