ENVIRONMENTAL IMPACT ASSESSMENT

FOR THE REMOVAL OF SEAGRASS AND BEACH REPLENISHMENT ACTIVITIES IN HERATHERA ISLAND RESORT, ADDU ATOLL, MALDIVES

Proposed by

Maldives Tourism Development Coorperation

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Executive Summary

This Environmental Impact Assessment (EIA) is an evaluation of the potential environmental, socio-economic and natural impacts of the proposal for removing seagrass and undertaking beach replenishment at Herathera Island Resort, Addu Atoll. The proponent of this project is Maldives Tourism Development Cooperation (MTDC) and the EIA consultant is CDE Consulting.

Introduction and Key Features of the Project

Project Background

The Herathera Island has been experiencing seaweed overgrowth for a number of years, even before construction began on the island. Similarly, the island does not have a natural beach system which is suitable for a resort product. An attempt was made in 2007 and 2008 to remedy these shortcomings by removing seagrass and undertaking beach replenishment. Unfortunately, the beach replenishment design and implementation was flawed and new seagrass colonies have started to emerge. The island is currently is a worse condition, particularly its beach system. These environmental issues are decreasing the economic value of the tourism product being offered Resort and is reaching a point where the product may be unviable. Immediate action is required to address these issues, thus, a new and improved beach replenishment and seagrass removal programme.

Project Objectives

- Improve the Tourism Product Offered on the Resort
- Aesthetic improvement of lagoon
- Aesthetic improvement of beach area
- Maintenance of swimming areas
- Mitigate Beach Erosion

Project Scope

The proposed project involves the removal of sea grass colonies and beach replenishment. Details of the proposed project components are outlined below.

Project Scope and work methodology

a) Sea grass removal

The primary component of the project is seagrass removal. Seagrass areas covering approximately 200,000 – 250,000 m^2 is proposed to be cleared (see Site plan in Appendix B), 100,000 m^3 of dredge waste. Two methods have been proposed for the project: 1) using a sand pump; 2) using an excavator and; 3) soft measures.

b) Beach Replenishment

Beach replenishment has been considered as part of the project to mitigate the severe erosion on the island. The dredged waste from the sea grass removal activity, after cleaning and sorting, will be used to replenish the a 2900 m beach up to 10 m from the existing shore line. Additional sand will be dredged from borrow areas within the lagoon using sand pumps and excavators. Replenishment will be carried out using a three staged process. The first stage will collect and filter sediments on designated sites. The second stage will transfer the cleaned sediments to severe erosion zones using trucks. The final stage will profile the beach using fine sand. For the direct replenishment, sand will be pumped or transferred via barges to a designated location, where loaders and trucks and move the material.

Project Schedule and Life Span

Mobilisation for the project will begin after the EIA is approved. The works are target for before the peak tourist season. It is anticipated that the completion of the whole project will take approximately 4-5 months.

Conformance to Laws and Regulations of Maldives and International Conventions

The key laws and regulations of the Maldives to which the proposal is applicable are:

- Environmental Protection Act,
- Environmental Impact Assessment Regulations 2007,
- Fisheries Act of the Maldives
- Tourism Act and Regulations
- Regulation on Sand Mining
- Ban on Coral Mining

This project conforms to these laws and regulations.

Environmental Impacts

The potential significant impacts from the project are summarized below:

Potential Adverse Impacts during Sand Pumping/Dredging

- Damage to coral reef, lagoon benthos and fish population due to turbidity and sedimentation during dredging

- Changes to coastal processes
- Potential marine water contamination from accidental oil spills
- Potential ground water contamination
- Noise and air pollution
- Vibrations

Potential Adverse Impacts during beach replenishment

- Changes to coastal processes leading to erosion.
- Sedimentation
- Potential marine water contamination from accidental spills
- Noise and air pollution

Potential Positive Impacts from the overall Project

- Improved tourism product
- Job opportunities
- Reduced cost of beach replenishment

Alternatives

The key alternatives considered for this project are as follows:

- "No-project" Alternative
- Alternative Dredge Waste (sand and rubble) Disposal Methods
- Alternative Seagrass Disposal Methods
- Alternate Borrow Areas
- Dredging Alternatives
- Sedimentation control measures

Environmental Monitoring Program

Monitoring program is based on the information requirements of the project.

The key areas highlighted in the program are:

- *Sedimentation*– Ensure that silt screens or bundwalls are in place during sand pumping works and check for murkiness of water by visual observation on a daily basis. In addition the water quality of the dredging site shall be monitored on completion, two months after completion and thereafter annually by checking the levels of turbidity, total suspended solids (TDS) and dissolved oxygen (DO) levels by laboratory analysis. In addition, the weather conditions and sea conditions (tidal mode and currents) shall be recorded so that dredging works can be avoided during harsh weather and sea conditions.
- *Marine Water Contamination* – All machinery that will be used for the proposed works/activities shall be properly tuned and maintained on a daily basis to avoid any leakage or accidental oil spillage.
- *Water Depth* – the depth of the water of the dredging site shall be monitored during the project and upon completion of the project.
- Erosion and coastal changes
- Beach profiles at given locations immediately after dredging works and there after annually.
- Beachline at high tide and low tide and eroding areas marked using GPS
- Longshore currents at beach profile locations and in selected points around the lagoon
- The proponent is committed to undertake the monitoring programme.

Conclusion

In conclusion, this assessment has comprehensively evaluated the components of the project, the exiting environment and the predicted impacts on the marine environment. The project is soundly designed based on experiences of previous projects and avoids the serious mistakes made during the previous project. There are significant marine environmental impacts from this project which cannot be totally mitigated. However, the scale of impacts can be reduced from significant-adverse to moderate with mitigation measures proposed in this report. Ongoing monitoring should be enforced by both the developer and the EPA to determine the extent of environmental impacts and review remedial measures.

1 INTRODUCTION

1.1 Purpose of the EIA

The purpose of this Report is to fulfil requirements under Article 5 of the Environment Protection and Preservation Act (4/93) of the Maldives to remove seagrass communities and beach replenishment activities in Herathera Island Resort.

This report is developed for Maldives Tourism Development Cooperation by CDE Consulting.

1.2 Project Need and Justification

- The Herathera Island Resort has been experiencing seaweed overgrowth for a number of years, even before construction began on 2006. This was reported in the first EIA undertaken for the island in 2006. Subsequently, two key measures were undertaken to prevent overgrowth of seagrass. First, a channel was dug between Herathera and Hulhudoo, effectively separating the two islands. It was expected that this project would facilitate the flow of currents from the oceanward side of the atoll to the lagoon wardside, thereby improving the water quality and controlling seagrass overgrowth. A separate EIA was undertaken for this project. Secondly, an extensive programme of seagrass removal was undertaken in 2008, by the new owner, Yacht Tours Private Limited. An EIA was not submitted for this project.
- Over the last few years, there has been a significant increase in the seaweed growth and its territorial expansion. The proponent has occasionally undertaken 'soft' measures to control the expansion of overgrowth with little success. This includes occasional clearing of overgrowing areas, especially close to the beach and in foreshore areas. The new overgrowth is taking place in the shallower areas of the reef flat as well as in 3 m deep lagoon.
- The presence of seagrass is having a detrimental effect on the tourism product offered on the island. First, the beaching of dead seaweed matter is reducing the aesthetic quality of the coastal environment leading to constant complaints from the limited guests. The cleaning activities to restore the beach environment quality are further generating numerous complaints due to privacy issues. Secondly, the area available for swimming is affected with the increase in seagrass coverage.
- Herathera is also known for lack of natural beach. The oceanward side has strong wave activity and therefore comprise of a coral rubble beach system. The original beach on the lagoonward side was minimal, with waves running up to the vegetation line. Coastal erosion, however, was not reported as serious issue in the first EIA.

- To remediate the problem, the new operator, Yacht Tour Private Limited undertook a beach replenishment project. Unfortunately the project was poorly designed and had disastrous results on the quality of the beach. The project involved replenishing the beach by excavating sediments from within 15-20 m of the existing beach. The material was poor and not suitable for a tourism product. Subsequently, the effects of erosion were severe: the fine sediments were transports back into the lagoon by wave activity and excavated holes next to the beach led to constant loss of sediments while the beach profile adjusted. The result was rubble dominated beach.
- Herathera Island has since been undergoing chronic severe erosion on its western side. Since the initial replenishment activities of 2008 it has lost approximately 3 m a year leading to the construction of temporary groynes to control the negative impacts.
- Since taking over from Yacht Tours Private Limited, the proponent has been seeking to sign a contract with a new operator. One of the requirements for this lease is the redevelopment of the beach to a standard acceptable as a tourism product. This project is partly aimed at restoring the beach to meet this requirement.
- The timing of the activity is crucial from an environmental impact minimizing perspective, since the island is currently undergoing stabilization following the recent redevelopment and beach replenishment activities. It is important that new developments be undertaken as soon as possible so that the natural coastal adjustment period can be used to undertake all major coastal modifications on the island.
- These environmental issues have decreased the economic value of the tourism product offered in Herathera Island Resort, to an extent where the resort may no longer be viable without remedial actions.

1.3 Aim and Objectives

The aim of this project is to improve the natural environment of the island to a standard which can offer a quality tourism product on Herathera Island Resort.

1.3.1 Aesthetic improvement of lagoon

As noted above, the presence of seagrass in the lagoon is generating numerous complaints as the guests are uncomfortable swimming in seagrass debris and in the dark lagoon bottoms created by the sea grass colonies.

1.3.2 Develop the beach to a standard expected in a coral island resort

Provision of a beach is of utmost priority and critical to the viability of the product offered on Herathera. The key task is to remedy the negative effects of the previous replenishment attempt by learning form the mistakes made during the design and implementation of the project.

1.3.3 Aesthetic improvement of beach area

The beach area is regularly being littered with seagrass debris. The cleanup effort requires cleaning twice a day. During high tides, sea grass debris is deposited along the high tide wash zones, reducing the aesthetic value of the beach. The volume of debris collected appears to be increasing day by day.

1.3.4 Maintenance of swimming areas

The swimming areas become unusable during certain times of the day due to the presence of sea grass debris.

1.4 Scope and Terms of Reference of EIA

The scope of this EIA is broadly based on the Environmental Impact Assessment Regulations 2007. The assessment more specifically adheres to the Terms of Reference (ToR) issued by the Environmental Protection Agency on 25 August 2010. The ToR is based on scoping meetings held between the stakeholders on 18 August 2010. A copy of the ToR is attached in Appendix A. The EIA report contains both natural and socio-economic assessments and includes the following main aspects.

A description of the project including the need for the project, how the project will be undertaken, full description of the relevant parts of the project, implementation schedules, site plans and summary of project inputs and outputs *(Chapter 1&2).*

A description of the pertinent national and international legislation, regulations and policies that are relevant and applicable to the project and a demonstration of how the project conforms to these aspects *(Chapter 3)*

Information about the exiting baseline environmental conditions of the site. These include coastal and marine environment of the site and natural hazard vulnerability of the site *(Chapter 4).*

An assessment of the potential impacts (environmental, social, and economic) during both construction and operational stages of the project as well as identification and cost of the potential mitigation measures to prevent or reduce significant negative impacts during both construction and operation stages of the project *(Chapter 5).*

Assessment of alternatives for the proposed project *(Chapter 6)*

Details of the environmental monitoring plan *(Chapter 7).*

1.5 Summary of Assessment Methodology

The process followed in the preparation of this EIA report consists of five parts. These are: scoping consultations; literature review; field surveys; analysis of results; and compilation of the assessment in the form of a report.

The first step of the process covered consultations with client and government agencies to determine the scope of the impact assessment. During this stage the client clearly outlined their development needs and assessment was geared to match the development plan and environmental assessment needs. The environmental assessment needs was determined based on the EIA Regulations 2007 and the issues brought forward by the Environmental Protection Agency in the scoping meeting.

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 similar developments in island settings. In this context, the EIA Regulations 2007, best practices from similar development activities, scientific studies undertaken in similar settings around Maldives and previous documents/historical publications was considered.

The third stage involved field assessment on the island and areas covered by the EIA scope. Conditions of the existing environment were analysed using established scientific methods. The fourth stage involved in house analysis using scientific analysis methods to identify, predict and assess the impacts and alternatives. These methods will be explained in detail in later sections.

The final stage involved compilation of individual consultants' findings.

1.6 Review of Similar Projects

As described above, a seagrass removal and beach replenishment project was undertaken in Herathera in 2007 and 2008. Although the proponent for that project was Yacht Tours Private Limited, MTDC was indirectly involved in its implementation. The previous project serves as guide to avoid the design faults and malpractices during its implementation. The following issues were identified during the previous project.

a) The design of the replenishment programme was poor and almost nonexistent. In particular the beach was not properly profiled and the sediment size and grading was not considered. Project was designed on the site and by the construction team.
b) The borrow areas were poorly chosen. First the sediment quality was not assessed before replenishment. Second, the borrow areas were adjacent to the beach causing extensive erosion of the replenished beach as it tried to readjust is foreshore and nearshore profile. The mini basins

created in the borrow areas acted as sediment sinks which attracted the finer material. Consequently, the basins comprised of clay material (very fine sand) which was difficult to use by swimmers.

c) There was no construction supervision by qualified professionals, particularly a person with environmental background. As a result the workers were not aware of the consequences of their actrivities.

d) There were no impact mitigation measures undertaken. As a result the lagoon was murky for over a year. The calm nature of the western lagoon during NE monsoon should have been considered during the project design.

e) There is no evidence that an EIA was undertaken by the previous operator, Yacht Tours Private Limited, before this project was undertaken. A properly conducted EIA may have flagged prevented the design and implementation limitations of the previous project.

This design of this project addresses these key short-comings of the previous project. Details of the design components are addressed in the next chapter.

This project also can use the experience of the beach replenishment activity in the neighbouring Shangri-la at Viligilli Island Resort and Spa, since both these island share similar geophysical settings. A similar seagrass removal and beach replenishment project was undertaken in Shangrila during 2007 and 2008. Unfortunately, their first attempt was similar to the project undertaken by Yacht Tours Private Limited in Herathera. Fortunately, the developer acknowledged the mistakes early-on and commissioned a new project to redevelop the beach of Shangri-la. The EIA consultants of this project designed the beach management system in Shangri-la and help supervise its implementation. The same team is also undertaking ongoing monthly beach monitoring in Shangri-la. This Shangri-la project was designed to suit the Maldivian conditions. The material on the original beach was matched with the borrow areas and the beach slopes were profiled to match the SW monsoon wave activity. Erosion prevention measures were also installed below water level after considering the nearshore profile of the beach. Hence, the Herathera Beach Management Plan document, the basis for the design of this project has already incorporated experiences form the Shangri-la project.

In addition to these two projects, the dredging and reclamation project in S.Hulhudhoo, S.Meedhoo, S.Hithadhoo and S.Feydhoo were also considered, both in terms of baseline conditions and likely impacts.

1.7 EIA Team Members

The team members of this EIA are:

Dr. Simad Saeed (Environmental Management and Planning Consultant, Team leader)

Dr. Ahmed Shaig (Coastal Environment Consultant)

Mr. Mohamed Faizan (Marine Environment Consultant)

Mr. Ali Moosa Didi (Surveying and cartography)

Mr. Mohamed Shinaz Saeed (Field Assistant and Diver)

The curriculum vitae's of the EIA consultants are attached in Appendix F of this report.

2 PROJECT DESCRIPTION

2.1 Project Location

Herathera Island is located on the eastern rim of Addu Atoll (see figure 2.1). It is approximately 3900 m long and 200 m wide, and has a land area of approximately 58 Ha (see figure 2.2). Herathera is one of the largest resort islands in the Maldives. The island is about 11 km from the Gan' International Airport. It's nearest inhabited island is Hulhudhoo-meedhoo just north of the island. The nearest resort is Shangri-la at Viligilli Resort (7 km).

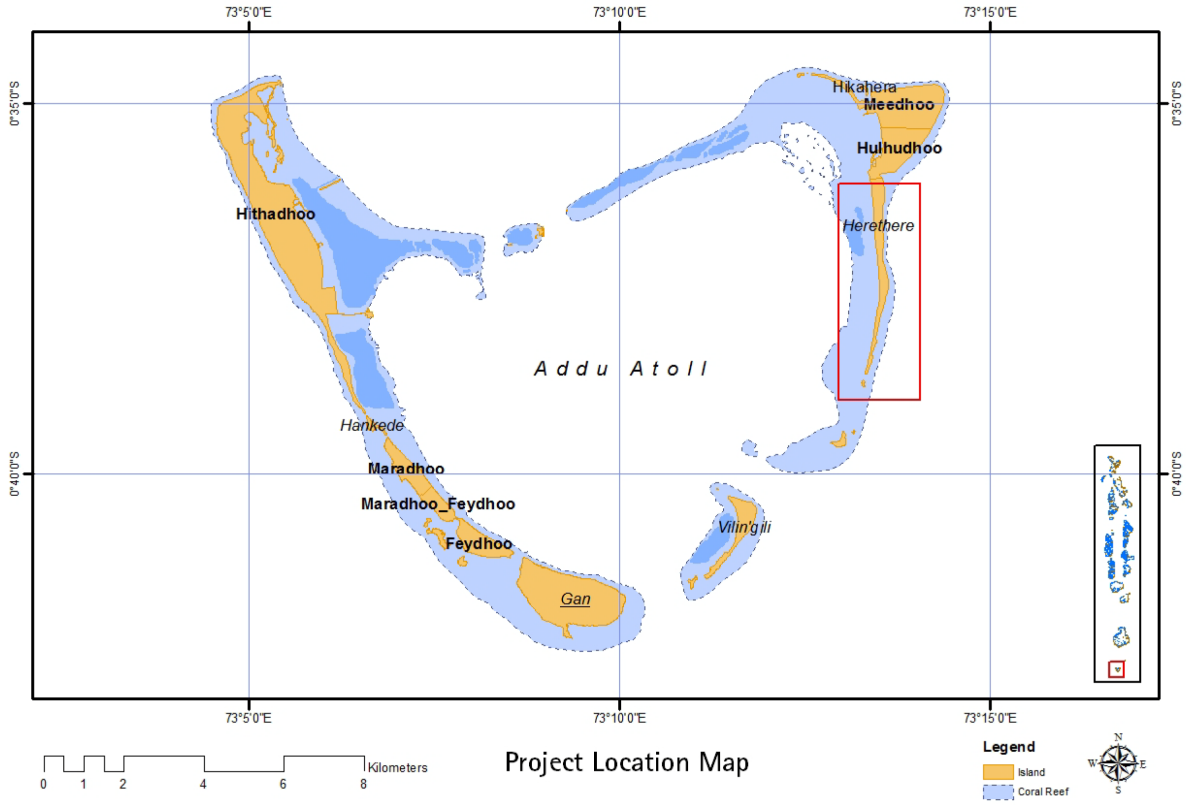


Figure 2.1: Location of proposed project site

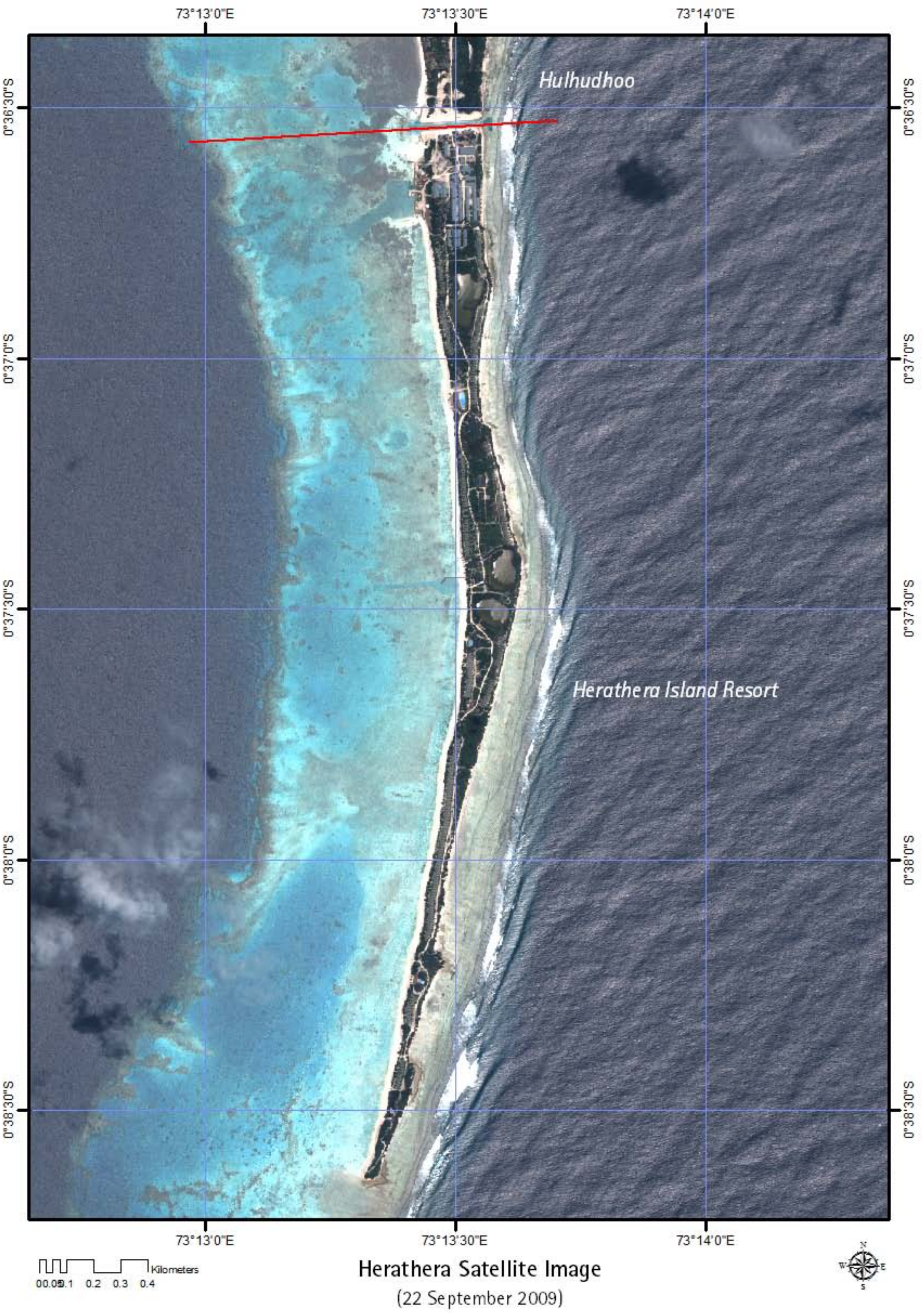


Figure 2.2: Detailed location of proposed project site

2.2 Project Site Plan

The proposed site plan for the project is presented in Appendix B. A Reduced version of the site plan is provided in Figure 2.3 below.

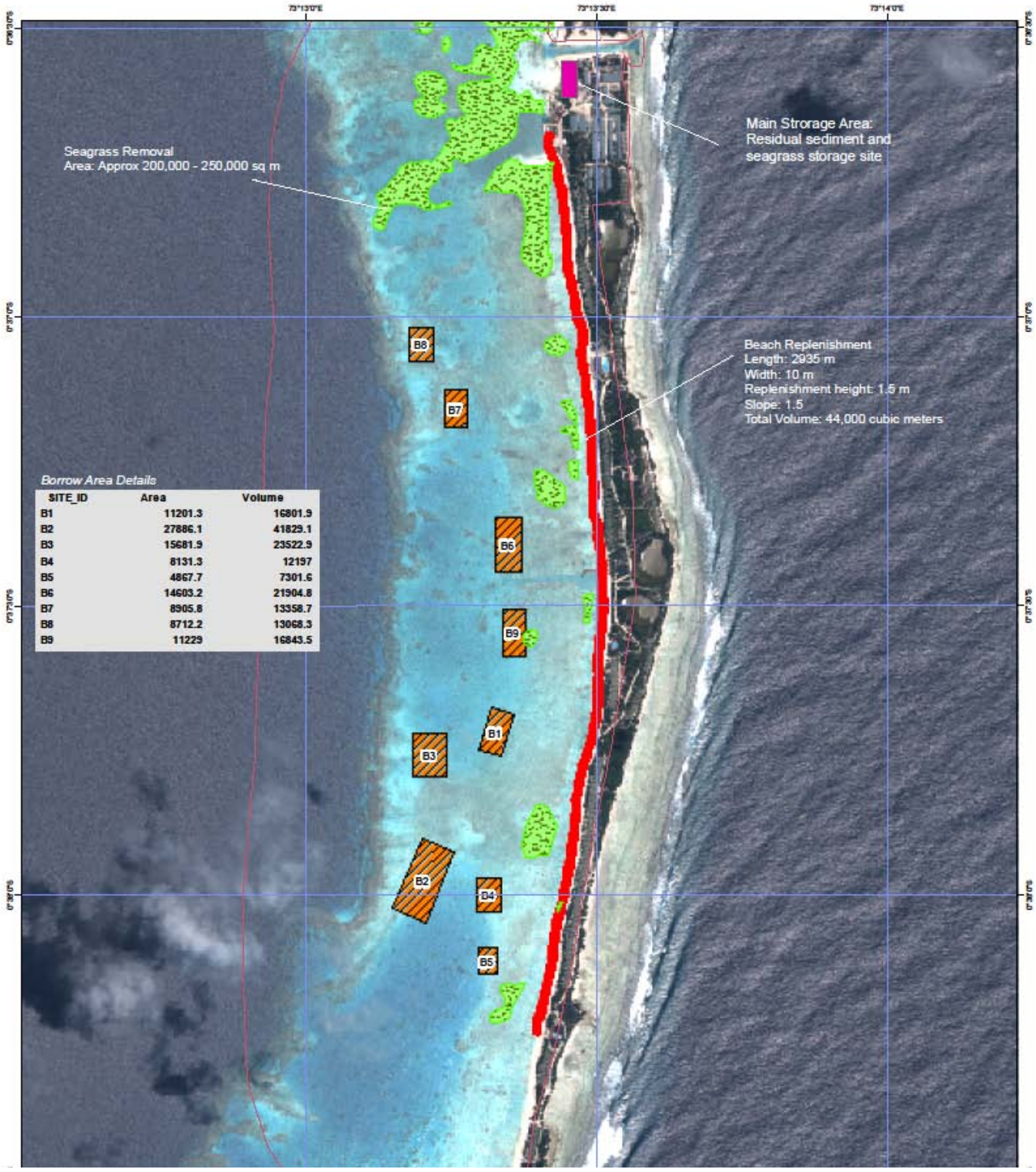


Figure 2.3: Site Plan

2.3 Existing Site Conditions

- The coastal environment of the proposed site has been significantly modified over the last 4 years; particularly after 2008 (see Figure 2.4). Key modifications include a channel cut through the island, extensive dredging activities, land reclamation, beach replenishment activities and sea grass removal activities. These activities have considerably modified the western shoreline of the island. Other modifications include temporary coastal protection structures along the western shoreline.
- Modifications activities have also been undertaken in the neighbouring Hulhudhoo.
- The natural process of the island is still functioning apart from the along shore sediment transport blockage caused by the service jetty and dredged basin.
- The Hulhudhoo-meedhoo area has a history of seagrass overgrowth going back till the 1960s. Growth around Herathera only began in the last 15 years.
- Current flow on the western side of the island is restricted due to the 4 km long island. Waves and currents during NE monsoon is negligible on the western side. Such calm conditions have been reported as being responsible for keeping the lagoon murky for over a year following previous sediment removal activity.
- There is a very strong current flow on the newly opened channel and the southern end of the island.
- Wave activity on the site is strongest during the SW monsoon.

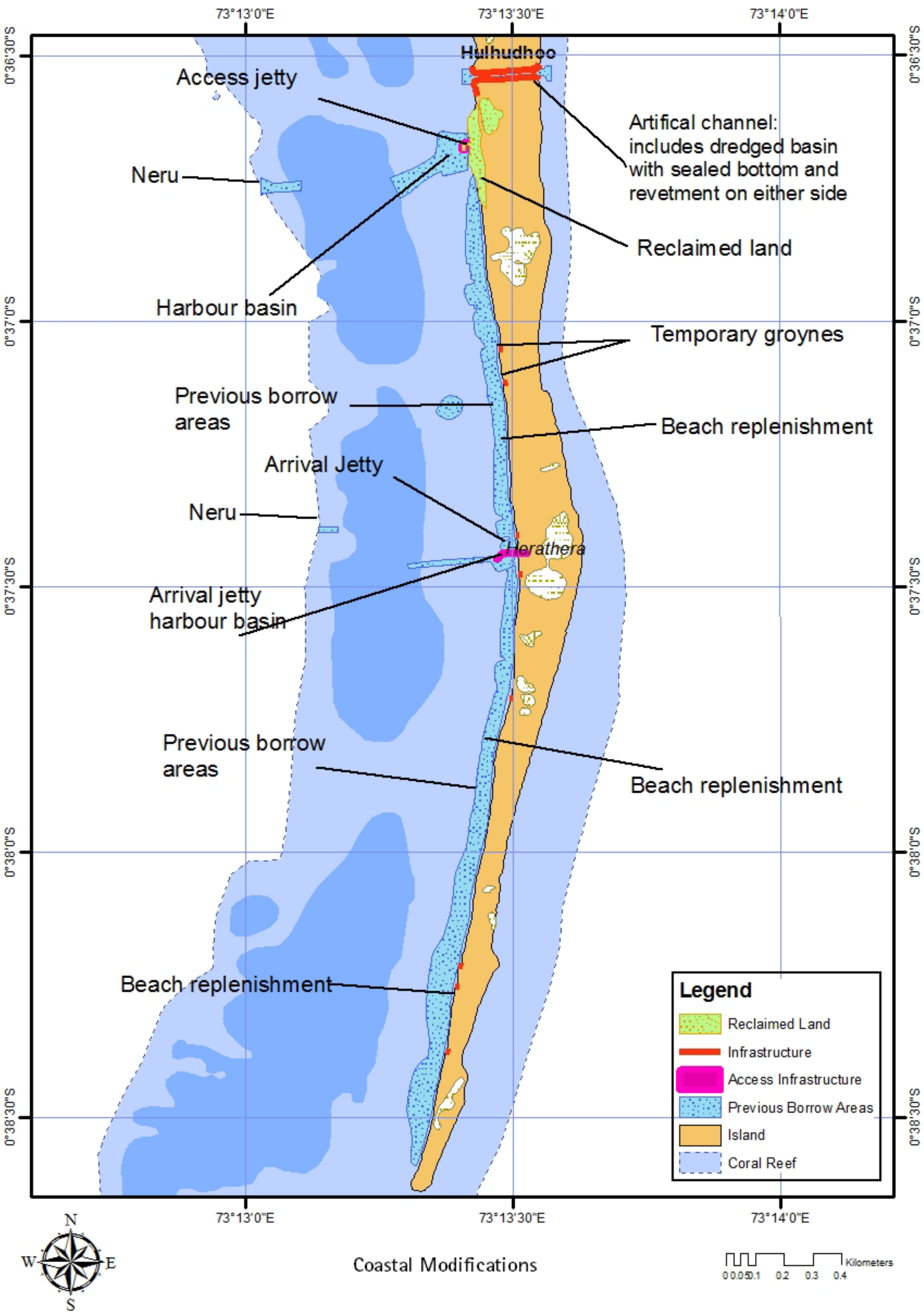


Figure 2.4: Summary of existing coastal modifications

2.4 Project Outline and Work Methodology

The proposed project involves the removal of sea grass colonies and beach replenishment. Details of the proposed project components are outlined below. The boundary areas affected by the project is shown in Appendix B.

2.4.1 Sea grass removal

Seagrass areas covering approximately 200,000 – 250,000 m^2 is proposed to be cleared (see Site plan in Figure 2.3 and Appendix B), creating up to 100,000 m^3 of dredge waste. Two methods have been proposed for the project: 1) using a sand pump; 2) using an excavator and; 3) soft measures.

a) Using an Excavator

The main method considered is using an excavator. The use of an excavator will require the placement of temporary sand beds to access the sea grass zones. Barges cannot be used for its deployment in the shallow areas (less than -1.5 m MSL) due to the shallow waters and deep draft of the barges. Once the excavators reach the sea grass zones, the top layer of the reef flat (0.2 to 0.3 m) will be scraped.

The dredged waste will be transported to designated locations on the beach or around the reclaimed area near the service jetty using trucks. These areas will be determined during construction. This is to minimise disruptions to guests during daytime. A second round of transportation may be required to move the material from collection sites to the main storage site (see Appendix B).

Once on the main storage are the material will be sorted for sea grass debris and fine to coarse sand. The seagrass debris will buried under the previously reclaimed wetland near the service jetty (see figure 2.4 and Appendix B) to create fertiliser and to make the reclaimed areas suitable for revegetation. The coarse to fine sand will be used for beach replenishment and profiling. The estimated percentage of residual debris including sea grass is 40%. Any larger coral pieces unsuitable for beach replenishment may be used in the future for construction and shoreline protection on the northwestern side (near staff area). Any excess sand stored in the area will be used in future construction and road works on the island.

b) Using a Sand Pump

The alternative method for removal is using sand pumps. Sand pumps will be placed on barges within the lagoon and sand, along with the seagrass, will be pumped in the designated areas. The top layer of the lagoon bottom, approximately 0.2-0.3m, will have to be cleared to ensure complete removal of the seaweed, particularly its root systems. The pumped sand will be filtered for sea grass and separated from the sand, as much as possible. The separated seagrass will be dealt with as specified above. A silt screen will be placed around the pump site(s) to minimise the chances of seagrass being dispersed into the lagoon.

The effectiveness of the sand pump will need to be tested in the hard reef flat areas and away from the coastline. The pumps have diminishing pumping capacity in distance beyond 150 m. Alternative methods as proposed below may be required for these zones.

c) Using 'Soft' Measures

Some sea grass areas could be considered for 'soft' measures. These include the use of plastic or rubber sheets over the sea grass zones to deny them sunlight. Sun light is essential for sea grass growth and this method has been implemented successfully in other resort islands. The down side is this approach is its temporary nature. This method may require repetition every 3-5 months.

Other options include using a specially designed rake during low tide, to remove the sea grass and its root system. These methods are however not applicable to areas with dense sea grass and in deeper waters.

Both these alternatives will be difficult to implement for this project due to the sheer size of the seagrass colonies involved.

2.4.2 Beach Replenishment

Beach replenishment has been considered as part of the project to mitigate the severe erosion and to remediate the negative effects of previous improper beach replenishment line (see Appendix B). The replenishment design details are as follows:

a) Beach length required to replenish: 2,935 m
b) Replenishment width: 10 m in general; in areas with severe beach losses, replenishment up to 15 m has been considered since the beach has already retreated well past the previous beach line.
c) Estimated total amount of sand required: between 45,000 to 50,000 m^3
d) Replenishment height: 1.5 m
e) Slope: 1.5

There are two sources for sand. First, the dredged waste from the sea grass removal activity will be used, where possible. This process will require filtering and may be time consuming but it may be more cost effective. Based on the experiences of the previous project, it is unlikely that the existing sea grass areas will provide enough material with the size of sediments required for beach replenishment. It has become apparent that these areas generally comprise of coarse coral rubble which are unsuitable for a beach as a tourism product. The second option for sourcing sand are the alternate borrow areas as shown in Appendix B. Approximately nine sites have been temporarily identified. A visual inspection of these sites has been undertaken but the actual volume of fine sediments is unclear. The estimated total volumes in these areas well exceed the requirements for beach replenishment. The idea behind this proposal is that not all of these sites will be used but selected sites with enough material. The most likely sites are B1-B5 on the southern half of the island. The volumes, area and location of each borrow site is presented in Appendix 5.

The methodology for beach replenishment and sand sourcing is mix between using excavators and sand pumps. All areas accessible with sand pumps will use sand pumps to extract sand. Sand pumps are more reliable as it partially filters material suitable for beach development. The extent of impacts on the bottom substrate is also minimal from sand pumps and the effort required to complete the task is also smaller using pumps. The second method is using excavators. All areas not accessible by pumps (due to distance) will use excavators to mine sand. Shallow waters will use a temporary sand bed and deeper water will use a barge to transfer sediments from the lagoon to shore. The already dredged access jetty area will be used for barge access.

The final stage of the replenishment activity will be beach profiling the beach using fine sand. The slope and height of the beach will be adjusted to design levels to ensure limited loss due to erosion.

2.4.3 Erosion Prevention

Based on the experience of Shangri-la a properly profiled and layered beach is likely to fair a lot better against erosion in these settings. However, a contingency plan of using submerged geotubes placed approximately 20 m away and parallel to the beach line has been considered. In addition, the use of temporary geo-bags as groynes has also been considered. However, these options will only be planned after monitoring beach changes and in line the Herathera Beach Management Plan.

2.5 Project Schedule and Life Span

Mobilisation for the project will begin after the EIA is approved. The works are target to end before the peak tourist season. It is anticipated that the completion of the whole project will take approximately 4 months.

In general, the first stage will concentrate on removing the seagrass removal and cleaning activities. This is expected to take 3 months to complete and is expected to be undertaken during the end of SW monsoon. It is not the ideal timing in terms of lagoon conditions but it may also help in preventing murky conditions for longer periods after construction.

The second stage will involve replenishment. This component is expected to start in parallel to the sea grass removal work and is expected to be completed within 4 months. Works are expected to be completed before the beginning of next NE monsoon. Work will begin from the south, where sediment is available and work its way up the coastline.

2.6 Labour Requirements and Availability

Due to the nature of the proposed project, the works will be put up for tender amongst pre-identified groups. It is projected that the total number of employees during the construction stage will be between 30 and 40. They will be based in a designated section of the staff area. Their daily requirements for food, water and other necessities will be provided within the existing staff services framework.

2.7 Waste Management, Logistics and Safety Measures

2.7.1 Construction Waste Management and Disposal

Construction wastes that will be created are mainly dredge material. As discussed above, some dredge material will be used for beach replenishment. Large coral remnants are not expected as the dredge depth is very shallow. The remaining unusable material will be stored for future use (see previous section).

A large quantity of marine green waste in the form of sea grass will be produced. It is proposed to bury the material under the reclaimed wetland in the staff area. This would ensure safe and cost effective disposal of the biodegradable material.

Small amounts of waste oil may be generated from the operation and maintenance of vehicles. All waste oil will be disposed as per the approved standards of the Environment Ministry.

Alternatively, all dredge waste can be transported to Thilafushi for controlled disposal or could be disposed to deep sea. However, the volume of waste will be large and may be uneconomical to transport such long distances.

2.7.2 Pollution and Emission Control Measures

The following measures will be taken to ensure minimal pollution during construction stage.

- Machinery will be properly tuned and maintained to reduce emissions and minimize risk of spills/leaks.
- All paints, lubricants, and other chemicals used on site will be stored in secure and bunded location to minimize risk of spill.

2.7.3 Sediment Containment and Turbidity Control Measures

The proponent is committed to prevent any sedimentation of the reef system from this proposed project. The following specific measures will be undertaken during the project.

- Establish silt-screens around the dredging/sand pumping area to control sediment disbursing. Silt screens will be removed after the sediment has been adequately settled within the lagoon. Screens will be required in both the borrow and replenishment areas.
- Undertake work during calm weather conditions.

2.7.4 Health and Safety Measures

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

2.8 Summary of Project 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 2.1 and the type of outputs (products and waste streams) and what is expected to happen to the outputs are given in Table 2.2

Table 2.1 Major Project Inputs

Input resource(s)	Source/Type	How to obtain resources
Construction workers	Local and foreign	Contractor's employees or by announcement
Engineers and Site supervisors	Local and foreign	Contractor's employees or by announcement
Water supply (during construction)	Desalinated water	From resort operations
Electricity/Energy (during construction)	Diesel	From resort operations
Machinery	Excavators, loaders, trucks, sand pumps, sand pump pipes, barges ..etc	Contractor's machinery or hire locally where available
Maintenance material	Maintenance parts and fluids required for the machinery and piping.	Import or purchase locally where available
Food and Accommodation	NA	From resort operations
Fire fighting equipment	Smoke Detectors, Fire Extinguishers...etc.	From resort operations
Fuel	Light Diesel, LPG Gas, Petrol,	Local suppliers

	Lubricants	
Telecommunication	Mobile phones, fax machines and internet facilities	From resort operations
Food and beverage bottles	PET bottles, glass bottles, packaging waste, plastic bags and various frozen, packaged and fresh food.	From resort operations

Table 2.2 Major Project Outputs

Products and waste materials	**Anticipated quantities**	**Method of disposal**
Green waste from sea grass	Large quantity	Buried under the reclaimed wetland area or sent to Hithadhoo waste site
Dredge waste	Large quantity	Used for beach replenishment and remaining material stored in a designated site near the staff area. Will be used for future construction and road development works.
Waste oil	Small quantities	Barrelled and sent to Thilafushi site during demobilisation.
Hazardous waste (diesel)	Small quantities	Barrelled and sent to Thilafushi site during demobilisation.
Noise	Only localised	Excavator and truck operation will be noisy. No option available.
Food waste	Small quantities	Managed under existing waste management plan of the island
Plastic and packaging wastes	Small quantities	Managed under existing waste management plan of the island

2.9 Demobilization

Demobilization plan depends on the contractor. In general, the proponent advocates a phased demobilization plan to commence in the last month of the contract. Machinery transported from Male' will have to be demobilized on one specific date.

3 POLICY AND LEGAL FRAMEWORK

These legal and policy provisions have to be fully respected in carrying out the proposed development. All contractors and sub-contractors will be informed of these requirements. This project conforms to all relevant laws and regulations of the Maldives.

3.1 Relevant Environment Legislation

3.1.1 Environment Protection and Preservation Act (Act no. 4/93)

- Environment Protection and Preservation Act of Maldives (4/93) is the framework law on environmental management in the Maldives. Articles 2, 4, 5, 6, 7, and 8 of the law are relevant to this project.
- Article 2 states that the concerned government authorities shall provide the necessary guidelines and advise on environmental protection in accordance with the prevailing conditions and needs of the country. All concerned parties shall take due considerations of the guidelines provided by the government authorities. The project proponent shall abide by any guidelines or advice given by the concerned Government authorities for the project. The concerned Government authorities are identified in this Chapter.
- Article 4 states that the Ministry of Housing, Transport and Environment shall be responsible for identifying protected areas and natural reserves and for drawing up the necessary rules and regulations for their protections and preservation. The proponent shall ensure that there is no negative impact from the proposed project on any protected areas.
- According to Article 5 (a) of the Act, an Environmental Impact Assessment study shall be submitted to the Ministry of Housing, Transport and Environment (MHTE) before implementing any activity that may have an impact on the environment. This EIA report is prepared and submitted by the project proponent to fulfil the legal requirement stipulated in Act (4/93) Article 5.
- According to Article 6, the Ministry of Housing, Transport and Environment has the authority to terminate any project that has any undesirable impact on the environment. A project so terminated shall not receive any compensation. The project proponent is aware of this provision and will take all practical measures to ensure there is no irreversible and significant negative impact of the project.
- Article 7 of the Environment Protection Act (4/93) prohibits the disposal of wastes, oil and gases in a manner that will damage the environment. Wastes, oil and gases has to be disposed off in areas designated by the Government. Hence, the project proponent shall use the existing Environmental Management Plan for the Heratheral Island Resort which specifies how the wastes, oil and gases generated by the project will be disposed.

- Article 8 of the Environment Protection Act (4/93) prohibits the disposal of hazardous wastes. Any hazardous wastes that may be generated from the project shall be transferred to the designated waste site in Thilafushi for disposal according to Government regulations and standards.

3.2 Relevant Regulations and Guidelines

- Environmental Impact Assessment regulations were issued by Environment Ministry on 1st May 2007. The first step in environmental assessment process involves screening of the project to be classified as one that requires an EIA or not. Based on this decision, the Ministry then decides the scope of the EIA which is discussed with the proponent and the EIA consultants in a "scoping meeting". The consultants then undertake the EIA starting with baseline studies, impact prediction and finally reporting the findings with impact mitigation and monitoring programme. This report follows the principles and procedures for EIA outlined in the EIA regulations.

- The EIA report is reviewed by MHTE following which an EIA Decision Note is given to the proponent who will have to implement the Decision Note accordingly. As a condition of approval, appropriate environmental monitoring may be required and the proponent shall have to report monitoring data at required intervals to the Ministry. The project proponent is committed to implement all impact mitigation measures that are specified in this EIA report. Furthermore, the proponent is committed to environmental monitoring and shall fulfil environmental monitoring requirements that may be specified in the EIA decision note as a condition for project approval.

- With the Tourism Law as the basis, the Ministry of Tourism has released environmental regulations for tourist resort development and operation in 2006. In the design, construction, and development of the beach the environmental regulations issued by the Tourism Ministry will be adhered to.

- Regulation on sand mining covers sand mining from uninhabited islands that have been leased; sand mining from the coastal zone of other uninhabited islands; and aggregate mining from uninhabited islands that have been leased and from the coastal zone of other uninhabited islands. This regulation is of direct relevance to the proposed project.

- Coral mining from house reef and atoll rim has been banned through a directive from President's Office dated 26 September 1990. Coral would not be mined and used in any stage or activity of this project.

- In the development of the beach, the proponent will follow the 01 February 2006 dated regulations issued by the Environment Ministry on the cutting down and uprooting of trees. This regulation has several clauses that are relevant to the project. These include: Article 2: Planting of two coconut trees for each coconut tree felled and planting of two trees for each tree felled in the island; Article 3: Prohibition on the removal of any vegetation within 15 meters from beach; and Prohibition on the removal of any vegetation from a mangrove system or wetland and within a perimeter of 15 meters around a wetland or mangrove system. The Article 3 of this regulation applies to this development and the proponent is committed to meet this obligation.

3.3 Environmental Permits Required for the Project

3.3.1 Environmental Impact Assessment (EIA) Decision Note

The most important environmental permit to initiate project work would be a decision regarding this EIA. The EIA Decision Note, as it is referred to, shall govern the manner in which the project activities must be undertaken. This EIA report assists decision makers in understanding the existing environment and potential impacts of the project. Therefore, the Decision Note may only be given to the Proponent after a review of this document following which the Ministry may request for further information or provide a decision if further information is not required. In some cases, where there are no major environmental impacts associated with the project, the Ministry may provide the Decision Note while at the same time requesting for further information.

3.4 Responsible Institutions

The main government institutions that have roles and responsibilities relevant to this project are summarised below.

3.4.1 Ministry of Environment

The Ministry of Environment is mandated for the effective implementation of the Environmental Protection Act of the country and has the statutory power over issues related to the environment. It has the central control over the environment protection, management, conservation and environmental emergencies. The Ministry operates mainly at a policy level and the more regulatory and technical assessment activities are mandated to the Environmental Protection Agency (EPA). In this respect EPA has now been mandated to manage all issues relating to Environmental Impact Assessment of individual projects.

The Ministry of Environment also seeks the advice of National Commission for the Protection of Environment (NCPE) on all significant environmental matters. The commission is appointed by the president and is mandated to advice the Minister of Environment on environmental matters such as environment assessment, planning and management, and political decisions with regard to the protection of environment.

3.4.2 Ministry of Tourism

The Ministry of Tourism is solely responsible to the affairs relating to development and operation of all tourist resorts and tourism developments in Maldives. All matters relating to the development of the beach and mining of sand should be communicated with Ministry of Tourism, who will arrange or facilitate for the matter to be dealt within the government framework. All regulations released by Ministry of Tourism and other agencies pertaining to the operation of tourism projects are monitored and implemented by the Ministry. Hence, the major contact point for this project is Ministry of Tourism.

3.4.3 Southern Province Office

Recently the Government has grouped the 20 administrative areas of the Maldives under seven provinces to facilitate the local governance system and decentralised decision making enshrined in the new constitution of the Maldives adopted in 2008. Addu Atoll belongs to the South Province and a Province Office has been established in Hithadhoo. A Minister of State for Home Affairs is responsible for the Province Office. The Province Office is the main focal point of Government Ministries in the North Central region and they co-ordinate and liaise with Government Ministries on all issues relating to the Province.

3.5 International Conventions

3.5.1 Convention on Biological Diversity

The Maldives is a party to the United Nations Convention on Biological Diversity. The objective of the convention 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". The proposed development activities outlined in this project does not fall on any area recognised for its ecological value. Therefore it is unlikely there will be a major loss of biodiversity. The loss is not going to be significant at atoll or national level. Yet, it is recommended that the developer ensures that silt screens are used during dredging works, construction of the jetty and breakwaters to minimise any impact on the marine biodiversity.

3.5.2 International Plant Protection Convention

The Maldives has become a party to the International Plant Protection Convention (IPPC) as a step to protecting native plant species in the Maldives from the risk of diseases introduced by imported plant varieties. The Maldives adhered to the IPPC on 3 October 2006 and the Convention requires that certificates of phytosanitary condition and origin of consignments of plants and plant products be used for import and export of plants and plant materials. Contracting parties have the full authority to regulate entry of plants and plant products and may prescribe restrictions on imports or prohibit importation of particular plants or plant products. Thus it is advisable that the proponent be aware of the requirements of IPPC and obtains the necessary phytosanitary certificates if any plants are to be imported to stabilise the beach or for landscaping.

3.5.3 UNFCCC and Kyoto Protocol

The Maldives is a party to the United Nations Framework Convention on Climate Change and the Kyoto Protocol to the UNFCCC. The objective of the Convention is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The IPCC defines mitigation “as an anthropogenic intervention to reduce the sources or enhance the sinks of green house gases.” The greenhouse gas inventory of the Maldives forms an integral part of the First National Communication of the Maldives to the UNFCCC. In March 2009, the President of the Maldives has announced the target to make Maldives carbon neutral by 2020. Hence, in the implementation of the project, careful attention needs to be given to ensure energy efficiency and reduce transport related fuel consumption. Furthermore, planting of beach vegetation would help in mitigation of greenhouse gas emissions from the project.

The IPCC defines adaptation “as an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects.” Various type of adaptation include anticipatory and reactive adaptation; private and public adaptation; and autonomous and planned adaptation. The adaptation policies and strategies of the Maldives are given in the Maldives National Adaptation Programme of Action (NAPA). The replenishment of the beach can be considered as a long term adaptation measure against beach erosion caused by rising sea levels.

4 EXISTING ENVIRONMENT

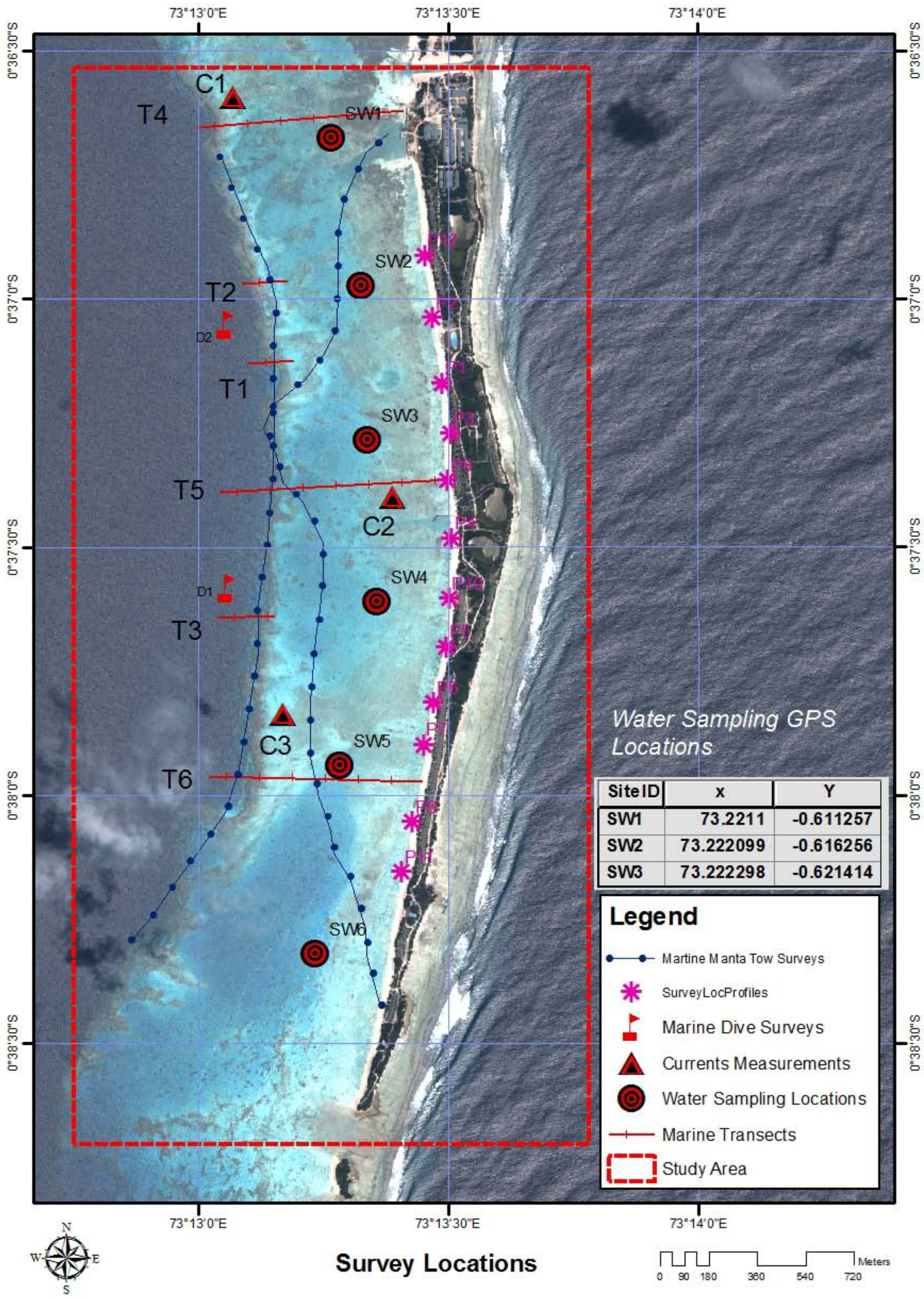
4.1 Study Methodologies

Herathera Island Resort has a Beach Management Pan prepared for the long-term management of its beach. Much of the high resolution data required for this EIA is available from the baseline studies undertaken for the preparation of this plan. Additional baseline data specific to the sea grass beds were analysed by using standard scientific methods.

The environmental components of the study area were divided into marine and coastal and terrestrial environment. The marine environment covered the lagoon habitats and coral reef system including coral patches, fish communities, marine water quality, seagrass patches and bathymetry of the site. The coastal environment covered the beaches and coastal processes including longshore sediment transport patterns and coastal erosion of the site. Particular attention was placed in detailed surveys of marine environment life and coastal processes, as these components are likely to involve the most significant environmental impacts.

Lagoon benthos and the reef system of the site were surveyed by conducting timed swims, quantitative LIT surveys and manta tows. Depths of shallow areas near the shore and seagrass beds had to be taken manually using a staff. Drogue method was used to measure the current. Tidal data was taken from previous research. To assess the marine water quality of the site, samples were collected in clean 1500ml PET bottles after washing them with water to be sampled. Parameters tested were turbidity, Dissolved Oxygen (DO), salinity, Suspended Solids (SS), pH, nitrate, nitrite, phosphate, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD). All parameters were analysed at the National Health Laboratory.

To assess the coastal environment of the site, 11 beach profiles were taken using standard levelling techniques. These profile locations are marked in Figure 4.1 below and matches most of the profiles taken in the initial EIA. The measurement of beach profiles involved standard practice of surveying with a staff and a dumpy level.



Site ID	x	Y
SW1	73.2211	-0.611257
SW2	73.222099	-0.616256
SW3	73.222298	-0.621414

Figure 4.1 Detailed Survey Locations

4.2 Physical Environment

4.2.1 Beach and Coastal Modifications

4.2.1.1 Closing the channel between Hulhudhoo and Herathera

During the late 1990's the natural channel between Hulhudhoo and Herathera was closed to provide more land for housing development in Hulhudhoo (see figure 4.2 below). Following this modification, severe erosion was experienced by Hulhuldhoo. It is also claimed that sea grass overgrowth became a major problem on the lagoonward side of the Hulhudhoo and Herathera and that atoll current circulation was severely affected. While these assumptions holds merit the severe extent of impacts suggested is questionable.

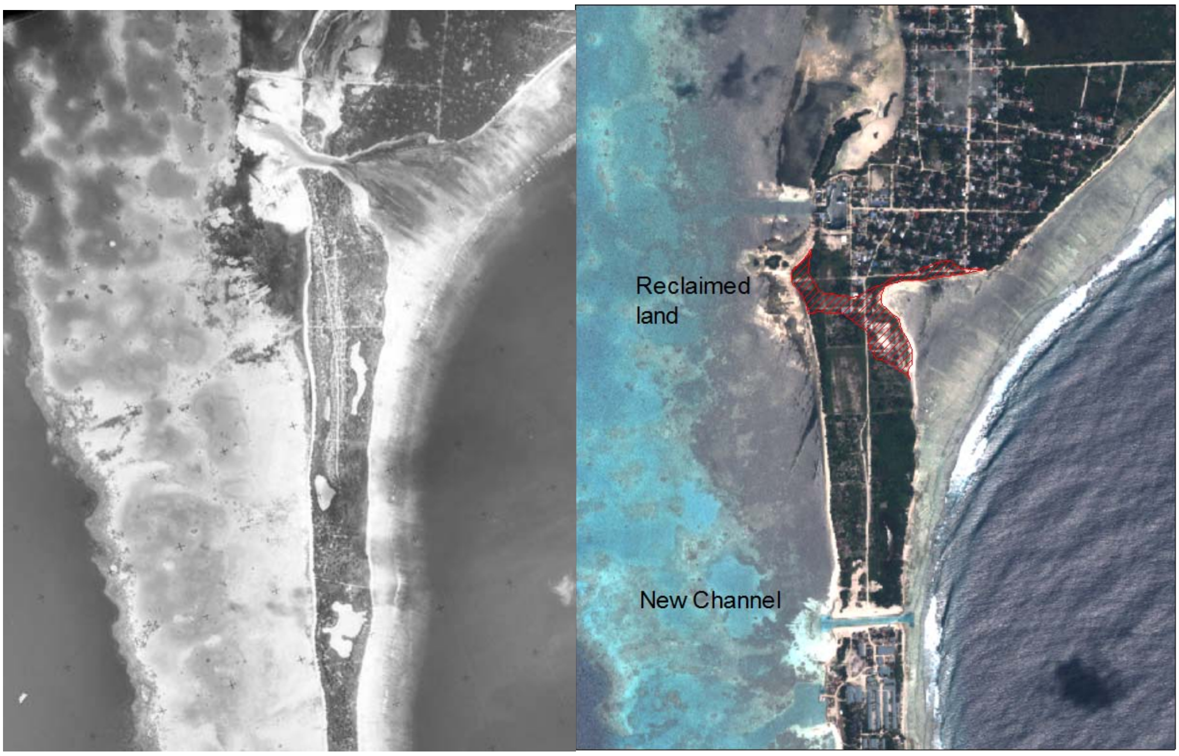


Figure 4.2: Major coastal modifications in Herathera over the last 40 years

4.2.2 Re-opening the channel in Herathera Island

In late 2008, a new channel was opened between Hulhudhoo and Herathera Island. The primary rationale for this change was: i) sea grass over growth due to restricted circulation and; ii) separation of inhabited Hulhudhoo and Herathera resort due to social reasons.

The new channel has led to the development of a sediment fan on the lagoonward side mouth of the channel, restricting sea grass growth in the area. However, the expected benefits of controlling sea grass overgrowth have not been realized due to a recently dug basin around the mouth of the channel. The rationale behind this development was to prevent sediment accumulation and minimize re-dredging activities. In a high-flow area such as this, this assumption is unfounded.

There have also been cases of severe over flow and flooding around the channel during the peak tides of Southwest monsoon, or *udha* season. The creation of a basin and low elevation on the sides may have been responsible for this effect.

There was observed severe erosion on the Hulhudhoo side of the channel, along the unprotected coastline adjacent to the channel.

4.2.2.1 Beach Replenishment and Seagrass Removal

Beach replenishment was carried out in 2008 with the dual intention to improve the beach product and to remove the sea grass communities. Historically the beach on the eastern side of the island is narrow and comprised of moderately coarse to fine sediments. These conditions made it unsuitable for use as a tourism product, particularly when one of the main attractions in Maldives is white sandy beaches. In addition, the sea grass over growth within the lagoon was reducing the aesthetic quality of the lagoon and the beach. Extensive costs and effort are required to regularly clean the beaches.

Hence, the beach replenishment project involved removing the seagrass colonies by dredging the lagoon and replenishing the beach using the dredge waste. These areas are identified in Figure 2.4 in Chapter 2. Unfortunately, the project was not implemented with careful consideration of geomorphologic conditions on the island. First, the lagoon bottom in the dredged area contained coarse materials which were largely unsuitable for a beach. Secondly, the sea grass removal activities were undertaken using an exactor, rather than a sand pump, leaving large holes close to the beach line.

The impacts of this activity are two-fold. First, the coarse material ware covered with moderately fine sand during the replenishment activity. However, the fine material will be quickly eroded by wave activity, which the new beach tries to achieve an equilibrium between sediment characteristics and wave activity. This has left behind large areas of coral out crops unsuitable as a tourism product.

Secondly, the dredged areas are acting as a sink to capture fine sediments eroded from the beach. Perhaps this was an intentional design. However, under normal circumstances the beach and its surrounding areas (‘sediment foot print’) needs to have a certain profile to maintain the beach. Usually, beach sediments are naturally deposited in the lagoon until the correct profile is achieved. Due to current modifications, this process can last up to a number of years and can incur severe erosion on the island.

4.2.3 Geological setup

- Herathera is one of the longest islands in the Maldives. The original island was about 5 km long, the second longest uninhabited island in the Maldives.

- The island appears to have formed by merging numerous islands. Evidence from island topography and vegetations system suggests at least four islands.

- The presence of a large number of wetlands, mangroves and relic rock out- crops suggest that storm activities have played a major role in formation and stabilization of the island. Wetlands are often an indicator of abrupt changes to coastline, which are highly likely during significant wave events.

- Much of the sediments available for the island is highly likely to have been produced due to its initial formation about 3000 years ago. New sediments may have been produced since then but the volumes are likely to be small.

- Swell wave events appear to play a major role environmental forcing for the island development. Waves refracted around the southern tip of addu atoll may have caused the island to grow towards north, rather than south.

- The small island on the southern end is likely to have been part Herathera once. The area has eroded significantly since then.

- There is a well developed spurs and groove system on the eastern rim of the reef system, suggesting significant wave activity. This pattern is present right around Addu Atoll, however.

4.2.4 Meteorology

4.2.4.1 Climate

The climate in Maldives is warm and humid, typical of the tropics. The average temperature ranges between 25°C to 30°C and relative humidity varies from 73 percent to 85 percent. The annual average rainfall is approximately 1,948 mm. As Maldives lies on the equator, Maldives receives plenty of sunshine throughout the year. Significant variation is observed in the climate between the northern and the southern atolls. The annual average rainfall in the southern atolls is higher than the northern atolls. In addition, greater extremes of temperature are also recorded in the southern atolls. On average southern atolls receive 2704 hours of sunshine each year. Table 4.1 provides a summary of key meteorological findings for Maldives.

Table 4.1 Key Meteorological Information of the Maldives

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

4.2.4.2 Monsoons

The climate of Maldives is characterised by the monsoons of Indian Ocean. Monsoon wind reversal significantly affects weather patterns. Two monsoon seasons are observed in Maldives: the Northeast (Iruvai) and the Southwest (Hulhangu) monsoon. The parameters that best distinguish the two monsoons are wind and rainfall patterns. The southwest monsoon is the rainy season while the northeast monsoon is the dry season. The southwest monsoon occurs from May to September and the northeast monsoon is from December to February. The transition period of southwest monsoon occurs between March and April while that of northeast monsoon occurs from October to November.

4.2.4.3 Winds

The winds that occur across Maldives are mostly determined by the monsoon seasons. The two monsoons are considered mild given that Maldives is located close to the equator. As a result, strong winds and gales are infrequent although storms and line squalls can occur, usually in the period May to July. During stormy conditions gusts of up to 60 knots have been recorded at Male'.

Wind has been uniform in speed and direction over the past twenty-plus monsoon seasons in the Maldives (Naseer, 2003). Wind speed is usually higher in central region of Maldives during both monsoons, with a maximum wind speed recorded at 18 ms-1 for the period 1975 to 2001. Mean wind speed as highest during the months May and October in the central region. Wind analysis indicates that the monsoon is considerably stronger in central and northern region of Maldives compared to the south (Naseer, 2003).

Winds recorded at Gan meteorological center indicates that heavy windy conditions occurred during south-west monsoons. Wind gusts of 35 mph to 45 mph were occasionally recorded when effects of cyclones from Arabian Sea were felt in the country. Direction of wind changes predominantly from northeast in the northeast monsoon to west and south-west in the southwest monsoon and variable direction of wind are experienced in the monsoon transition periods.

Table 4.2 summarises the wind conditions in southern Maldives throughout a year. Medium term meteorological data from Gan meteorological center (see Figure 4.3, Figure 4.4 and Figure 4.5) and findings from long-term Comprehensive Ocean-Atmosphere Data Set (COADS) are used in this analysis.

Table 4.2 Summary of General Wind Conditions from Gan Meteorological Center

Season	**Month**	**Wind**
NE - Monsoon	December	Predominantly from NW-NE.
	January	High Speeds from W
	February	
Transition Period 1	March	From all directions. Mainly W. High Speeds from W.
	April	
SW - Monsoon	May	Mainly from W.
	June	High Speeds from W.
	July	
	August	
	September	
Transition Period 2	October	Mainly from W.
	November	High Speeds from W

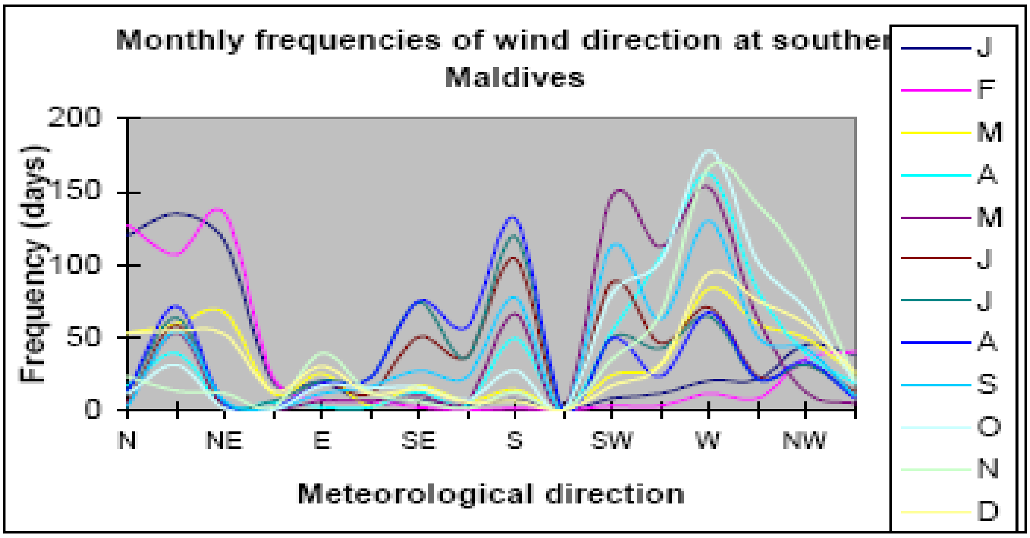


Figure 4.3 Monthly Frequencies of Wind Direction in Southern Maldives based on Gan Meteorological Center 10 year Data (adapted from Naseer, 2003).

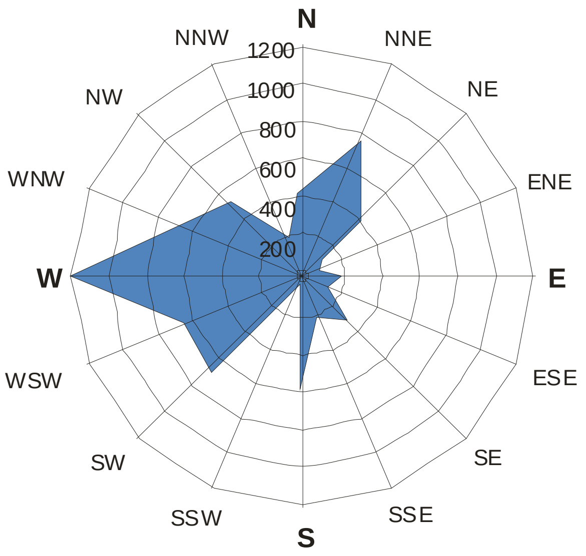


Figure 4.4 24 Year Wind Frequency Recorded at Gan Meteorological Center.

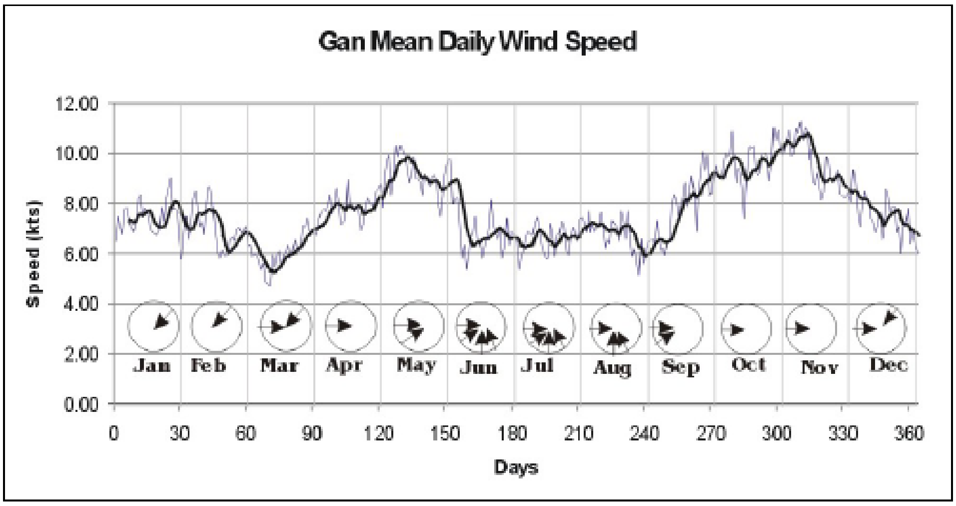


Figure 4.5 Mean Daily Wind Speed and Direction Recorded at Gan Meteorological Center. Arrows Indicate Dominant Wind Direction (Adapted from Naseer, 2003)

The project site is expected to receive regular annual strong winds during the peak SW monsoon.

4.2.5 Hydrology

4.2.5.1 Waves

There are two major types of waves reaching the coasts of Herathera. Long distance swells waves and monsoonal wind waves. Studies in undertaken in Fuvahmulah provides an insight into the wave regimes around the region (see table 4.3).

Table 4.3 Wave regimes in neighbouring Fuvahmulah Atoll

Season	Total	Long Period	Short Period
NE - Monsoon	Predominantly from E-S. High Waves from W	From S-SW	Mainly E-NE. High waves from W
Transition Period 1	Mainly from SE-E	From S-SW	Mainly from NE-SE
SW - Monsoon	From SE-SW. Mainly from S. High Waves also from W	From S-SW	Mainly from SE-S. High waves from West
Transition Period 2	As SW monsoon	From S-SW	From SE-W. Higher waves from West

The local monsoon waves generated mainly during the NE monsoon affects the eastern coastline of the island. These waves are generally with a period of 3-8 seconds and some time at 1.5 m high in open ocean. The estimated wave propagation pattern is plotted in the map below.

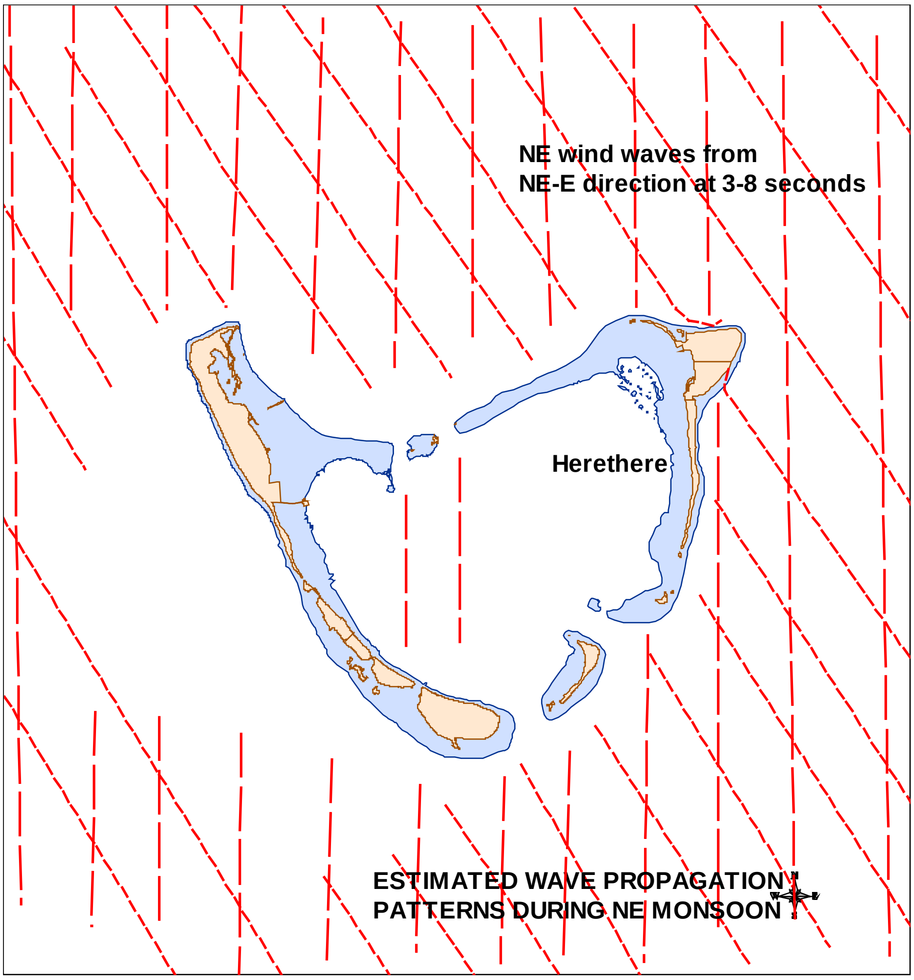


Figure 4.6 : Estimated wave propagation patterns during NE monsoon

The long distance swell waves approach mainly from a S-SW direction and is dominant throughout the year. These waves come with a wave period of 14-20 seconds with a maximum height of 3.0 m in open ocean. The estimated wave propagation pattern for swell waves are plotted in figure below.

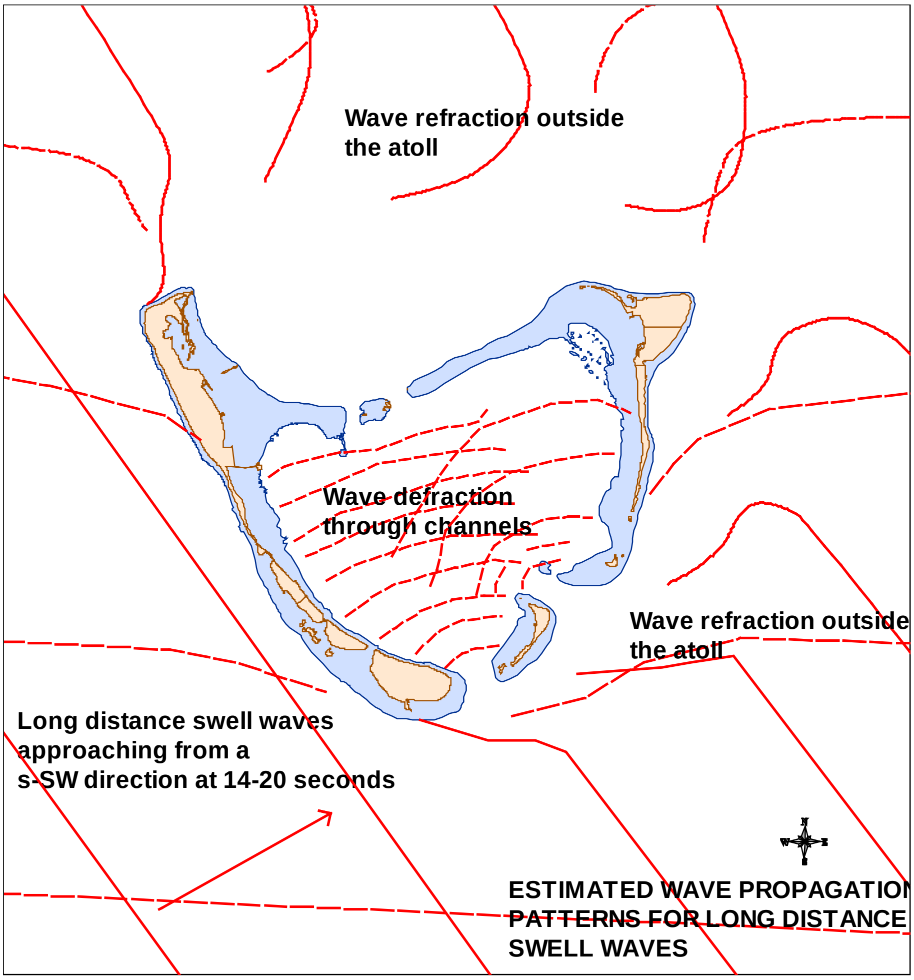


Figure 4.7: Estimated wave propagation patterns for swell waves

During the SW monsoon winds generated within the atoll can create wind waves within addu atoll with a wave period of 2-5 seconds and with wave heights at 0.5 m.

Hence, Herathera site is affected by wind waves from the east during the NE monsoon and wind waves form within the atoll during SW monsoon. The long distance swell waves refract around the atoll but reaches the eastern shoreline. Moreover, the residual waves diffract through Gan channel and may reach the eastern shoreline of Herathera. Hence all three wave sources play an important role in the shoreline stabilization and island development in Herathera.

Wave activity may be strongest on the eastern side during the peach SW monsoon in May and around October and November. In addition, storm events are likely to cause significant run-up onto the coastline, perhaps, leading to sediment loss.

4.2.5.2 Currents

Long term monitoring of currents are required to establish a meaningful pattern for coastal change analysis. In the meantime, the following general characteristics could be derived from studies elsewhere in Maldives.

Currents that affect the reef system of the proposed site can be caused by tidal currents, wind-induced currents and wave-induced currents.

It is presumed that generally current flow through the country is defined by the two-monsoon season winds. Westward flowing currents are dominant from January to March with the change in current flow pattern taking place in April and December.

In April the westward currents become weak while the eastward currents start to take over.

In December the eastward currents are weak with the westward currents becoming more prominent.

Currents at the time of survey were highest on the southern end and near the dredged channel. Currents in the central parts of the lagoon were slow moving and generally in a northerly direction during high tide and in a westerly direction during low tide.

Figure 4.8 below presents the estimated current flow pattern around Herathera. The patterns shown in blue are the estimated general pattern throughout the year. This is based on the fact that there are year round long distance swell waves reaching the reef system. The strength of the currents on the oceanward reef flat is likely to be strongest during the NE monsoon and transition periods. Current flow during the SW monsoon is generally eastward with a southeasterly direction. This pattern has assisted in the island evolution and to the specific shape and location of the island. The newly opened channel and southern tip of the island experiences strong current activity during peak NE monsoon.

Current measurements in the project site showed fairly constant speeds of 0.2m/s during flood and 0.1m/s during ebb. The currents flowed in a easterly to a south easterly direction during the surveys. Currents are generally weak in the lagoon, which partly explains the mu

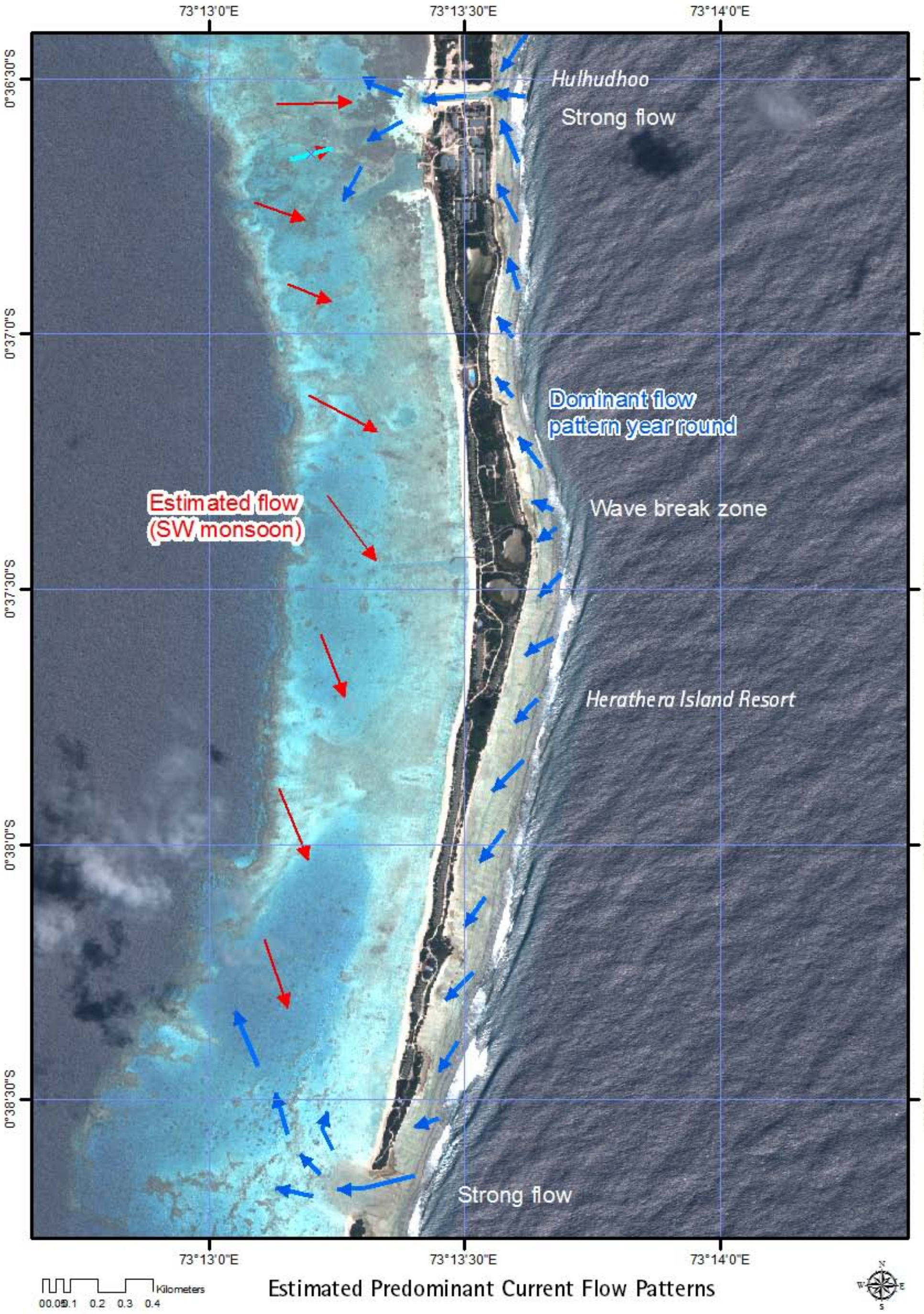


Figure 4.8 Estimated current flow pattern around Herathera

4.2.5.3 Bathymetry

A detailed bathymetric survey of the island and its reef system within the project boundary was undertaken during September 2010. Survey results have been summarised in bathy charts presented in Appendix D. A reduced version is presented in Figure 4.9. The depth figures presented are in meters below MSL.

The reef flat areas on the western side have a fairly flat depth ranging from -1.0 to -1.3m MSL. Areas west of the island gently slope into the deep lagoon.

The most notable feature on the reef system is the three deep lagoons at the centre. The northernmost two lagoons have depths ranging between -3.0 to -4.0. The southern lagoon is the deepest reaching -6.0 m MSL.

There are two dredged reef entrances with a depth ranging from -2.5 to -3.0m. The harbour basins created around the arrival jetty is about -2.5m deep and around the service jetty is about -3.0 to -3.5 m.

A areas adjacent to the coastline has be dredged to a depth between -0.3 to -0.7 leaving an unnaturally deep profile next to the beach. The depths may have changed since replenishment due to sedimentation.

The planned seagrass removal areas are generally within -1.0 m to -1.3 m MSL. The proposed borrow areas are generally from the deep lagoon slopes with depths ranging from -1.0 m to -3.0 m.

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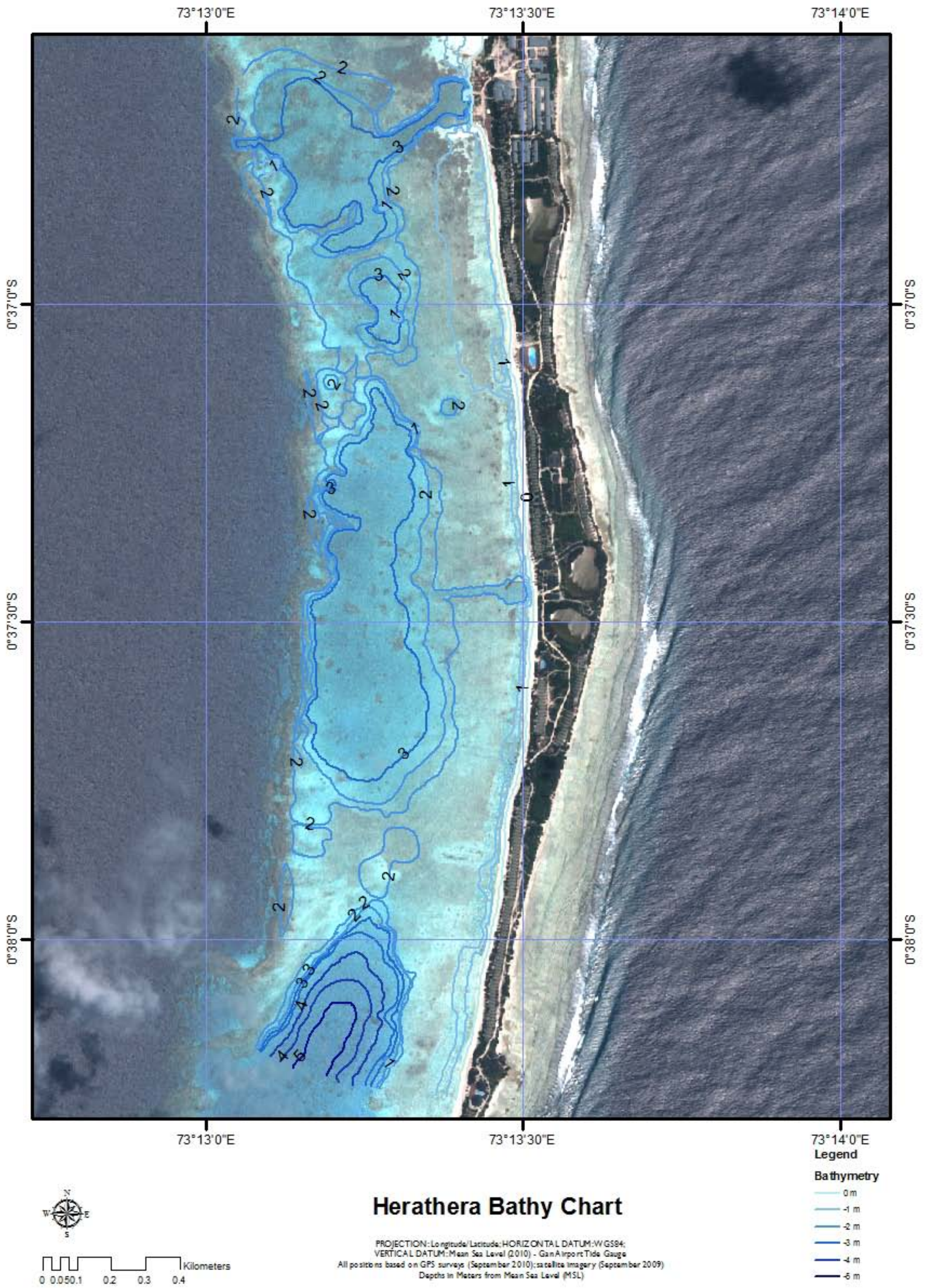


Figure 4.9 Bathy chart

4.2.6 Beach

4.2.6.1 Beach erosion and coastal changes

Historical changes

Historical changes to beach were analysed by comparing aerial photographs from 1969 against satellite imagery from 2005 (prior to construction) and 2009. The analysis shows that the coastline has been relatively stable. Severe erosion was observed on parts of the eastern coastline (see figure 4.10). Much of the significant changes are manmade, particularly on the northern half of the island. Significant changes were also observed on the southern end of the island where a 2.8 ha small island has been reduced to 0.6 ha over the last 40 years.

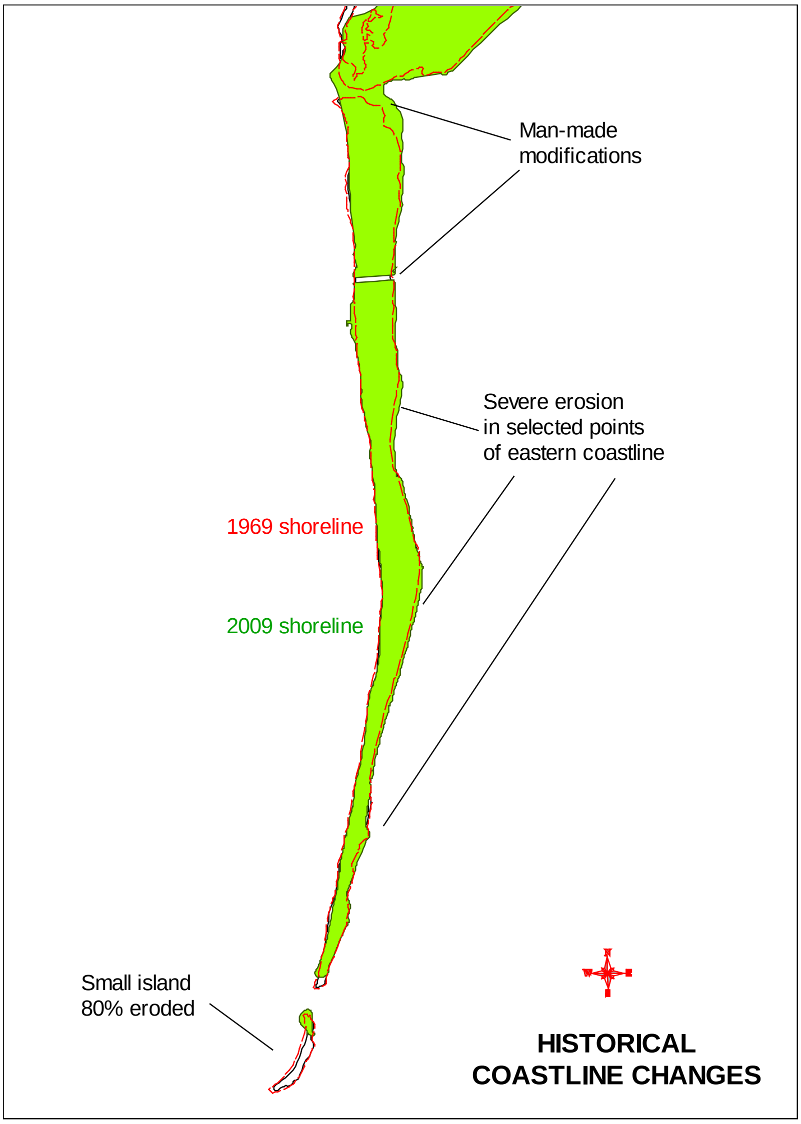


Figure 4.10: Historical changes to shoreline

Current Erosion

Erosion is prevalent around the island. The eastern coastline is generally stable but is undergoing erosion at selected points.

Erosion on the western coastline cannot be quantified easily due to the recentness of beach replenishment activities. All areas on the western coastline are presently eroding (see next section).

More details on erosion and accretion patterns are presented in the next section.

4.2.6.2 Detailed description of Beach Conditions

Beach Zoning

A beach zoning plan has been proposed for the Beach Management Plan of Herathera See (Figure 4.11). The zones represent changes in various geophysical characteristics and developments on the island.

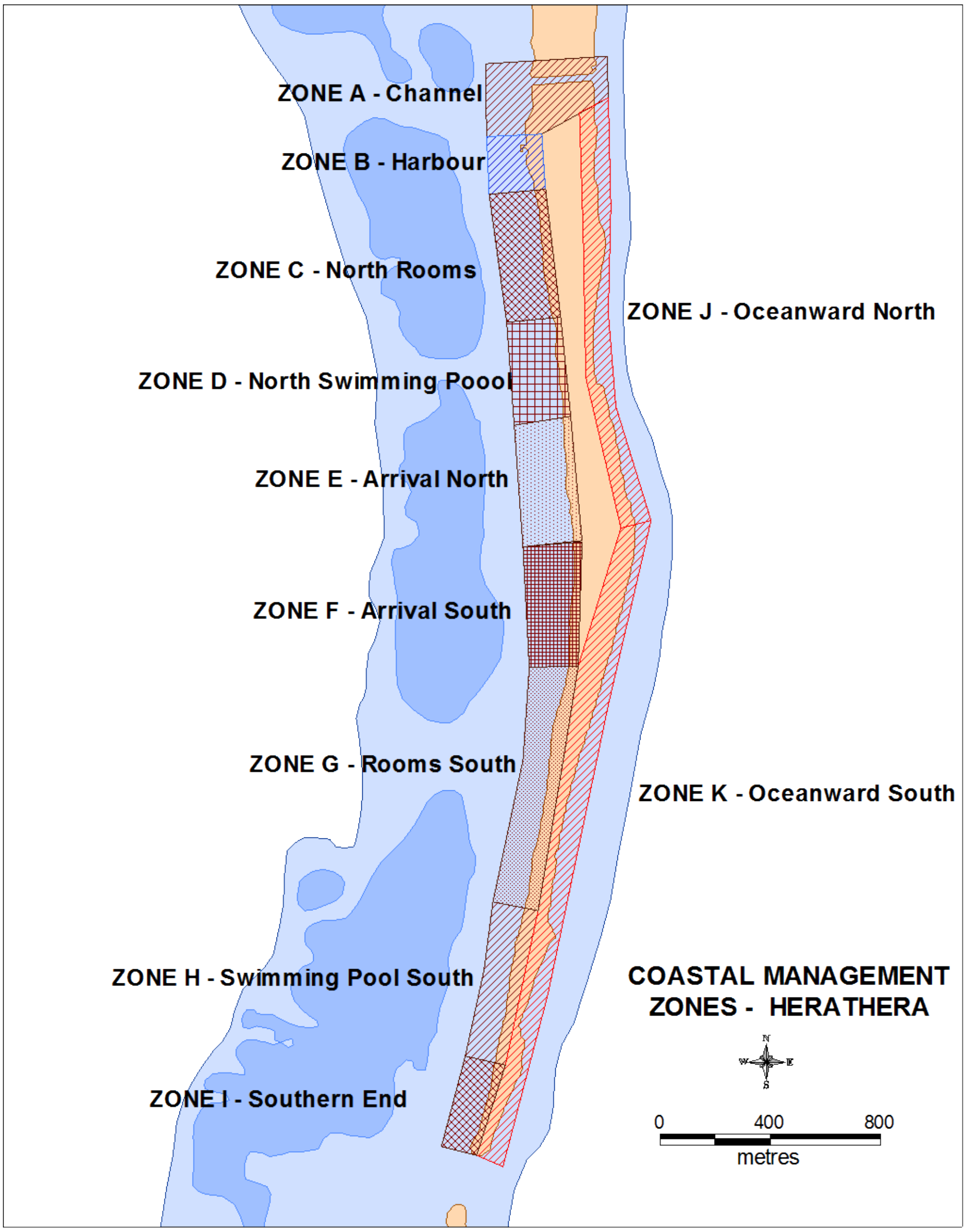


Figure 4.11: Beach zoning plan

Zone A – Channel

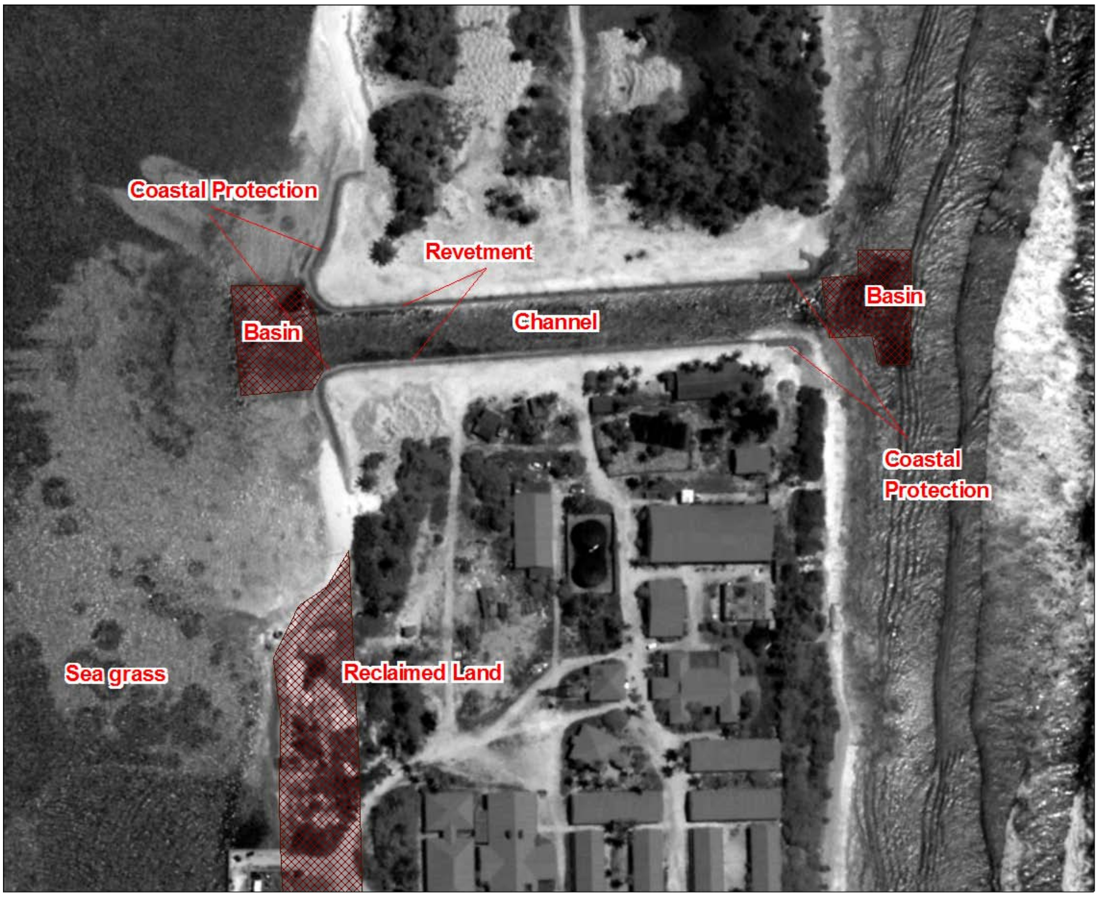


Figure 4.12: Characteristics of Zone A

Zone A is characterized by the following extensive coastal modifications.

- The dredged channel and its associated protection infrastructure (breakwaters, revetment and basins)
- Land reclamation around the harbor area.
- The ocean ward side is undergoing erosion following the construction of the breakwater.
- There is an extensive sea grass bed.
- The presence of the deep basins is preventing the desired effects on sea grass overgrowth.
- The channel is presently experiencing severe flooding events during the high tides and udha season – some elements of the design may be causing overtopping.
- The area should be treated as a low priority for beach management as there is no merit in preserving or developing a beach in this zone.

Zone B – Harbour area

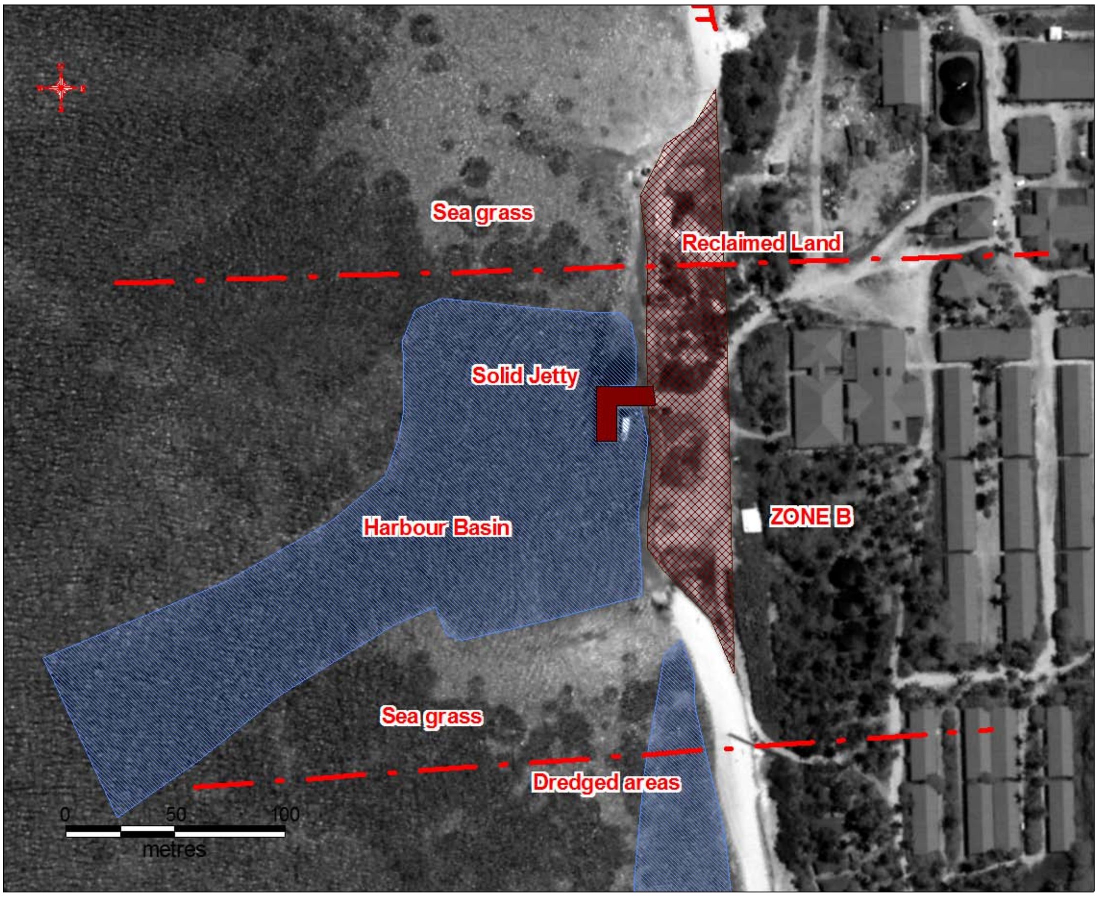


Figure 4.13: Characteristics of Zone B

Zone B is also characterized by extensive coastal modifications.

- The dredged harbor basin
- Land reclamation around the harbor area.
- A solid jetty
- There is an extensive sea grass bed.
- The presence of the deep basin and the solid jetty prevents the flow of sediments along the coastline, essentially separating the coastline at this point.
- Beach conditions are poor, mainly comprising rubble.
- The southern end of this zone comprise of fine sediments deposited from the long shore drift.

– A lot of sediment, particularly those used in previous replenishment has been deposited in the deep basin.

– The area should be treated as a low priority for beach management as there is no merit in preserving or developing a beach in this zone.

Zone C - North Rooms

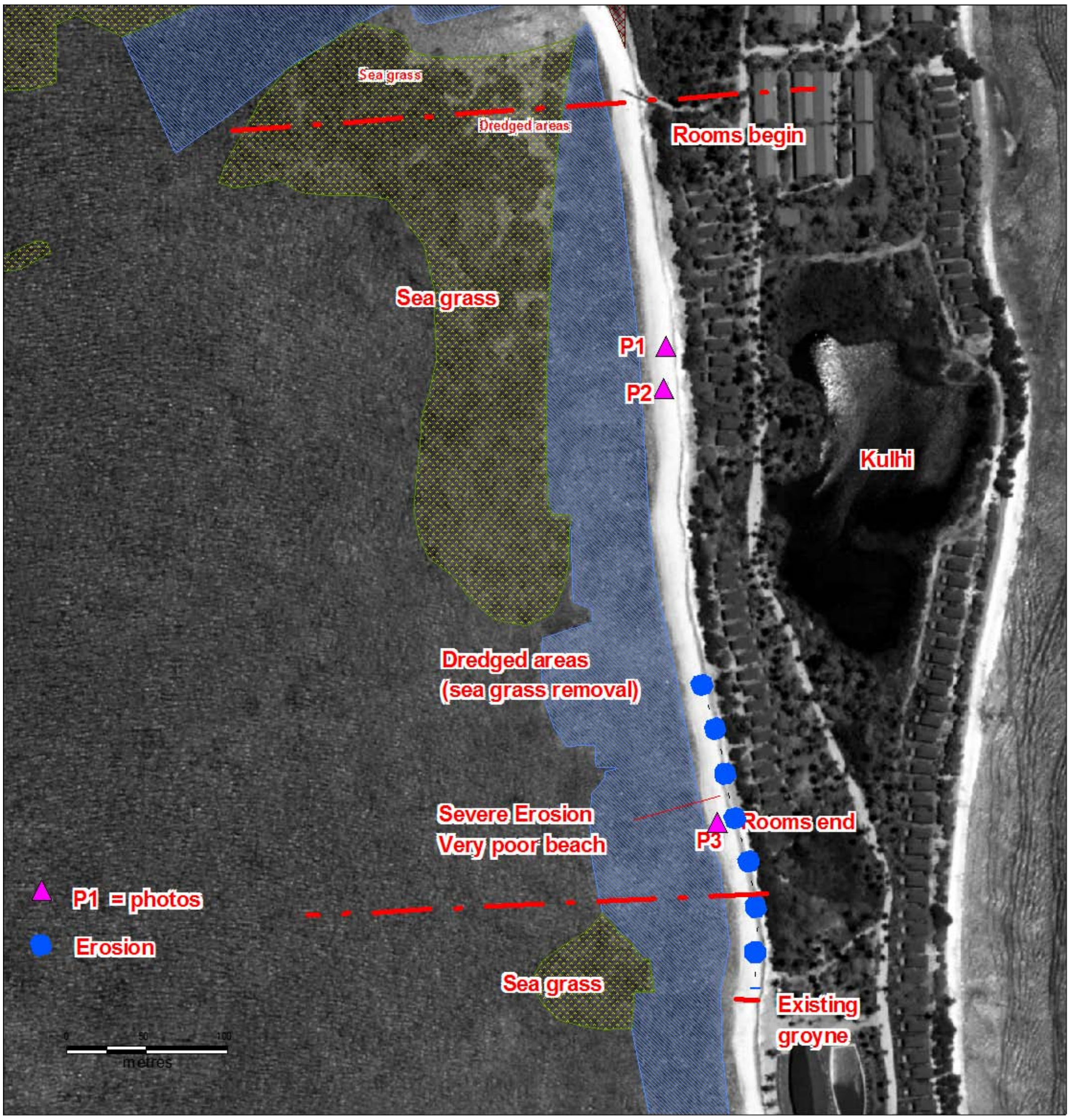


Figure 4.14: Characteristics of Zone C

– Zone C is also characterized by an extensive beach system with varying beach conditions. The northern half contains moderately coarse to fine sediments (see Figure 4.14 –4.15) while the southern end comprises of coral rubble (see Figure 4.16 below). The southern half is unsuitable as a tourism product.

– The southern area is undergoing extensive erosion. As a result the coarse rubble is exposed while the fine sediment in transported into the dredged lagoon area.

– The general profile of the northern half is shown in Figure 4.17 below. It appears that, over time, a fine layer of sediment (3-5" deep) is being accumulated on top of the coarse replenished beach. The material sits between the high tide wave run-up line and low tide line. Coarse materials are exposed on the top and around the low tide line.

– There is algal growth on the exposed coral rubble.

– There are dead sea grass littered along the entire stretch Zone C.

– Erosion mitigation and beach cleaning required in this zone.

Figure 4.15: Beach conditions in survey point P1 (see map above)

Figure 4.16: Beach conditions in survey point P2 (see map above)

Figure 4.17: Beach conditions in survey point P3 (see map Above)

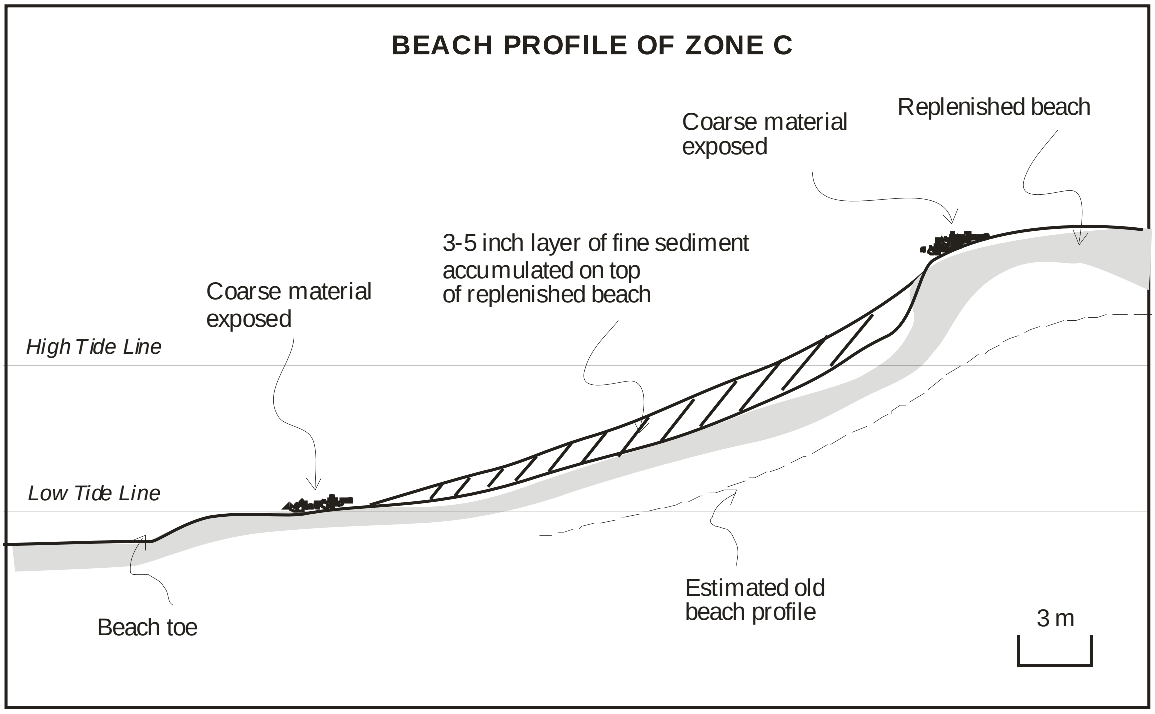


Figure 4.18 Typical beach profile of Zone C

ZONE D - North Swimming Pool

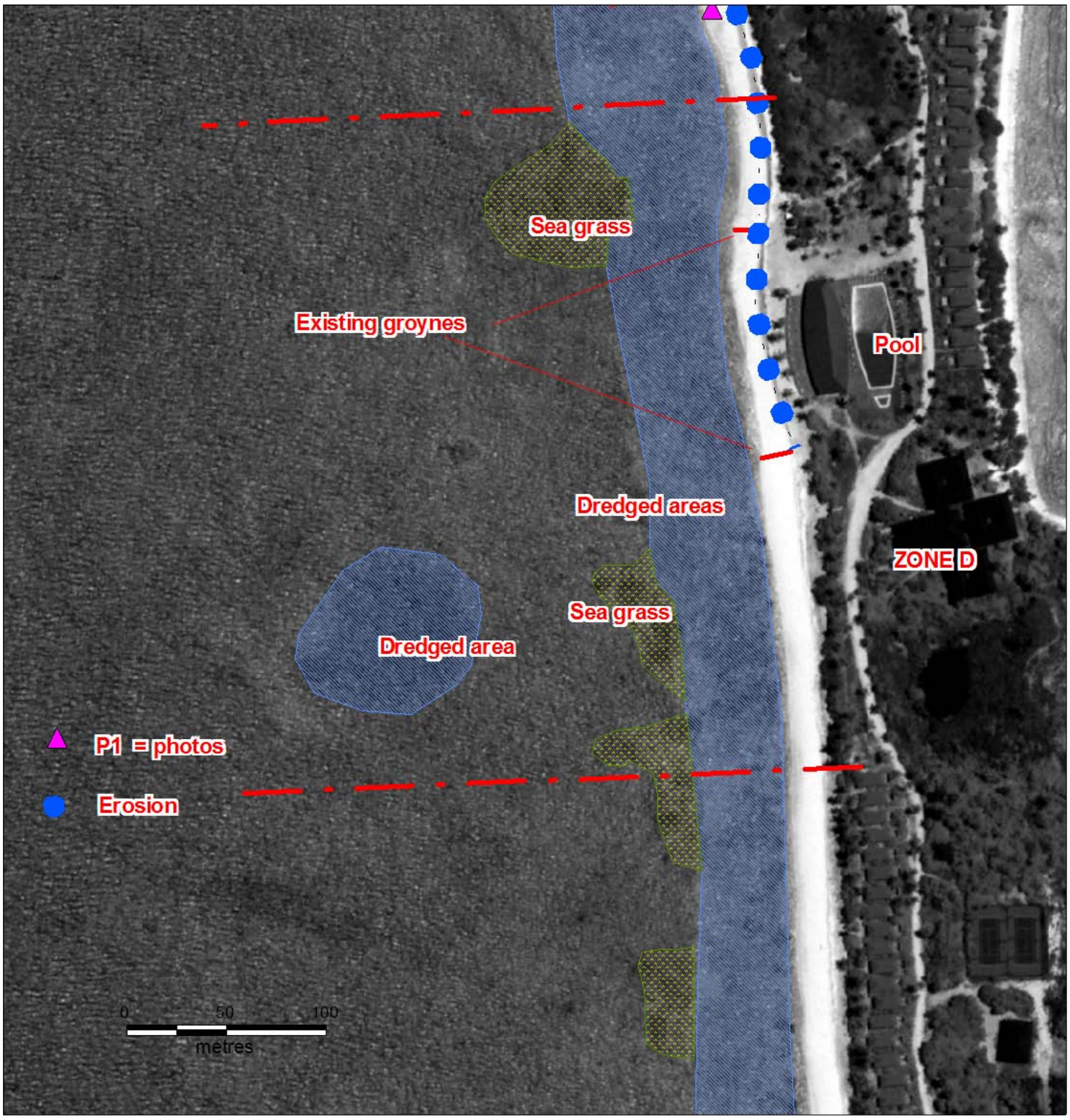


Figure 4.19: Characteristics of Zone D

- Similar to Zone C, Zone D is also characterized by extensive erosion, leaving behind a stretch of coral rubble. The north part of Zone D, particularly around water sports area, is unsuitable as a tourism product.
- The southern area is undergoing accretion, at the time of the survey. Beach sediments mainly comprise of coarse to moderately fine sediments.
- The general profile to zone C.
- There is algal growth on the exposed coral rubble.
- There is dead sea grass littered along the entire stretch.

– Erosion mitigation and beach cleaning required in this zone.

Zone E - Arrival Area (North)

Figure 4.20: Characteristics of Zone E

– Zone E is one of the most crucial beach areas of Herathera: it is the arrival area of the island which provides the first impression of the beach system. Unfortunately, this area is characterized by severe erosion towards the jetty (see figure 4.21 below). The northern half is relatively healthy with coarse to moderately fine sediments. The area north of the arrival jetty is unsuitable as a tourism product.

– The most likely cause of severe erosion in this area is the presence of dredged basin and a groyne (under the jetty) which is blocking the sediment flow.

– There is dead sea grass littered along the entire stretch.

– Erosion mitigation and beach cleaning required in this zone.

Figure 4.21: Beach conditions at survey point P4 (see map Above)

ZONE F – Arrival Area South

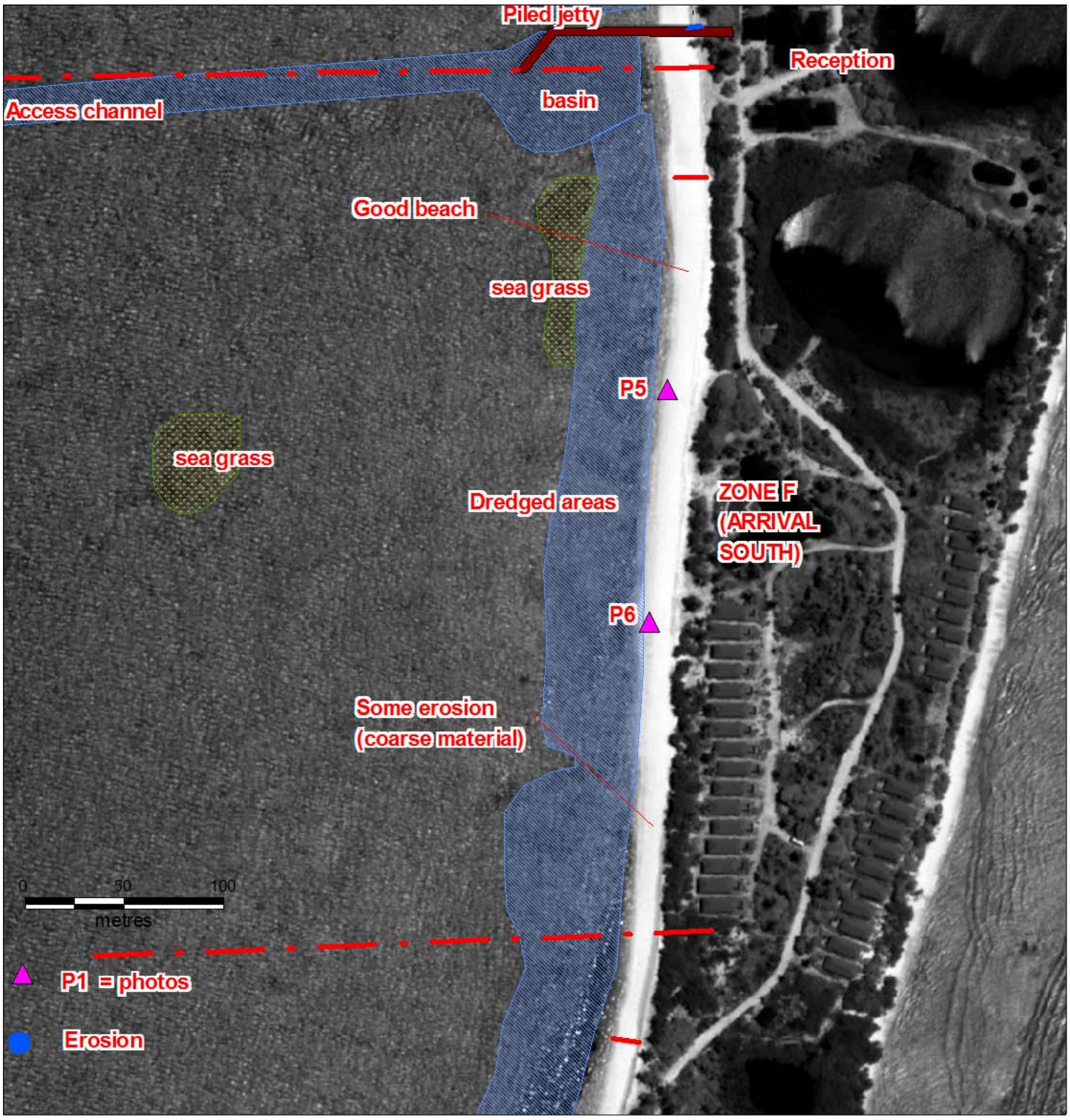


Figure 4.22: Characteristics of Zone F

- Zone F is the most stable beach area of Herathera, at the time of the survey. The beach area immediately south of the jetty comprise of fine sand. Sediment quality decreases towards south (see figure 4.23 and 4.24 below).
- Sediment flow is prevented in the area due to the dredged basin and a groyne (under the jetty).
- There is dead sea grass littered along the entire stretch.
- Beach cleaning required in this zone.

Figure 4.23: Beach conditions at survey point P5 (see map Above)

Figure 4.24: Beach conditions at survey point P6 (see map Above)

Zone G – Rooms South

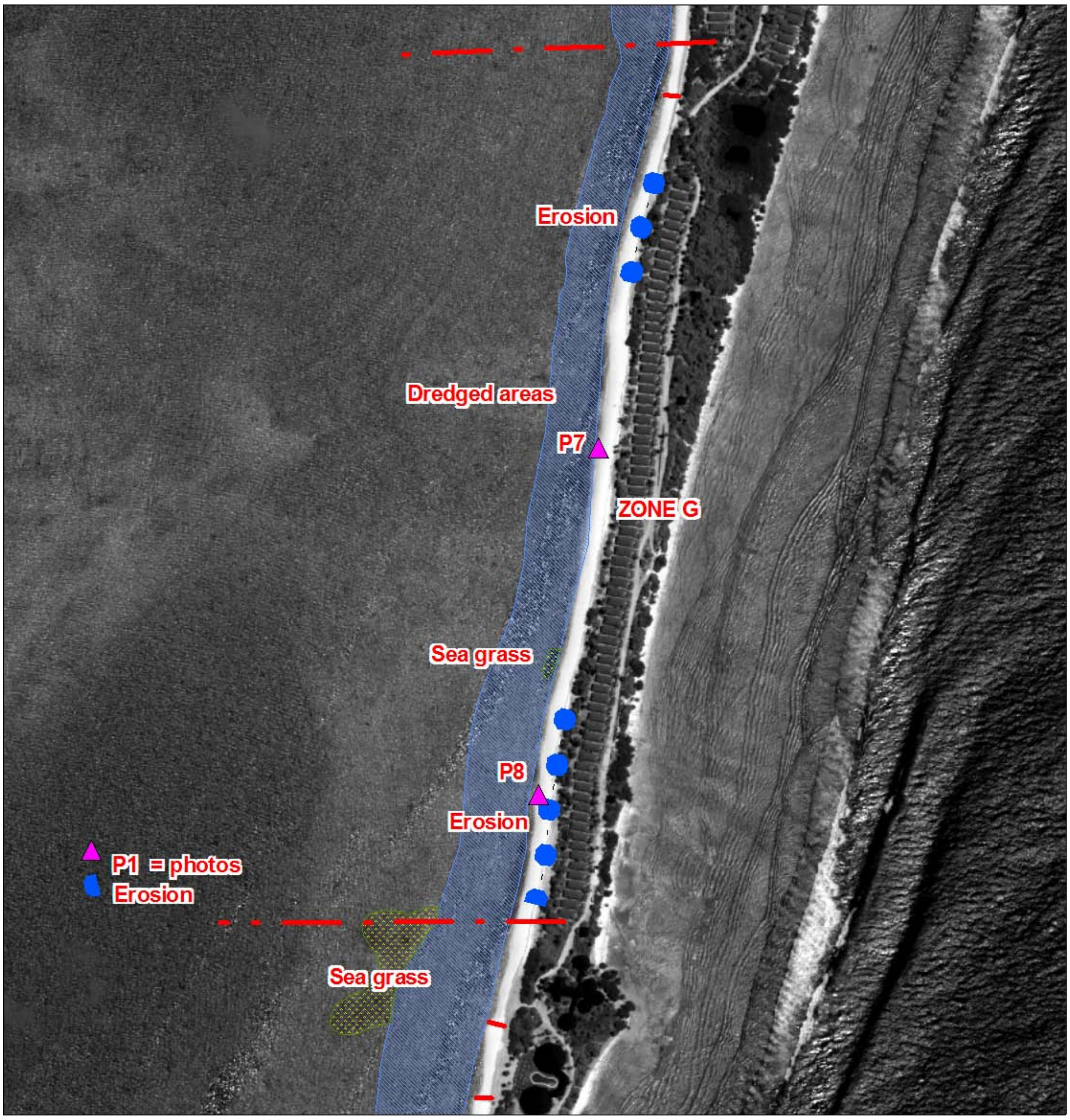


Figure 4.25: Characteristics of Zone G

- Zone G has moderate levels of erosion, increasing in severity towards south (see figure 4.26 and 4.27 below).
- Beach composition is moderately coarse in the north and coarse in the south.
- There is dead sea grass littered along the entire stretch.
- New sea grass patches are growing in the dredged area.
- Erosion mitigation and beach cleaning required in this zone.

Figure 4.26: Beach conditions at survey point P7 (see map Above)

Figure 4.27: Beach conditions at survey point P8 (see map Above)

ZONE H (Swimming Pool South) and Zone I (Southern End)

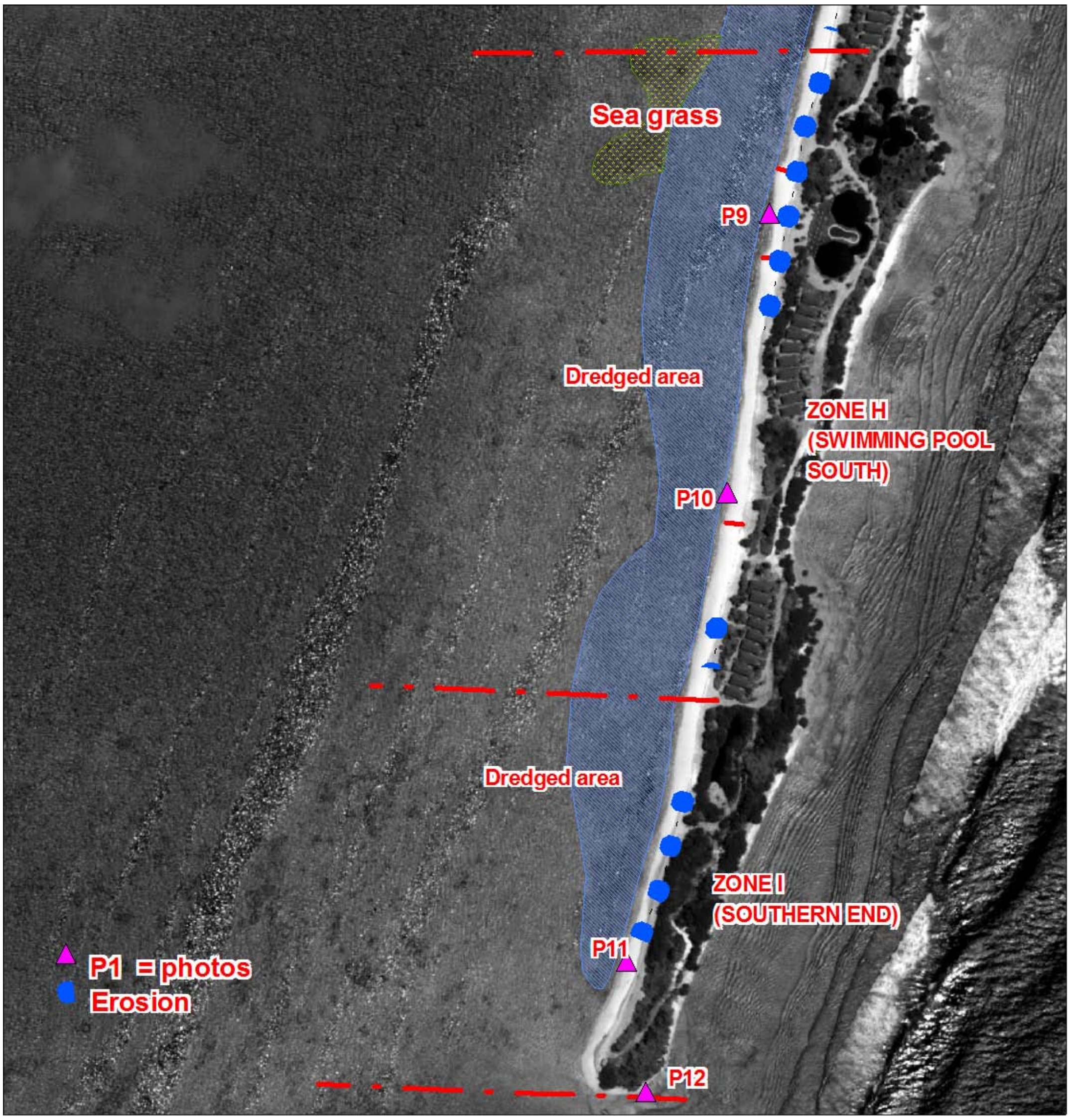


Figure 4.28: Characteristics of Zone H

- Zone H has moderate to high levels of erosion with area of coral rubble (see figure 4.29 and 4.30 below).
- Beach composition is moderately coarse in the north, fine in the middle and coarse in the south.
- There is dead sea grass littered along the entire stretch.
- Erosion mitigation and beach cleaning required in this zone.
- Zone I is not developed but has undergone beach replenishment.

- There is moderate erosion at the time of the survey
- Beach materials are coarse on eroded areas and moderately fine in all other areas.
- The natural beach composition is visible in this area, which comprise of very coarse coral rubble.
- There is a large beach rock system on the south eastern end of the island (see figure 4.32).

Figure 4.29: Beach conditions at survey point P9 (see map Above)

Figure 4.30: Beach conditions at survey point P10 (see map Above)

Figure 4.31: Beach conditions at survey point P11 (see map Above)

Figure 4.32: Beach conditions at survey point P12 (see map Above)

4.3 Biological Environment

4.3.1 Introduction

The aims of these assessments were to determine the overall condition of the house reef of the island, identify the different types of corals and fish species in the reef and also to qualitatively determine the availability of fine sand in the area.

First assessment was conducted on the 22nd of December 2009; major components of the marine ecosystem surveyed were the reef-flat, reef slope, benthic sandy areas, fish communities and sea-grass habitats.

The second assessment was conducted on the 15th of August 2010; percentage coral cover (both live and dead) and sand cover was recorded for a selected portion of the house reef. In addition two locations were selected to conduct detailed assessments; and the various genera of corals that occur at them were recorded. In addition, any threats observed to the coral reefs were noted down.

4.3.2 Description of existing Marine Environment

The marine environment around the island has being heavily modified since the filling of the area between Herathera and Hulhudhoo. A channel has been dredged between Herathera and Hulhudhoo to facilitate exchange of seawater. Large areas of sea-grass have also been removed from the near-beach areas. The dredge spoil obtained during the sea-grass removal was used for beach maintenance.

These coastal activities must have changed the hydrodynamic flow patterns in many respects. The impacts of these coastal modifications are not well documented since there was no systematic monitoring of the effects of these coastal modifications in the Maldives (Kench et al. 2006).

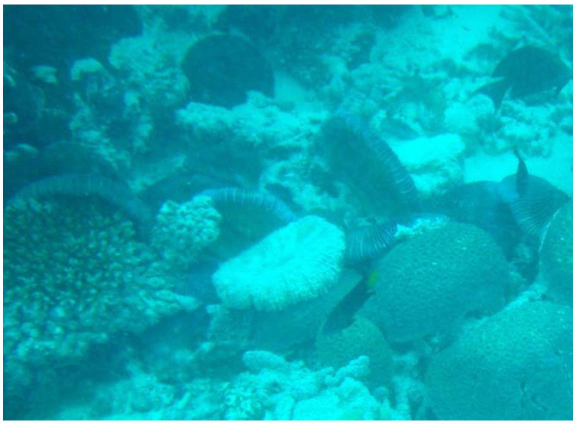
4.3.2.1 Marine survey sites

Details of the survey sites are presented in Figure 4.1 above.

4.3.2.2 Site D1

The coral reef at D 1 area is relatively well developed with about 20 to 50 percent live coral cover at the observed areas. The bottom of reef edge was dominated by coral rock followed by *Acropora* table, and branching corals plus *Goniastrea* sp and *Echinopora* sp. The reef on the western side forms a somewhat steep slope with very good live coral cover. A sandy terrace was observed at the D 1 area (Figure 4.33). The depth of this sandy area is about 8-10m. Considerably large amount of fine sand can be extracted from this region.

Most commonly encountered genera of hard corals are: *Acropora, Astreopora, Diploastrea, Echinopora, Favia, Fungia, Galaxea, Goniopora, Goniastrea, Hydnophora, Laptoria, Lobophyllia, Platygyra, Porites, Pocillopora*



Solitary corals

Varieties of corals

Fine sand (at 9m depth)

Massive corals (Favids)

Figure 4.33 Benthic substrate observed at site D1

4.3.2.3 Fish communities at D1

The result of 10 minutes swim for fish count along D 1 area, revealed that the abundance and diversity of fish is moderately good on the around the reef-slope. This may be due to the presence of a number of live coral colonies. Since most of the area was covered with rock and live coral, fishes associated with this type of environment were encountered. The dominant fish taxa observed in the surveyed area included surgeon fishes, butterflyfishes, wrasses parrotfishes and damselfishes (see Table 4.4). The presence of *Acropora* coral colonies was associated with the occurrence of large number butterfly fishes this area. These fishes are an indicator of reef health. The abundance of fish was given in abundance categories. A = Abundant, C = Common, R = Rare.

Table 4.4: Results of the fish encounter survey at sites D 1.

Family	Species	Abundance
Acanthuridae	Acanthurus leucosternon	A
Acanthuridae	Acanthurus lineatus	R
Acanthuridae	Acanthurus triostegus	R
Acanthuridae	Naso brevirostris	R
Acanthuridae	Ctenochaetus sp.	C
Balistidae	Melichthys indicus	R
Carrangidae	Caranx melampygus	R
Chaetodontidae	Chaetodon auriga	C
Chaetodontidae	Chaetodon citrinellus	R
Chaetodontidae	Chaetodon meyeri	R
Chaetodontidae	Chaetodon triangulum	C
Chaetodontidae	Chaetodon trifasciatus	C
Chaetodontidae	Chaetodon trifascialis	R
Labridae	Helichoeres hortulanus	R
Labridae	Hemigymnus melapterus	R
Labridae	Labroides dimidiatus	C
Labridae	Gomphosus caeruleus	R
Labridae	Thalassoma hardwicke	C
Lutjanidae	Lutjanus gibbus	C
Lutjanidae	Lutjanus kasmira	R
Mullidae	Parupeneus barberinus	C
Mullidae	Parupeneus bifasciatus	R
Nemipteridae	Scolopsis bilineatus	R
Pomacanthidae	Pygoplites diacanthus	R
Pomacentridae	Chromis viridis	C
Pomacentridae	Dascyllus aruanus	R
Pomacentridae	Pomacentrus indicus	C
Pomacentridae	Stegastes sp.	C
Siganidae	Siganus sp.	R
Scaridae	Cetoscarus bicolor	C
Scaridae	Scarus sordidus	C
Scaridae	Scarus frenatus	C
Serranidae	Cephalopholis argus	R
Zanclidae	Zanclus cornutus	R

4.3.2.4 Site D 2

The coral reef at D 2 area is also well developed with about 30 to 50 percent live coral cover at the observed areas. The bottom of reef edge was dominated by coral rock followed by *Acropora* branching and massive forms of *Porites* and *Echinopora* sp. No sandy areas were present at the deeper reef slope at this site. The coral genera found at this site is rather similar to site 1.

Varieties of corals

Fine branching coral (*Acropora*)

Favid (*Diploastrea*)

Soft coral

Figure 4.33: Benthic substrates observed at the site D 2.

4.3.2.5 Fish Communities at D 2

The result of 10 minutes swim for fish count along D 2 area, revealed that the abundance and diversity of fish is moderately good on the around the reef-slope. The dominant fish taxa observed in the surveyed area included surgeon fishes, butterfly fishes, wrasses parrotfishes and damselfishes (see Table 4.5). The presence of *Acropora* coral colonies was associated with the occurrence of large number butterfly fishes this area. These fishes are an indicator of reef health. The abundance of fish was given in abundance categories. A = Abundant, C = Common, R = Rare.

Table 4.5: Results of the fish encounter survey at sites D 2.

Family	Species	Abundance
Acanthuridae	Acanthurus leucosternon	A
Acanthuridae	Acanthurus lineatus	R
Acanthuridae	Naso brevirostris	R
Acanthuridae	Ctenochaetus sp.	C
Balistidae	Melichthys indicus	R
Carrangidae	Caranx melampygus	R
Chaetodontidae	Chaetodon auriga	R
Chaetodontidae	Chaetodon citrinellus	R
Chaetodontidae	Chaetodon meyeri	R
Chaetodontidae	Chaetodon trifasciatus	R
Chaetodontidae	Chaetodon trifascialis	R
Haemulidae	Plectorhinchus sp	R
Labridae	Helichoeres scapularis	R
Labridae	Hemigymnus melapterus	R
Labridae	Labroides dimidiatus	C
Labridae	Gomphosus caeruleus	R
Labridae	Thalassoma hardwicke	C
Lutjanidae	Lutjanus bohar	C
Lutjanidae	Lutjanus gibbus	C
Lutjanidae	Lutjanus kasmira	C
Mullidae	Parupeneus bifasciatus	R
Pomacanthidae	Pygoplites diacanthus	R
Pomacentridae	Chromis viridis	C
Pomacentridae	Dascyllus aruanus	R
Pomacentridae	Pomacentrus indicus	C
Siganidae	Siganus sp.	R
Scaridae	Cetoscarus bicolor	C
Scaridae	Scarus sordidus	R
Scaridae	Scarus frenatus	C
Serranidae	Cephalopholis argus	R
Serranidae	Variola louti	R
Serranidae	Plectropomus leavis	C
Zanclidae	Zanclus cornutus	R

4.3.2.6 Reef invertebrates

Only a few species of mollusks and echinoderms were encountered in these 2 sites (see Table 4.6). This may be due to the nocturnal nature of mollusks and echinoderms. What was observed during the timed swims is presented in the table below.

Table 4.6: Results of the invertebrate encounter survey – SITES D1 and D2

Common name	Count D1	Count D2
Giant clam	6	2
Sea cucumber	3	6
Feather star	-	1
Starfish	6	7
Urchins	5	3

Sea cucumber

Feather star

Figure 4.35 some of the invertebrates encountered at site D 2

4.3.2.7 The seagrass ecosystem

Seagrass beds are known to have high ecological value as they provide important food resources to a range of fish and invertebrates (King 1981; SunAqua 2002), both directly (grazing by fish and turtles) and indirectly (through detrital food chains, or provision of shelter to other associated flora and fauna). Furthermore, seagrasses provide structural habitat, shelter and nursery areas to a range of marine flora and fauna, including many species of invertebrates and fish of fisheries value (e.g., King, 1981; Haywood 1995; SunAqua 2002). This may be true for the extensive seagrass beds found in neritic environments. The significance of seagrass ecosystems to Maldivian environment and biodiversity has not been studied yet. However, it is known that seagrass beds play a very important role in protecting shoreline erosion. In the cases Maldives the presence of seagrass around an island has been linked to the eutrophication in coastal areas. The presence of seagrass in the reef-flat of many fishing island is an indicator of this.

Seagrass was observed almost all around the island. The main species observed was of seagrass (*Thalassia hemprichii*). The density of the sea grass varied depending on the locality. The density of the sea grass is controlled by wave energy and strong current in some areas.

Table 4.7 Seagrass species observed

Family	Species
Sygnathidae	Corithoichthys haematopterus
Gerreidae	Gerres sp.
Lethrinidae	Lethrinus harak
Labridae	Helichoeres scapularis
	Labroides dimediatus
	Cheilio inermis
	Coris frerei.
Acanthuridae	Acanthurus triostegus
	Zebrasoma scopus
Mullidae	Parupeneus barberinus
	Parupeneus bifasciatus
Pomacentridae	Abudefduf biocellatus.
	Pomacentrus nagasakiensis
	Pomacentrus chrysurus
Balistidae	Rhinecanthus aculeatus
Siganidae	Siganus sp.
Tetraodntidae	Canthigaster benetti

The emperor fish *Lethrinus harak* may be considered as an indicator species of the health of the seagrass area. This species generally inhabits in healthy seagrass beds. Most other species that were observed are herbivores that graze on epiphytes. Schools of siganids (Thah-mas) were seen. This species is often used as a food fish in this atoll.

Only a few invertebrates were observed within the seagrass zone. This may be due to the timing of survey, since most of the molluscs and other echinoderms are nocturnal. Thick growth of sea grass also camouflages them making it hard to find. Some of the invertebrates observed at the seagrass area included String-of-beads sea cucumber (*Synapta* sp.), Common black sea cucumber and some bivalve species.

4.3.2.8 Visual assessment of the reef-flat of the western side

The beach and marine environment of the island has been heavily modified with the intension of improving the environmental condition of the area and to provide greater guest satisfaction with respect to the beach and sea. These modifications included:

- Dredging a channel between Hulhudhoo and Herathera
- Attempted removal of seagrass at the sea adjacent to the beach
- Widening the beach using the excavated material.

The outcome of these modifications as of yet are not very promising. It is true that dredging the channel between Hulhudhoo and Herathera has improved the quality of marine environment on the western side mouth of the channel. However the large portion of the lagoon on the western side still remains turbid and murky. The removal attempt of seagrass was also not successful since the seagrass has been removed only very close to the beach. Large patches of seagarss can be seen within the seagrass removed area. In fact, the removal by excavation of seagrass has increased the murkiness of the area. Due to the way seagrass was removes large and dangerously deep ditches are present very close to the beach. The widening of the beach using the excavated material without proper filtration is exposing coral rubble at the beach area. These rubble are spreading out into the lagoon bottom adjoin the beach. The observations made on the western side of the reef-flat are summarized in the diagram below.

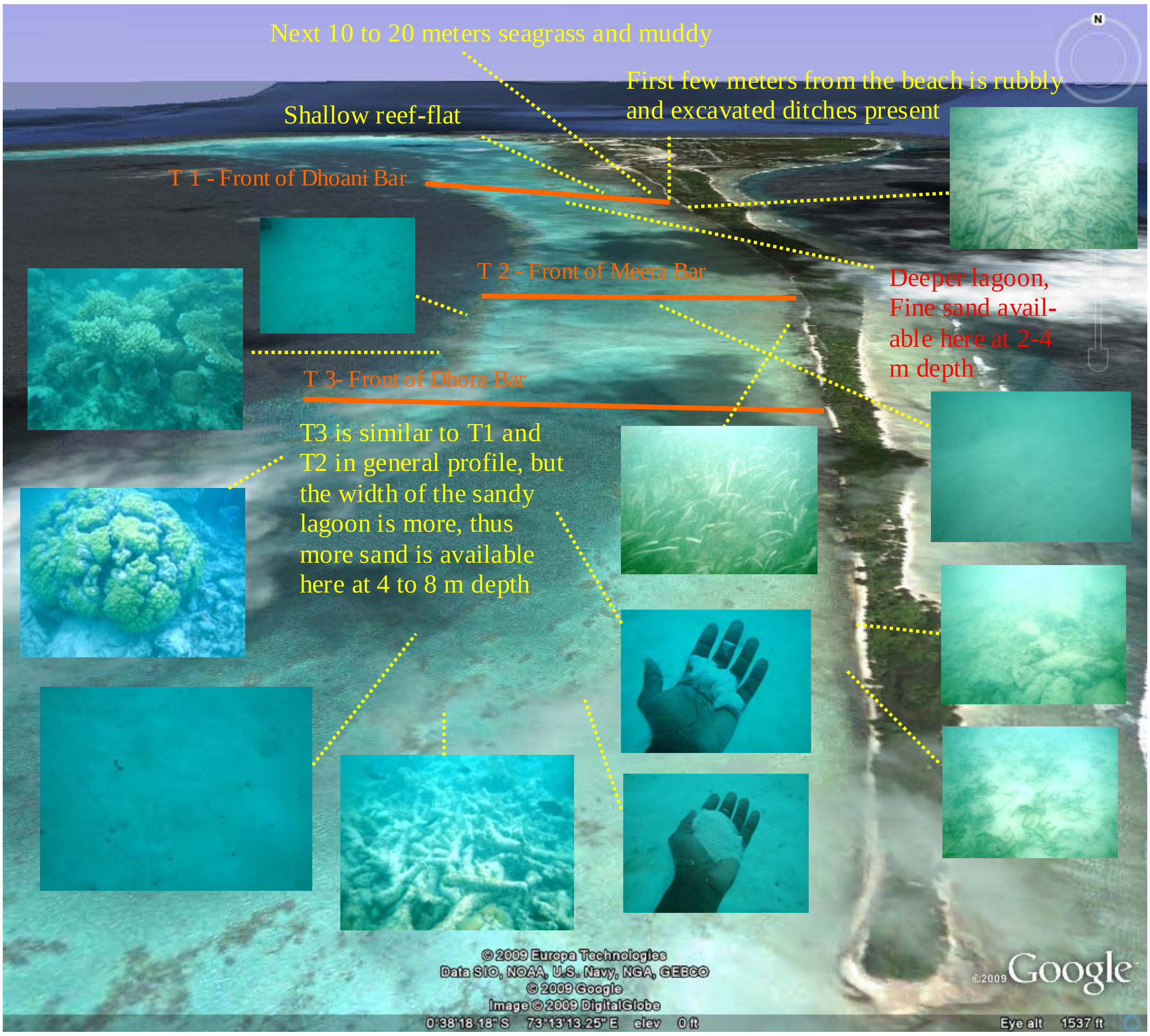


Figure 4.36 Summary of visual observations made

4.3.2.9 Manta Tow

The manta tow was conducted along the lagoon ward reef of the island. Due to low visibility the tow had to be conducted for approximately 800 m of the 4 km reef, as shown in figure 4.1.

Approximate hard coral cover for this sampling area is 40%, while 60% was sand and rubble. Less than 20% of the corals observed shows varying degrees of coral bleaching; especially on Acropora table species. In addition white patches on submassive corals were widespread throughout the whole tow, this is possibly due to grazers such as parrot fishes in the area. Few plastic bags were also observed caught on the reef.

Main types of corals observed during the tow were; Acropora table corals and submassive corals. It should be highlighted here due to high sedimentation a large portion of the corals were covered in sand.

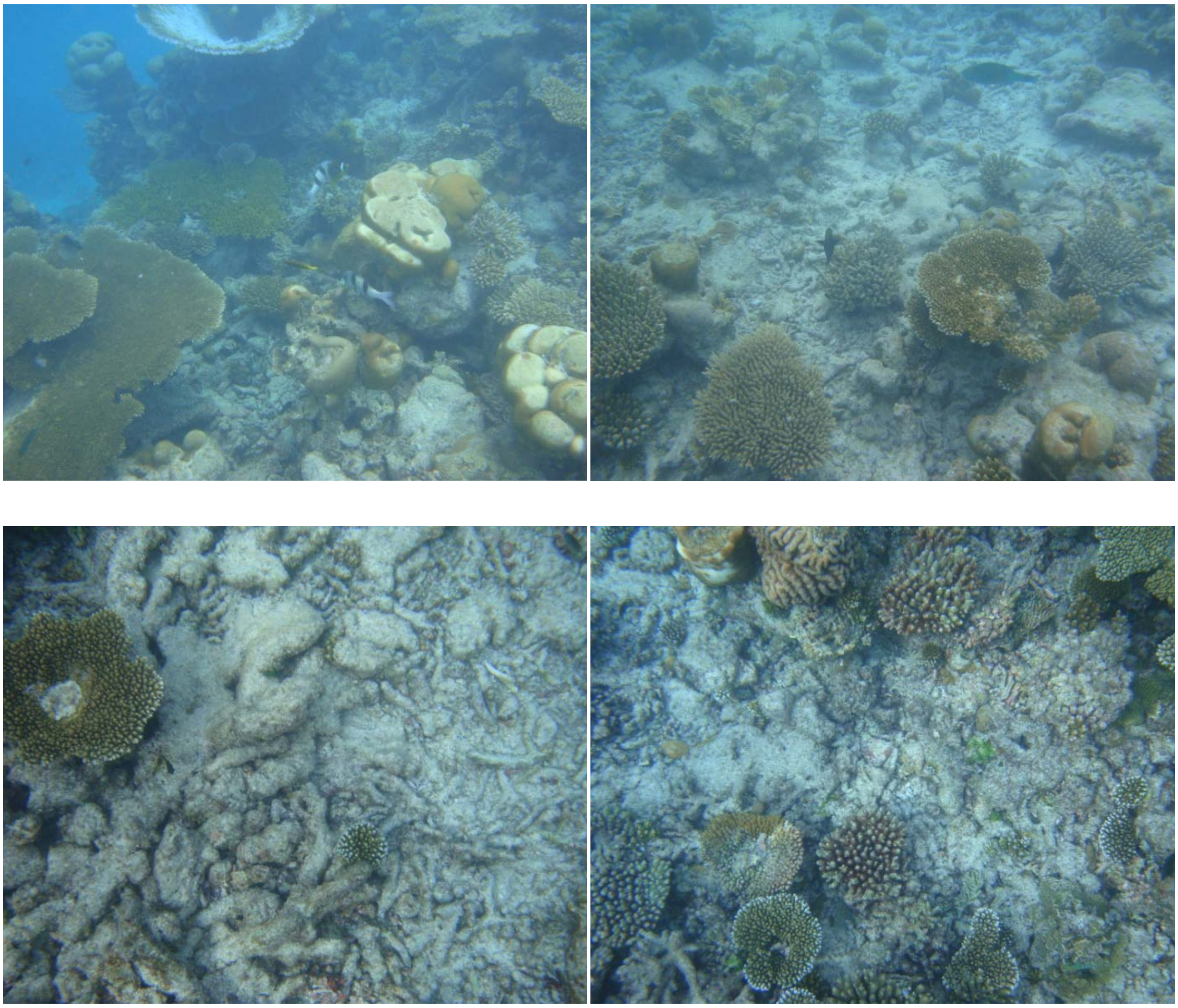


Figure 4.37 Selected photos along the tow line

4.3.2.10 Transect surveys

It was planned to conducted three perpendicular transects along the house reef of the island, however due to low visibility only two transect assessments were done at selected locations along the tow line.

4.3.2.11 Transect 1

Total number of coral species along the transect was recorded, predominant type of coral observed at this site was of the genera Acropora. It should be noted that few incidences of coral bleaching was observed in this station, however most bleaching was limited to the upper surface of the corals.

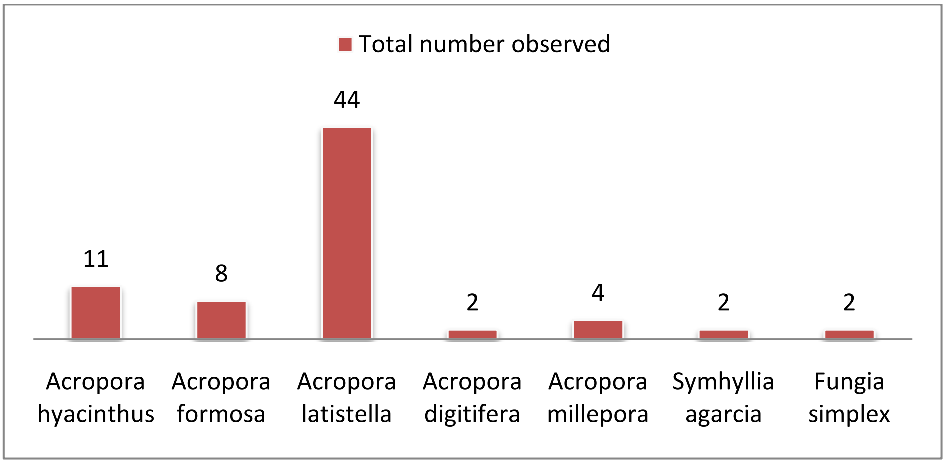


Figure 4.38 Species composition and population at transect 1

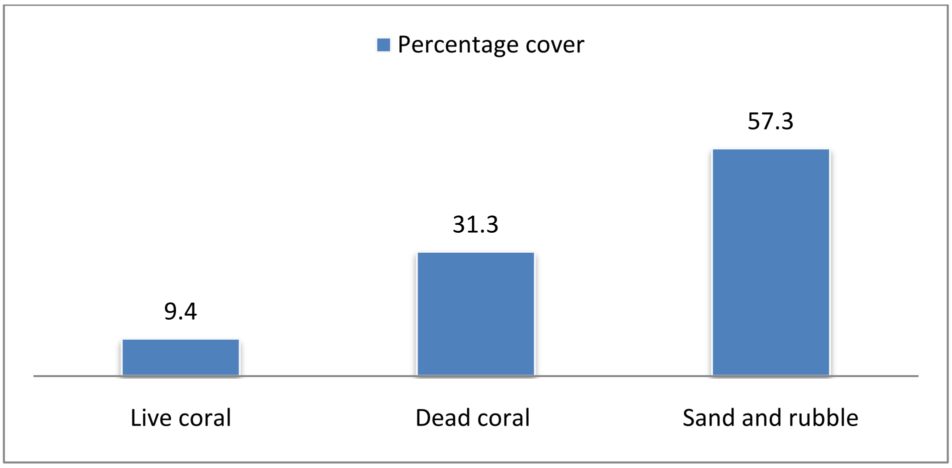


Figure 4.39 Reef benthic composition at transect 1

4.3.2.12 Transect 2

As observed in station 1, the predominant coral genera observed in this station is also Acropora. As shown in figure 10, percentage live coral cover at this station is approximately 9%. Large portion of this transect was covered with sand and rubble.

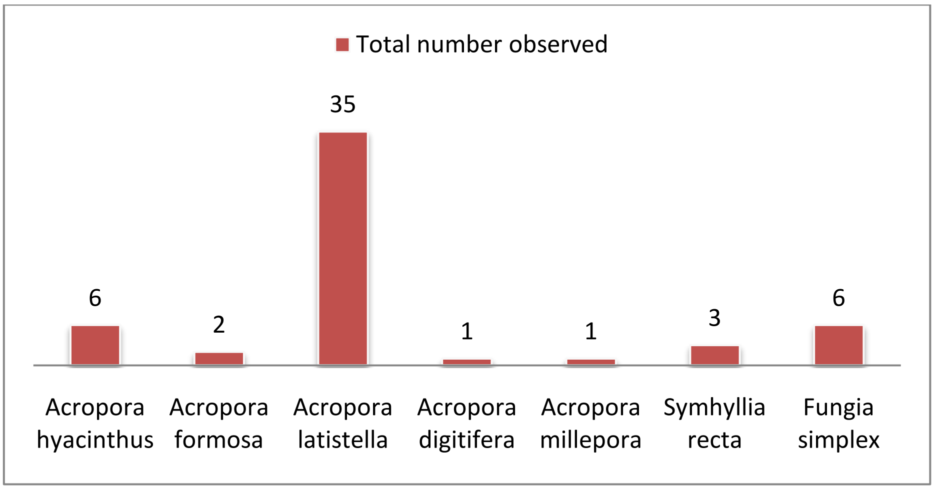


Figure 4.40 Specoes composition and population at transect 2

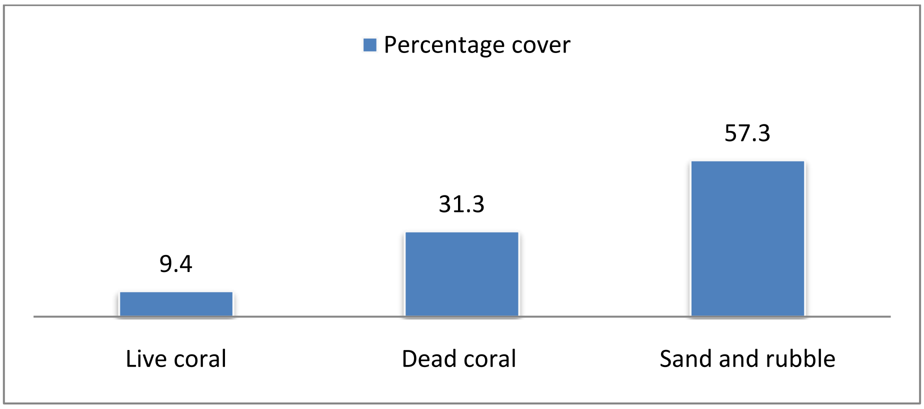


Figure 4.41 Reef benthic composition at transect 2

4.3.2.13 Marine water quality

The main objective of the marine water sampling and testing was to determine baseline water quality conditions. The data is used to establish "action levels" for determination of whether the proposed development may have an adverse effect on marine water quality of the site.

Tests were conducted to determine the quantity of following parameters present in the samples; pH, turbidity, total organic carbon, reactive phosphate, biological oxygen demand and faecal Coliform.

Table 4.8 Results of water quality results

Parameter Tested	SW L1	SW L2	SW L3	SW L4	SW L5
Physical Appearance	Clear	Clear	Clear	Clear	Clear
pH	8.4	8.4	8.4	8.3	8.3
Turbidity	5 NTU	5 NTU	7 NTU	7 NTU	6 NTU
Total Organic Carbon	10.1 mg/L	10.7 mg/L	11.4 mg/L	11.2 mg/L	11.6 mg/L
Reactive Phosphate	0.07 mg/L	0.05 mg/L	0.13 mg/L	0.1 mg/L	0.08 mg/L
Biological Oxygen Demand	10 mg/L	12 mg/L	14 mg/L	16 mg/L	12 mg/L
Faecal Coliform Count	0	0	0	0	0

pH levels between 6.5 to 8.5 is considered acceptable as pH within this range is not too acidic or alkaline to cause health problems (such as eye irritation) to those using these water bodies. pH levels at the sampling locations of Herethera range from 8.3 to 8.4.

All parameters measured indicate that seawater samples taken from these locations are within the acceptable ranges.

4.4 Hazard Vulnerability of the Site

According to the UNDP Disaster Risk Assessment Report of Maldives in 2006, Herathera is located in an area exposed to tsunamis, wind storms, storm surges and swell waves. It does not identify the island as being exposed to swell waves. The 2004 tsunami did not have much impact on the island but a future, severe magnitude tsunami along specific points of the Sumatran Ridge is likely to flood the entire island.

A detailed risk assessment study undertaken on S. Feydhoo and S. Hithadhoo could be considered as an indicator of the type of impacts on Herathera. However, caution should be raised to the fact there are number of parameters which determine the actual hazard vulnerability of an island. Based on the reports, the Feydhoo could be exposed to swell waves, storm surges, tsunami, heavy rainfall and strong winds (see Table below). These findings have major implications for Herathera which could be severely damages following a coastal flooding event, particularly since the island very narrow and low lying. The resort needs to consider disaster mitigation planning early on.

Table 4.9 Predicted disaster risks in S. Feydhoo Island (Source DHRAM 2 – UNDP & MPND)

Rapid onset flooding hazards

Hazard	Max Prediction	Impact thresholds			Probability of Occurrence		
		Low	Moderate	Severe	Low Impact	Moderate Impact	Severe Impact
Swell Waves *(wave heights on reef flat – Average Island ridge height +1.8m above reef flat)*	NA	< 2.0m	> 2.0m[1]	> 3.0m	High	Low	Very Low
Tsunami *(wave heights on reef flat)*	3.0m	< 2.0m	> 2.0m[2]	> 3.0m	Moderate	Low	Very low
SW monsoon high seas *(wave heights on reef flat)*	2.0m	< 2.0m	> 2.0m	> 3.0m	Very High	Very low	Unlikely
Heavy Rainfall *(For a 24 hour period)*	284mm	<75mm	>75mm	>175mm	High	Moderate	Low

Slow onset flooding hazards (medium term scenario – year 2050)

Hazard	Impact thresholds			Probability of Occurrence		
	Low	Moderate	Severe	Low	Moderate	Severe
SLR: Tidal Flooding	< 2.0m	> 2.0m	> 3.0m	Moderate	Very Low	Very Low
SLR: Swell Waves	< 2.0m	> 2.0m	> 3.0m	Very high	Moderate	Low
SLR: Heavy Rainfall	<75mm	>75mm	>175mm	Very High	Moderate	Low

[1] Impact on southern half of island will be severe if floods higher than 1.5m. The northern half has an artificial high ridge.
[2] If tsunami approaches from within the atoll lagoon impact can be severe beyond 2.5m.

Other rapid onset events

Hazard	Max Prediction	Impact thresholds			Probability of Occurrence		
		Low	**Moderate**	**Severe**	**Low**	**Moderate**	**Severe**
Wind storm	NA	<28 knts	> 28 knts	> 40Knts	Very High	Moderate	Low
Earthquake (MMI value[3])	III	< IV	> IV	> VI	Low	Unlikely	none

[3] Refer to earthquake section above

5 POTENTIAL IMPACTS AND MITIGATION MEASURES

5.1 Introduction

This Chapter will discuss all the potential impacts (positive and negative) associated with the proposed development activities and suggest mitigation measures for all potential negative impacts. Impact identification and mitigation measures were primarily based on stakeholder consultations, literature reviews, professional judgment and past experience from similar projects.

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

Activity → Causal Factor → Potential Impacts → Short Term Effects → Long Term Effects

In addition, the significance of impacts was determined based on the following characteristics:

- Nature of impact (direct/ indirect/cumulative)
- Spatial distribution of impact
- Duration of impact
- Reversibility of impact
- Magnitude of impact
- Negligible: No significant impact
- Minor: The impact is only short term and reversible on the long run
- Moderate: The impact maybe irreversible and cause long term concerns but most likely short term and reversible.
- Major: the impact is long term and irreversible

Table 5.1 shows a summary of the characteristics of the potential impacts identified and the significance of each impact. It should be noted that impacts correspond to the worst-case scenario in absence of any mitigation measures.

Table 5.1: Summary Characteristics of the Potential Impacts Identified and the Significance of Each Impact

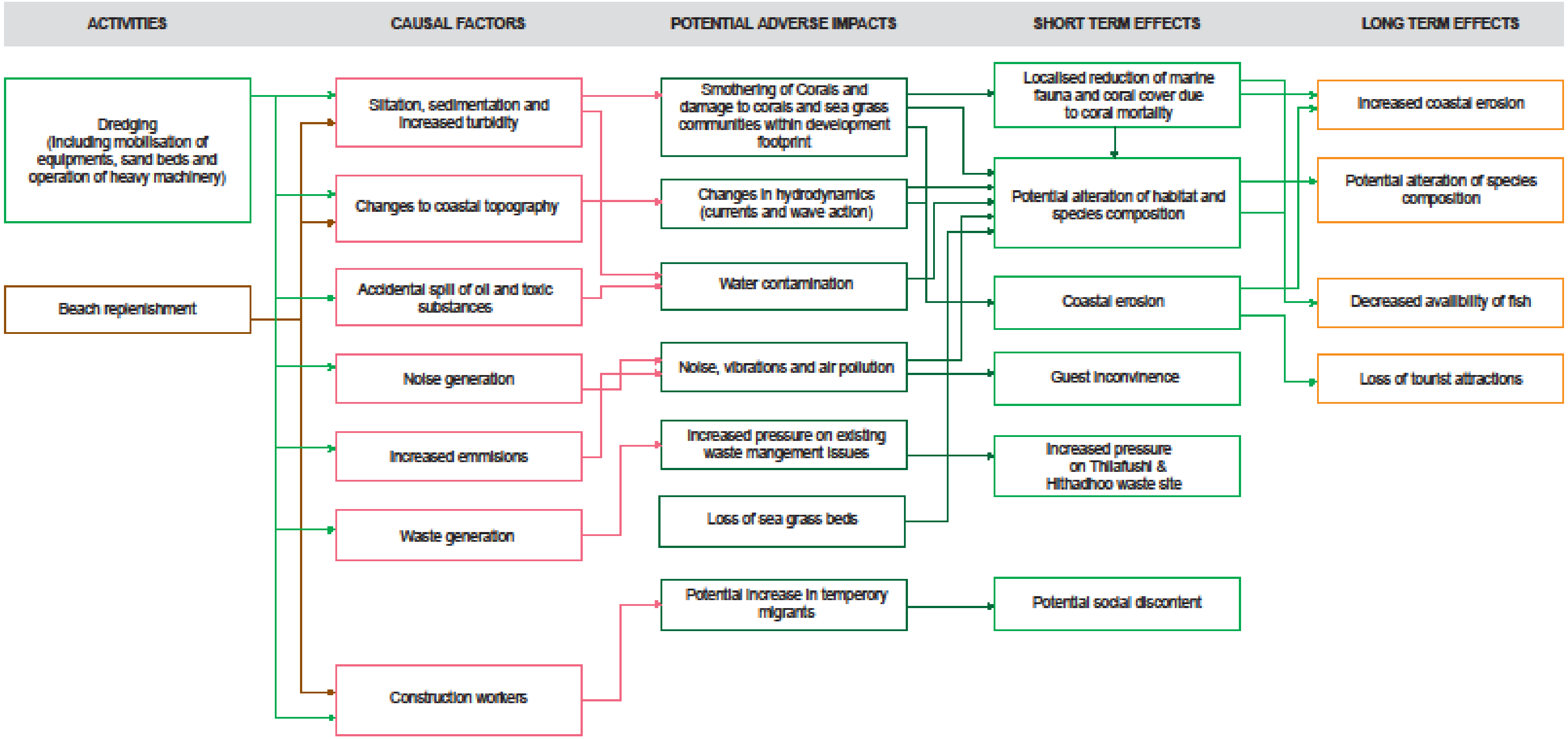
Impact	Nature	Spatial Distribution	Duration	Reversibility	Magnitude	Significance
Smothering of lagoon habitats	Direct	25 - 30 Ha	Short term	Yes	Major	Significant
Loss of sea grass habitat	Direct	25 Ha	Long term	No	Major	Significant
Smothering of coral reefs	Direct	2000 m^2	Medium term	Yes	Minor	Insignificant
Increased Coastal Erosion	Direct	Western coastline (~ 4000 m)	Long-term	No	Moderate	Significant
Marine water contamination from accidental oil spills	Direct	1-500m^2	Short term	Maybe	Moderate	Insignificant
Pollution (air/noise)	Direct	1-300 m^2	Short term (only during the project)	Yes	Minor	Insignificant
Generation of waste	Direct	Thilafushi Herathera waste site	Short and Long-term	No		Insignificant
Improved tourism product	Direct & indirect	Herathera and Addu Atoll	Long term	No	Major	Significant
Controlled erosion (beach replenishment)	Direct	Western shore line (~4000 m)	Short- to medium-term	-	Moderate	Significant

5.2 Brief Description of Potential Impacts and Suggested Mitigation Measures

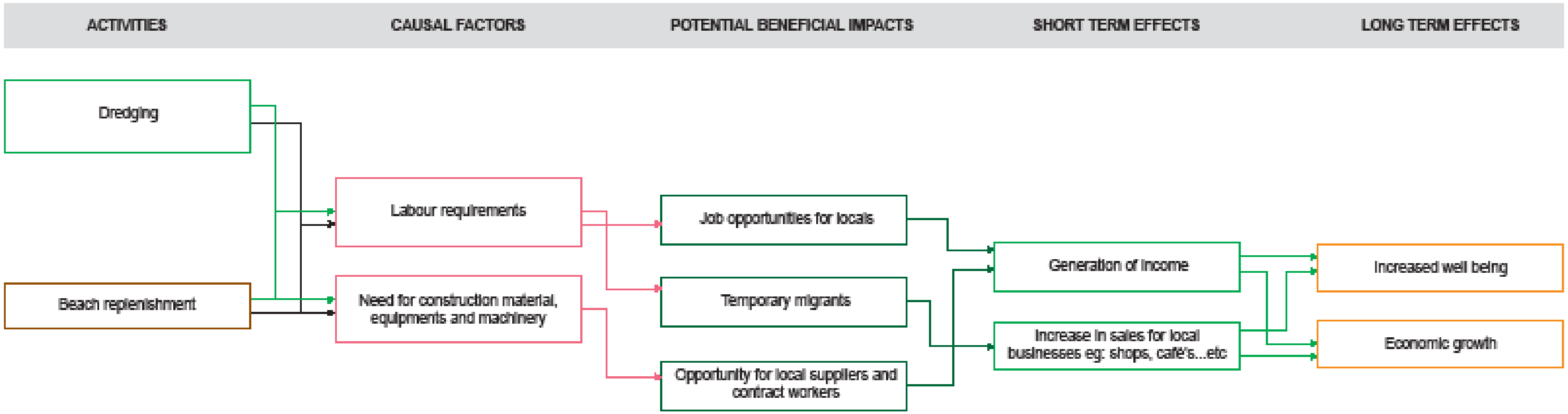
This section will provide a brief description of each of the potential impacts illustrated in the flowcharts and suggest appropriate mitigation measures for all potential adverse impacts.

A summary of the potential negative and positive impacts during construction and operation stage of the report is provided in the diagrams in the next four pages. Details of the key impacts provided in the following subsections.

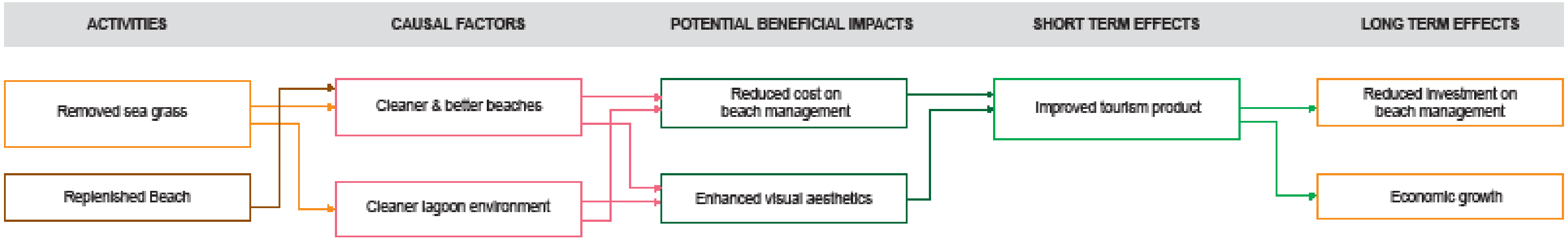
POTENTIAL NEGATIVE IMPACTS FROM SEA GRASS REMOVAL AND BEACH REPLENISHMENT



POTENTIAL BENEFICIAL IMPACTS DURING CONSTRUCTION PHASE



POTENTIAL BENEFICIAL IMPACTS DURING OPERATIONAL PHASE



5.2.1 Potential Adverse Impacts during Construction phase and Suggested Mitigation Measures.

5.2.1.1 Smothering of Corals and reduced light to marine organisms

During dredging as well as beach replenishment works, a significant amount of siltation and sedimentation of the lagoon waters is anticipated. Similarly, increased turbidity of the lagoon water is expected. These factors will cause adverse impacts such as smothering of corals and reduced light penetration to the coral and benthic communities. Under normal circumstances, corals have a self cleansing mechanism and can withstand a certain rate of sedimentation. Hence, 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 lagoon.

There are no major coral colonies with the immediate dredging area. However, during the SW monsoon, it is highly likely that sediment will be transported long distances along the reef flat and reach the lagoon and oceanward reef slope. In addition the strong currents during tidal flood around the artificial channel will cause some material to be deposited on the reef slope. On the positive side these the dispersal may help to kill seagrass without dredging in some parts.

Therefore it is vital to take proper mitigation measures to avoid siltation, sedimentation and turbidity as much as possible.

Mitigation measures to prevent from smothering of corals

- Silt-screens or bund-walls shall be established around the project site to control sediment disbursing. This includes sea grass removal zones, borrow area and replenishment zones.
- All construction works will be undertaken during calm weather conditions particularly when wave activity will be calmer.

5.2.1.2 Changes in Hydrodynamics

During dredging as well as beach replenishment works there is a high likelihood abrupt change to coastal hydrodynamics. This may lead to temporary erosion on the island and changes to coral growth. Of particular concern is the immediate severe erosion that may follow these activities as the coastal process tries to adjust to the changes. The dredged areas are likely to act as sediments sinks and it may take a number of years before the lagoon conditions stabilise against the prevailing conditions. However, since much of the sediment will be borrowed from lagoon slopes the impacts from sediment sinks are likely to be reduced.

Mitigation measures to manage hydrodynamic changes

- Beach replenishment should be carried out slightly wider than the planned width to anticipate and compensate for adjustments.

- Continuous monitoring to identify abnormal activity.

5.2.1.3 Water Contamination

During dredging as well as replenishment works, any accidental spill of oil and toxic substances will contaminate the marine and/or groundwater.

Furthermore, significant quantities of waste will be generated from all construction related activities where any mishandling of solid (non-biodegradable) waste and hazardous waste will also contaminate the marine water. Therefore, special care should be taken when handling oil, solid waste and hazardous waste to entirely avoid any accidental spills and leakage.

Mitigation measures to prevent from water contamination (marine and/or ground water):

- All machinery will be properly tuned and maintained
- All paints, lubricants, and other chemicals used on site will be stored in secure and bunded location.
- Oil, solid waste and hazardous waste will be handled carefully and transported in sealed containers in properly bunded vehicles/vessels
- Construction activities will be carried out under the supervision of a suitably experienced person.

5.2.1.4 Noise, Vibrations and Air Pollution

During the mobilisation of equipments and operation of heavy machinery for dredging works and beach replenishment, it is anticipated that significant noise will be generated. Such vibrations may alter species behaviour in the short term. In addition, dust and emissions from vehicle and machinery exhausts will degrade the air quality. However, these adverse impacts will be short term and can be mitigated to avoid nuisance to the resort.

Mitigation measures for noise, vibrations and air pollution

- All construction works will be carried out during day time to minimise nuisance to the resort and disturbances caused to nocturnal fauna such as birds and fruit bats that uses auditory communication.
- All vehicles and machinery will be tuned and well maintained to minimise air pollution

5.2.1.5 Loss of Seagrass habitats

There will be a complete loss of seagrass habitats on the western lagoon of the island. This will include the sea grass beds, bottom dwelling organisms such as molluscs, sea urchins, sea cucumbers and marine worms, seagrass algae and some juvenile fishes. However, most fish species are highly adaptive and may avoid the dredged area due to turbidity. Slow moving organism may be lost. The construction of the bund wall also may trap some fish species.

For the rest of the marine organisms, the loss of habitats may force them to move to alternate locations, most likely to sea grass beds off Hulhudhoo or into the newly growing sea grass colonies. Sea grass is often a feeding ground for a number of species, particularly turtles. Loss of habitat may force such animals and organisms to seek alternative habitats.

Sea grass also has its benefits to the coastal environment processes by trapping sediments and stabilising lagoon bottom. This is known to be a natural method of shoreline stabilisations. Removal of seagrass will affect the sediment transportation and stabilization rates.

Oh the other hand, it could be argued that this particular species of sea grass is incompatible with tourism products offered in the Maldives. The resorts in Maldives are largely seeking to sell their pristine white beaches and clear lagoons. Seagrass aesthetically negates both these advantages. Hence, the seagrass bed will have to be sacrificed if a resort is to be operated on Herathera.

Mitigation measures reduce impacts on marine organisms

- Leave the out-lying smaller sea grass patches as it is to facilitate migration of surviving organisms.
- Do not close of off the bund wall in a single day. Give at least two tide cycles before it is closed.

5.2.1.6 Increased pressure on existing waste management facilities

The amount sea grass waste generated from this project will be immense. The existing facilities (Hithadhoo waste site) will not be able to handle the new waste. The available option is to locate the material on the island in a designated zone. The sediment can be stored for long-term usage but the seagrass needs to be buried. Burying and storage of marine sediments on land may cause saltwater to seep into the ground water system. There will also be a smell in the area immediately after the disposal.

Mitigation measures for waste management

- Designate a specific location on the island to store and dispose material and avoid using existing facilities.
- Use special machinery, if require, to dispose sea grass (for example preparing fertilisers)
- Use polythene or similar geotextile material to establish a liner between the ground water and the deposited marine sediments. This is to prevent salt water intrusion. Mechanisms will have to be established to slope and divert the salt water to the sea.

5.2.2 Potential Adverse Impacts during Operational Phase and Suggested Mitigation Measures

5.2.2.1 Changes in Hydrodynamics

As in the construction stage, it is highly likely that there will be considerable changes to hydrodynamics during the operation stage. First, the creation of a dredged basin deeper that the surrounding reef flat will cause sediment to settle into it. This may result in the loss of beach material from the beach.

Mitigation measures to manage hydrodynamic changes

- Continuous monitoring to identify abnormal activity and implement mitigation measures when needed.

5.2.3 Potential Beneficial Impacts during Construction Phase

The potential beneficial impacts during the construction phase of the proposed development are mainly socio-economic impacts. These include:

- Employment opportunities during construction works
- Business opportunity for local suppliers (construction material, lighting, sanitary ware, furniture, white goods, cutleries…etc)
- Opportunity for local contract workers
- Opportunity for locals to rent out equipments, machinery, vehicles and vessels.
- Increase in sales for the local businesses such as shops and cafés

5.2.4 Potential Beneficial Impacts during Operational Phase

The potential beneficial impacts during the operational phase of the proposed development include:

- Better tourism product.
- Guest satisfaction and reduced complaints
- Reduced cost on beach cleaning

5.2.5 Mitigation Costs

Table 5.2 Cost of Mitigation Measures for Impacts during Construction Phase

Impact	Mitigation Measures	Costs
Smothering of Corals	- Silt-screens or bund-walls will be established at around the project site to control sediment disbursing. - All construction works will be undertaken when wave activity will be calmer.	US$ 10,000 NA
Water Contamination (Marine and/or Ground water)	- All machinery will be properly tuned and maintained - All paints, lubricants, and other chemicals used on site will be stored in secure and bunded location. - Oil, solid waste and hazardous waste will be handled carefully and transported in sealed containers in properly bunded vehicles - Construction activities will be carried out under the supervision of a suitably experienced person. - Leachate protection liners for sediment storage zone	US$3000 US$2000 US$1500 US$2000 US$7000
Noise, Vibrations and Air Pollution	- All construction works will be carried out during day time - All vehicles and machinery will be tuned and well maintained to minimise air pollution	NA US$5000
Increased pressures on waste management facilities	- Designate specific equipment to transport and handle waste.	US$20,000

6 ALTERNATIVES

6.1 "No-project" Alternative

The following no project options have been considered.

No beach replenishment

Leave sea grass beds as they are.

The comparison of benefits of each alternative is provided in the table below.

Table 6.1 Summary of no project alternative

Options	Advantages	Disadvantages
No Beach replenishment	Limited impacts on the lagoon and reef Impacts avoided from beach erosion due to replenishment	- Poor beach product - Decline in occupancy and reputation of the resort – loss of income - Costs of beach cleaning (removing coral pebble) - costs of erosion prevention - continuous loss of beach ecology due to regular beach cleaning (removing rubble)
Leave sea grass beds as they are	Marine habitats are not disturbed Alteration of sea bed and potential future erosion avoided	- Poor beach product - Decline in occupancy and reputation of the resort - Aesthetically unpleasant lagoon - Aesthetically unpleasant beach due to beaching of seagrass. - costs of erosion prevention

Given the disadvantages of existing conditions on the island and virtual impracticality of promoting a beach resort under present conditions, the preferred option is to go ahead with the project.

6.2 Alternative Dredge Waste (sand and rubble) Disposal Methods

Table 6.2 Summary of alternative dredge waste disposal for sand and rubble

Options	Advantages	Disadvantages
Use for beach replenishment (Preferred Option 1)	- Optimises cost effectiveness. - Enhances the beach as an economic product. - Avoid introduction of seagrass species into other reef systems.	- Future coastal erosion related to replenishment. - Negative impacts on coral reef and lagoon benthos related to sedimentation and turbidity.
Storage on the island future use (Preferred Option 2)	- Avoids the impacts of unnecessary land reclamation - Avoids impacts of marine disposal	- Storage space takes up land - Potential seepage of saltwater into groundwater system. - Affects of traffic and potential seepage of saltwater into ground water during movement of sand laden trucks. - Costly
Deep sea disposal	- Minimal disruption to the existing coastline	- High cost of transport makes it less cost effective - Additional dredging required to bring in large transport barges - Spillage during transport.
Place the material back in the basin after separating seagrass.	- Reduces impacts from coastal process changes related to a dredged basin.	- Extensive sedimentation during the replacement and afterwards due to loose material. - Not cost effective
Land reclamation in Herathera	- Cost effective method to create new land - Land available for new development	- Plenty of land already available and new land will only be an excess. - Additional environmental impacts due to coastline changes
Land Reclamation in Hulhudhoo	- Provides a contribution to the community development - Additional land for Hulhudhoo	- Additional costs, particularly since there is a channel separating the two islands. - Social complications

6.3 Alternative Seagrass Disposal Methods

Table 6.3 indicates the alternative disposal methods for seagrass waste.

Table 6.3 Summary of alternatives for seagrass disposal

Options	Advantages	Disadvantages
Burial under previously reclaimed wetland area near staff area. (Preferred Option)	- Provides options to create fertiliser for landscaping. - Avoids impacts of marine disposal - cost effective disposal	- Storage space takes up land - Potential seepage of saltwater into groundwater system. - Affects of traffic and potential seepage of saltwater into ground water during movement of sand laden trucks. - Costly
Disposal to Hithadhoo Waste site	- Minimal disruption to the existing coastline - Minimal chance of seagrass being dispersed on to the reef. - Safe disposal	- High cost of transport makes it less cost effective - Spillage during transport and transfer of live sea grass in Hithadhoo reef system. - Additional pressure on Hithadhoo waste disposal site which is currently over burdened and lacks disposal equipment.
Deep sea disposal	- Minimal chance of seagrass being dispersed on to the reef. - limited impacts on terrestrial environment	- High cost of transport makes it less cost effective - Spillage during transport and introduction of sea grass in other reef system due to drifting material.

The alternatives available are limited and increases the foot print of seagrass movement. The preferred option is disposal on site.

6.4 Alternate Borrow Areas

Table 6.4 indicates the alternative borrow areas available for the project and Figure 6.1 shows a map of the alternate locations. These areas are in additional to the sea grass removal zones.

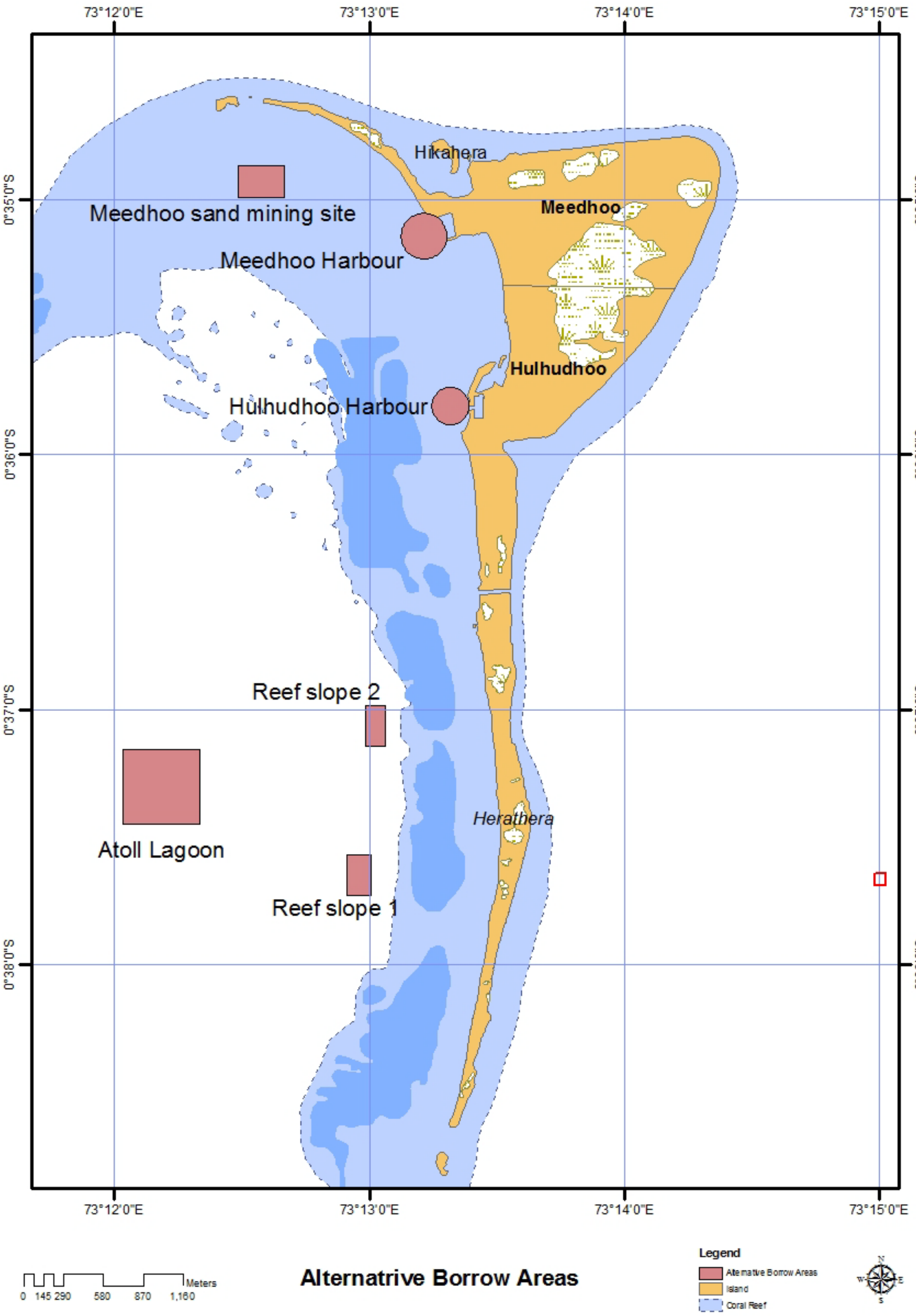
Table 6.4 Summary of alternative borrow areas

Alternative location	Advantages	Disadvantages
Choice of sites from among those already identified from inner lagoon slopes.	Very cost effective. Impacts limited to a smaller foot print Avoid social conflicts of resource sharing with atoll population	- Chances of lagoon basin becoming murky for long periods are high due to the large foot print of activities within the lagoon. - Potential negative impacts on the reef patches within the lagoon.
Outer reef slope	Large volumes of sand from one or two locations are guaranteed Impacts on lagoon benthos minimal Quality sand is good for replenishment	Smothering of corals and increased siltation on the reef slope Potential damage to reef during barge operations Extensive use of barges to transport sediments causing some spillage in lagoon and reef. Takes more time and is more expensive, as it requires specialized equipment.
Meedhoo sand mining area	Large volumes of quality sand guaranteed	Expensive to extract and transport Socio-economic conflicts with sand miners and Meedhoo population Reduced volume of sand in one of the key sand mining sites for the atoll. Have to pay a hefty royalty to the government.
Hulhudhoo or Meedhoo Harbour	Large volumes of sand guaranteed Provides an social and economic benefit for the local community and Province Office	Quality of sand not guaranteed and will require additional costs for sorting. Transportation expensive Social complications if the requirements of the resort do not meet the expectation of the inhabited islands.

Atoll basin	Large volumes of sand from one or two locations are guaranteed Impacts on lagoon benthos minimal. Can be done in very quick time	Requires specialised dredgers and workers Not cost effective for a small scale project. Affects on water column and surrounding marine life.
Sand mining areas in Huvadhoo Atoll	Large volumes of sand from one or two locations are guaranteed	Expensive and slow Socio-economic complications Reduced volume of sand in one of the key sand mining sites for the atoll. Have to pay a hefty royalty to the government.

The options available for borrow areas are numerous and environmental impacts of these sites are more-or-less similar, apart from deep lagoon dredging. The best practicable option comes down to costs which is lowest when borrowed from the reef lagoon.

Figure 6.1: Alternative borrow areas.



6.5 Dredging Alternatives

Table 6.5 indicates the alternative methods for dredging of the harbour basin.

Table 6.5 Summary of Dredging Alternatives

Dredging Method	Advantages	Disadvantages
Sand pumping (preferred option 1)	Least impact option. Very cost effective. No additional dredging or bundwall creation required	- Cannot remove the sea grass roots entirely - May not be possible to operate barges at low depths. - Cannot pump long distances. - smothering of corals and increased siltation.
Excavator on temporary sand bed (preferred option 2)	Most common method practiced by contractors for small scale projects Does not require specialized skill Very cost-effective	Smothering of corals and increased siltation due to extra dredging for the creation of temporary sand bed
Excavator on barge (preferred option 3)	Environmentally friendly due to less siltation and avoidance of unnecessary dredging	Difficult to operate in limited work space Extra costs associated with additional equipments such as a tug to haul the barge
Cutter Suction Dredger	Dredging works can be completed within a short time frame	Requires highly skilled operators Not suitable for small scale dredging works High costs
Manual Removal	Most environmentally friendly option.	Very slow process; cannot remove large areas in this manner. Cleared areas may reappear after 3 months

The preferred option is to use a sand pump. Any areas that cannot be removed using a pump should remove using an excavator on a barge. Areas that are two shallow for barge operation should use an excavator on temporary sand bed.

6.6 Sedimentation control measures

Table 6.6 indicates the alternative technologies for the sediment containment.

Table 6.6 Summary of sediment containment measures

Type of Measure	Advantages	Disadvantages
Bund Wall	Environmentally friendly Durable Cost effective	High impact on marine environment. Cheap option
Silt screen (preferred option)	Durable Easy to handle Environmentally friendly	Large quantities not locally available Costly.

For all sand pumping activities and dredging for beach replenishment, silt screen is preferred. For the removal of seagrass areas, silt screen is the primary option but if the area is too large then bund walls may be considered.

7 ENVIRONMENTAL MONITORING PLAN

7.1 Introduction

This Chapter will outline the monitoring plan for the proposed project. Environmental monitoring is essential because, although with proper mitigation measures, the overall environmental damage can be significantly minimized, an unforeseen impact may still occur. Furthermore, some of the impacts predicted may turn out to be far greater than predicted, making mitigation measures ineffective. Therefore, in order to avoid or reduce the chances of such events, regular and frequent environmental monitoring is vital.

7.2 Objectives of the Monitoring Plan

Herathera Island Resort already has an environmental monitoring plan. The purpose of this plan is to prescribe additional activities or modifications to the existing monitoring plan based on the project activities.

The main objectives of the monitoring plan are:

- identify whether the predicted impacts are accurate and mitigation measures taken are effective
- identify any unforeseen impacts so that appropriate mitigation measures can be taken at the earliest
- identify whether the community reaps the predicted employment opportunities and socio-economic benefits
- identify and resolve any issues of social unrest at the earliest
- eliminate or reduce environmental costs

7.3 Aspects of the Monitoring Plan

Table 8.1 below summarizes the key aspects of the monitoring plan. The Table indicates the methodology, frequency and estimated cost for each monitoring attribute that will be required for the proposed project.

Table 7.1 Aspects of the Monitoring Plan

Monitoring Attribute	**Indicator**	**Methodology**	**Frequency**	**Estimated Cost**
Water Contamination (Marine)	Water quality	Laboratory analysis	Upon completion of the project, two months after completion and thereafter annually	US$50 per survey
Waste monitoring	Waste generation levels	Waste census	Once during the construction and annually during operation	US$150 per survey
Marine Water Contamination	Oil spills	Visual observation	Daily for the duration of the project	NA
	Oil leakage from machinery or vessels	maintenance and tuning of all machinery & vessels	Weekly during the construction phase	US$50 per week
Coral reef health	Percent of live coral cover Fish abundance	Line transect or photoqudrat surveys; manta tows	Monthly during construction and quarterly thereafter.	US$200 per survey
Erosion and Coastal Changes	Beach profiles	Surveying using level, staff, compass & D-GPS	Two months after completion of the project and thereafter annually.	US$100 per survey
	beach line (at high tide & low tide)	D-GPS tracks along the beach		
	Longshore currents	Drogue method		

Water Depth	Water Depth	Sonarmite or handheld echosounder	Two months after completion of the project and thereafter annually.	US$100 per survey

7.4 Monitoring Report

Based on the data collected, a detailed monitoring report will be compiled annually and submitted to the relevant government authorities for compliance. The report will include methodologies and protocols followed for data collection and analysis, quality control measures and indicate the uncertainties. This form part of the Annual Environmental Monitoring Report of the resort.

7.5 Commitment for Monitoring

The proponent is fully committed to undertake the monitoring program outlined in this Chapter (refer Appendix F of this report).

8 Public Consultation

Pubic consultation was undertaken with Hulhudhoo and Meedhoo residents regarding the proposed project. Unfortunately the team was unable to meet the Island Development Committees during the field visits due to a series of social activities and meeting that were held on the island. Hence, random individuals, including some of the key Island Administration personnel were interviewed.

The general method followed was to introduce the rationale, project components, methodology, key impacts and mitigation measures, followed by a discussion on the perception on the project and suggestions on improving it. The persons interviewed are listed in table below. The major findings of the consultation are summarised below.

a) Everyone welcomed and supported the project. Almost all of them encouraged to speed up the project so that Herathera could become fully operational and the locals could benefit from the growth of tourism.
b) Some of them highlighted the mistakes done in the previous project and asked to avoid those.
c) There was request by farmers to supply the sea grass debris for use as fertilisers. However, the logistics and costs involved in such an activity are substantial.
d) There were suggestion to improve the work methodology
    a. Kill the seagrass before removing it so that the chances of regrowth are limited and it is easier to remove them.
    b. Advised not to use an excavator as experience form past project is that it makes the waters murky for longer periods. However, this was mainly due to lack of mitigation measures to prevent siltation rather than the use of excavators.
    c. There suggestion to put in sea walls to protect the beach as previous experience shows that erosion is inevitable.
    d. There were some suggestions to include local labour who knows the place well and will care for the environment as it close to their own island.
    e. There were also suggestion to create more openings (channels) in Herathera facilitate sediment flow.

Table 8.1: List of persons consulted

	Name of person	Island	Designation
1	Ali Manik	Hulhudhoo	Self-employed
2	Mohamed Abdulla	Hulhudhoo	Not stated
3	Ibrahim Shareef	Hulhudhoo	Not stated
4	Hassan Futha	Hulhudhoo	-
5	Ahmed Musthafa	Hulhudhoo	Hulhudhoo Office
6	Ahmed Nasif	Hulhudhoo	Former Maalimee
7	Ibrahim Shareef	Hulhudhoo	Teacher
8	Ahmed Riza	Hulhudhoo	Self-employed
9	Abdul Sameeu	Meedhoo	Self-employed
10	Ibrahim Didi	Hulhudhoo	Hulhudhoo Councillor
11	Mariyam Shazleen	Meedhoo	Manager, BML Hulhudhoo-meedhoo branch
12	Hassan Shahid	Meedhoo	Meedhoo Councillor

Note: Contact details have not been included as some of them objected to put their phone number

APPENDIX A – Terms of Reference

APPENDIX B – Site Plan

APPENDIX C – Beach Profiles

Beach profile locations are presented in Figure 4.1.

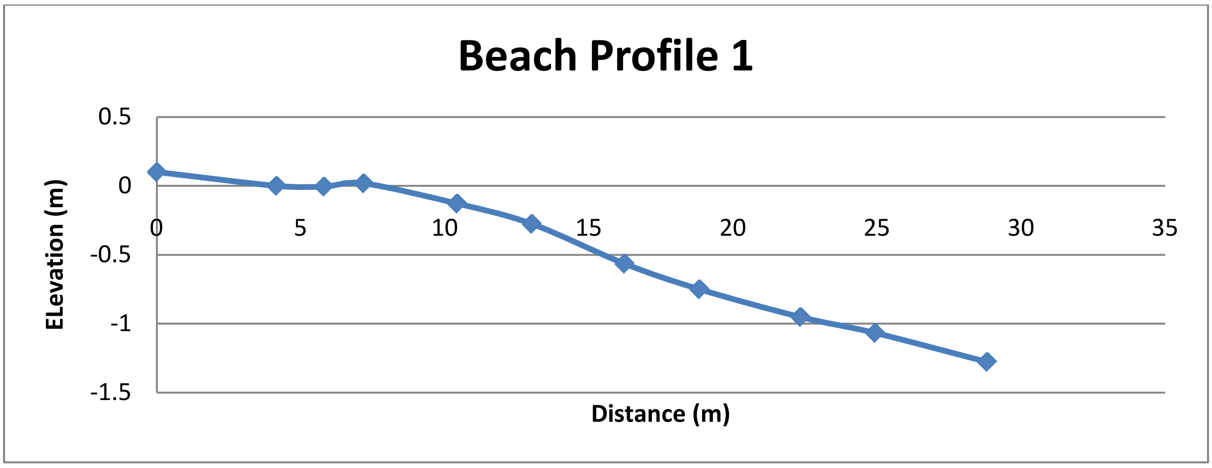


Figure C-1: Beach Profile 1

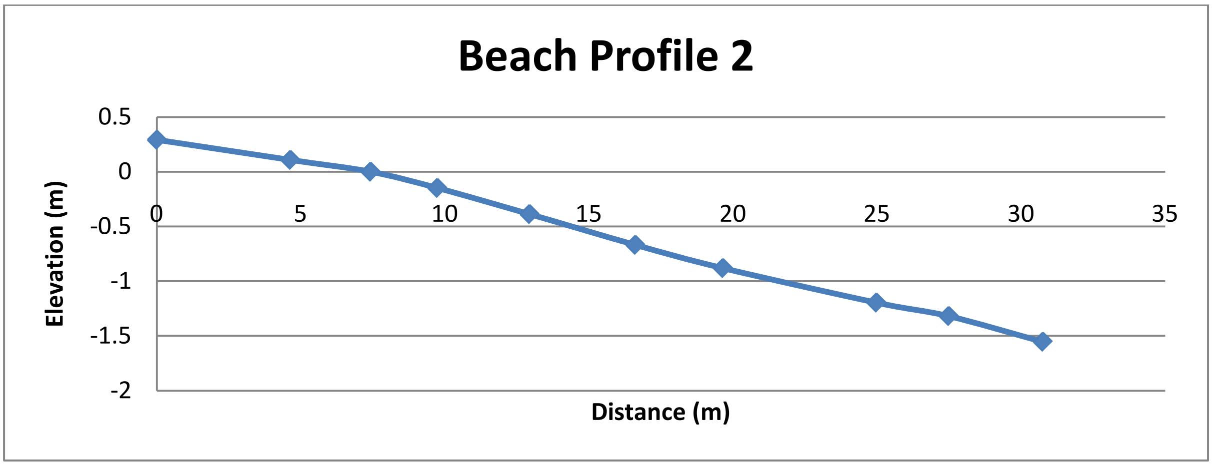


Figure C-1: Beach Profile 2

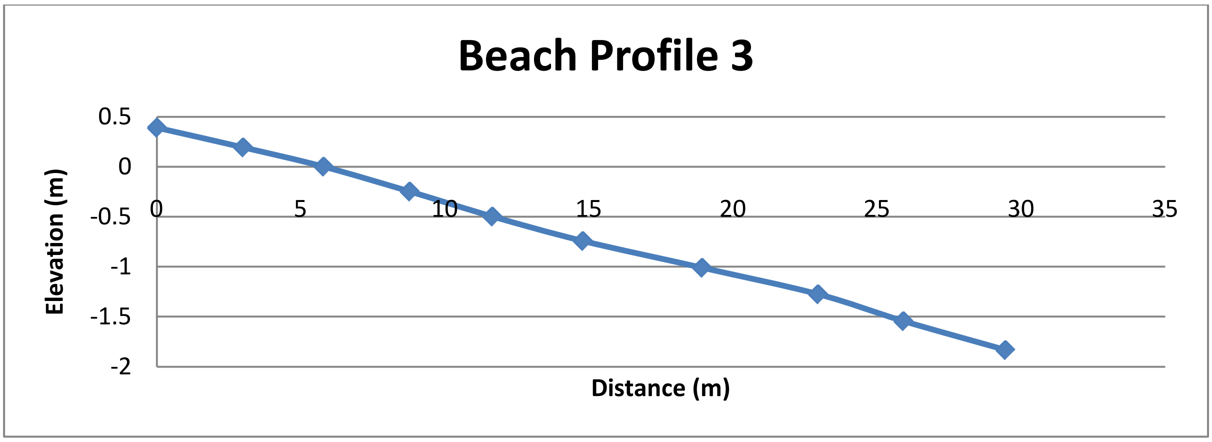


Figure C-1: Beach Profile 3

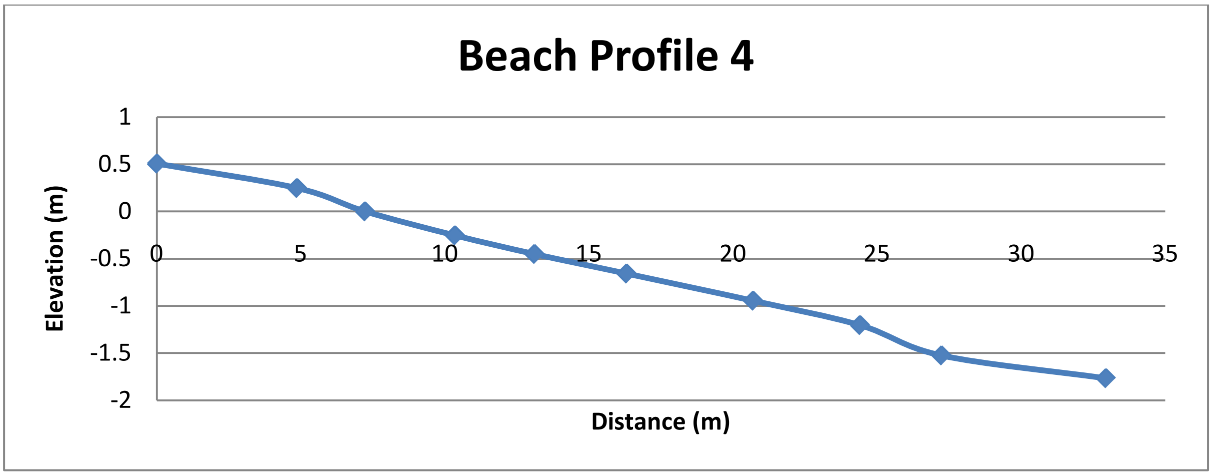


Figure C-1: Beach Profile 4

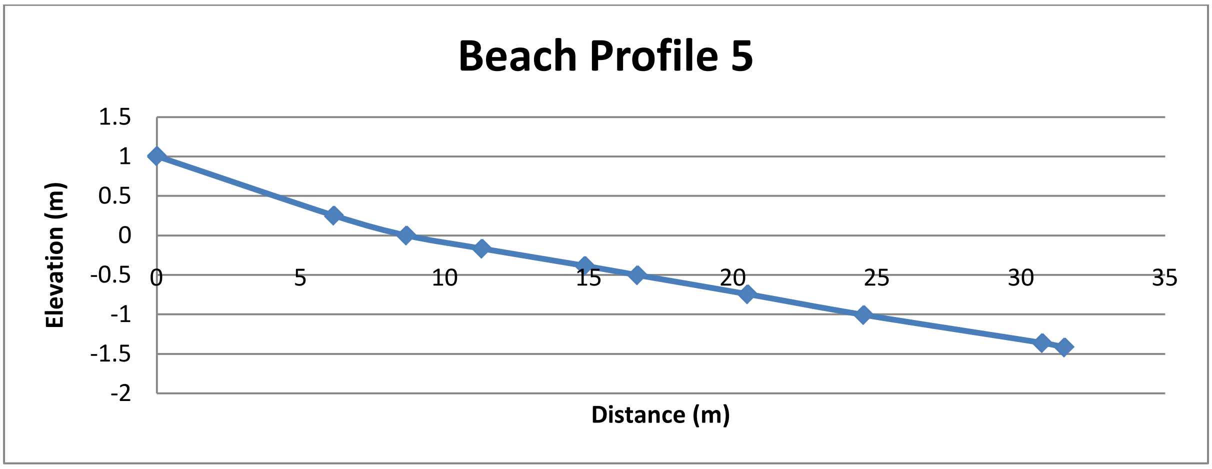


Figure C-1: Beach Profile 5

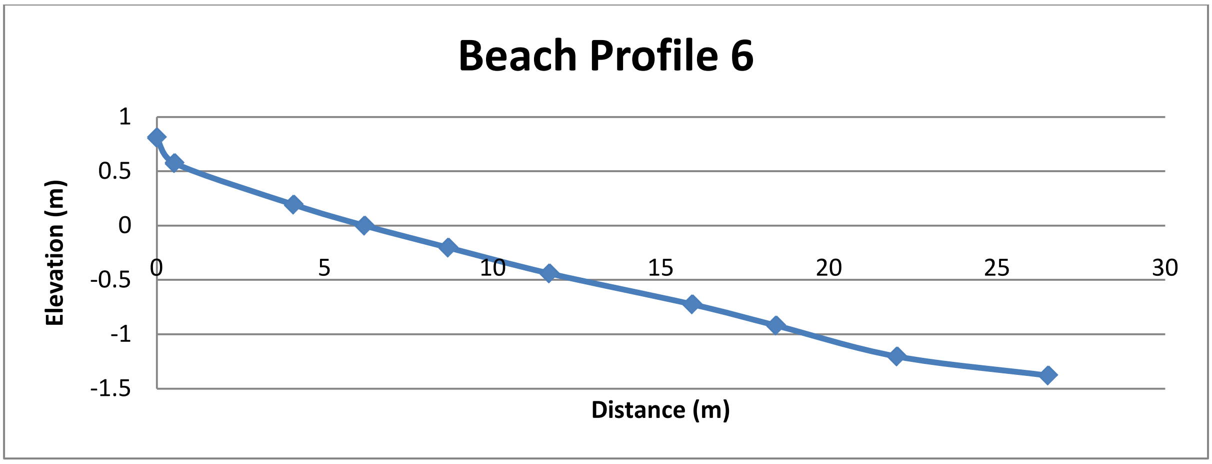


Figure C-1: Beach Profile 6

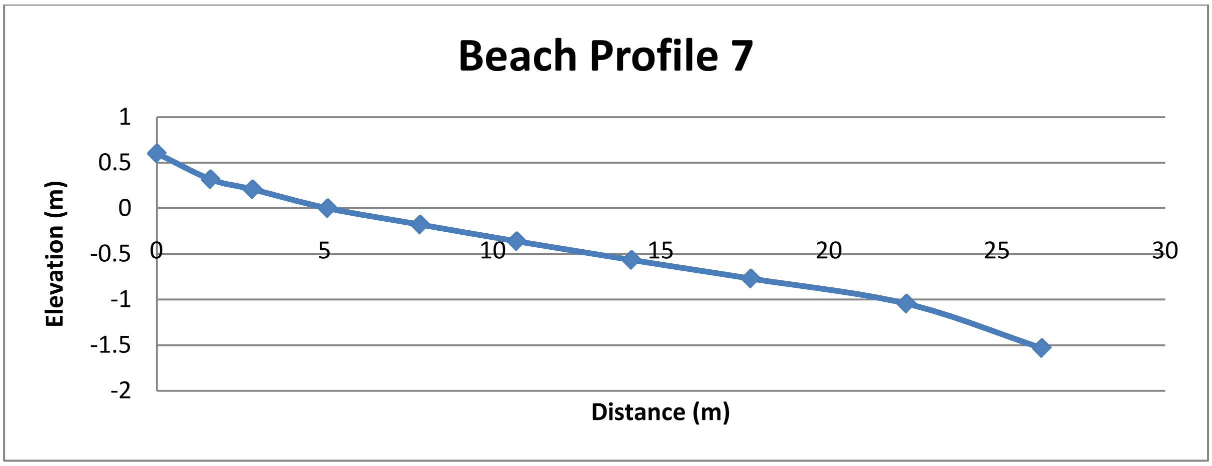


Figure C-1: Beach Profile 7

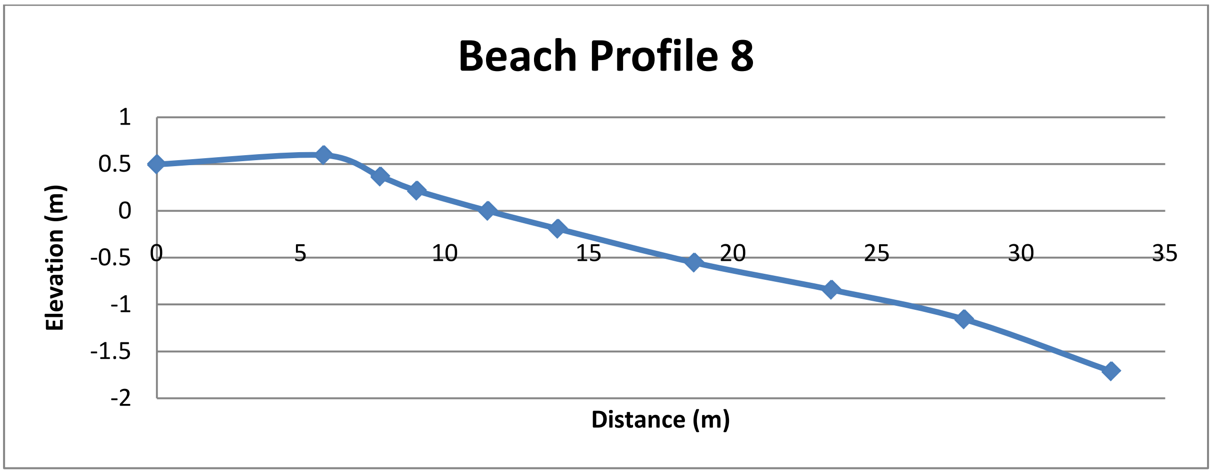


Figure C-1: Beach Profile 8

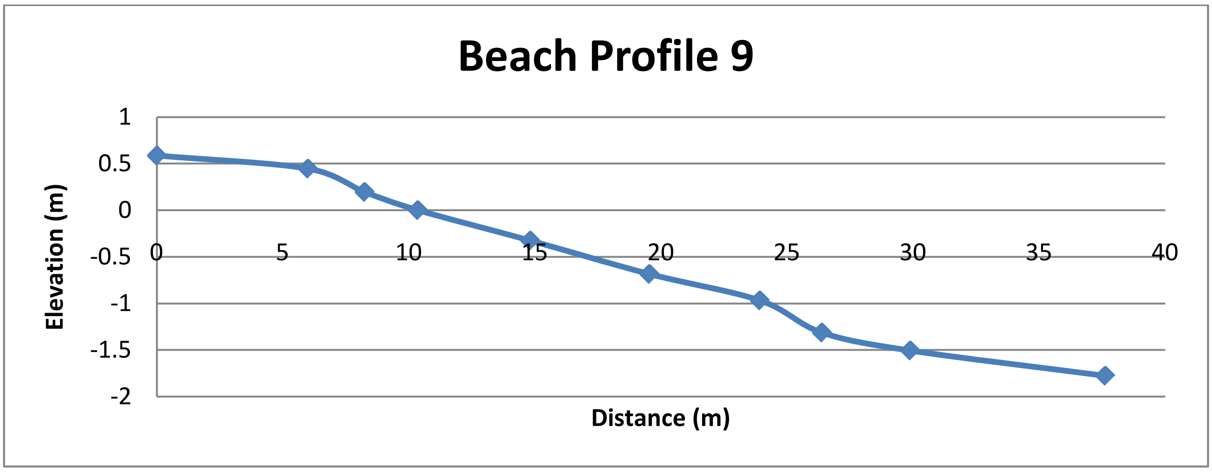


Figure C-1: Beach Profile 9

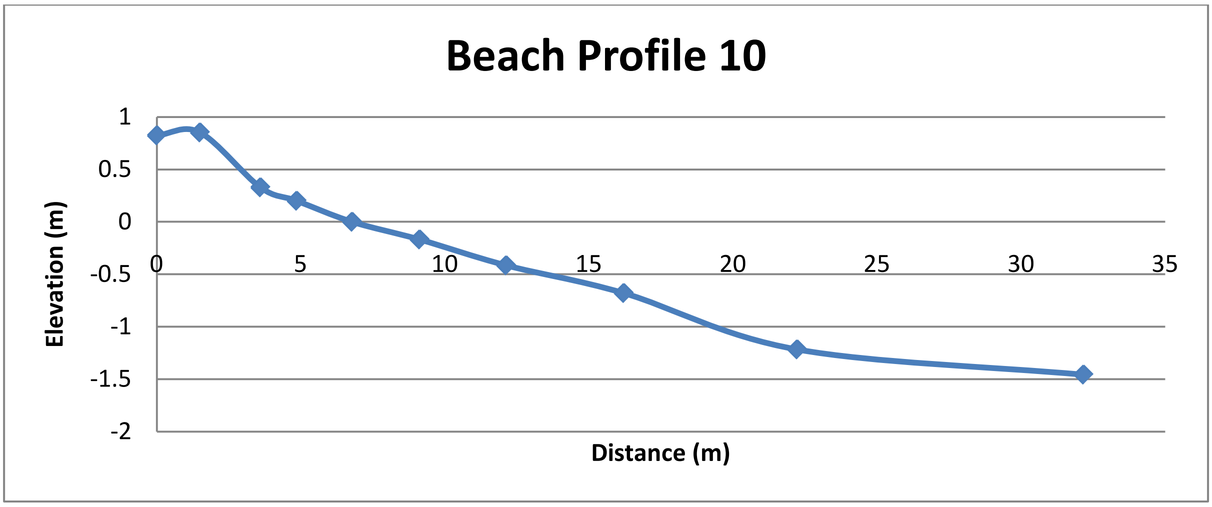


Figure C-1: Beach Profile 10

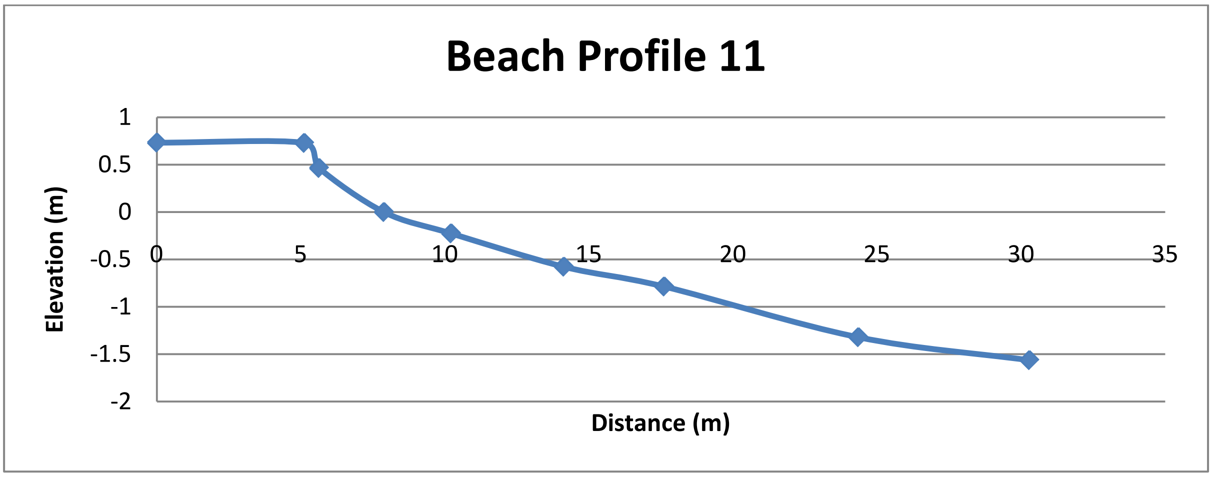


Figure C-1: Beach Profile 11

APPENDIX D – Bathy Chart

APPENDIX E – CV's of Consultants

APPENDIX F – Commitment to Monitoring