

ENVIRONMENTAL IMPACT ASSESSMENT

For the Proposed Harbour Development at
Dhangethi, Alifu Dhaalu Atoll, Maldives

Proponent: Ministry of Construction and Public Infrastructure, Maldives

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April 2008

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Non Technical Summary

This report discusses the findings of a social and environmental impact study undertaken by Water Solutions Pvt. Ltd. at the request of the Ministry of Construction and Public Infrastructure. The project involves the development of a new harbour in Dhagethi, Aalifu Dhaalu Atoll. This project is initiated by the government of Maldives as part of the Access Programme implemented by the MCPI.

The environment of Dhangethi may be described as properly managed, with several environmental achievements including appropriate solid waste management, development of a sewerage system with nearshore outfalls to some degree, modest housing with ventilation, appropriate level of urban planning, beach and recreational areas for the residents and visitors including tourists visiting the islands from neighbouring resorts.

Stakeholder consultations were held with various groups, including the community and the client in order to incorporate the socio-economic components in the project. It was observed that the community of Dhangethi is independent and people are ready to make a difference by community involvement, participation and empowerment that has achieved through the economic prosperity that have achieved through tourism in the region.

Environmental impacts were assessed for both the construction and operation phase of the project. Most of the environmental impacts of the project have been identified as resulting mainly from excavation and disposal of excavated materials. The main impact of dredging would be that of excessive sedimentation on the nearby reef areas. This impact is considered to be a moderate but short-term impact. Development of the harbour would have irreversible impact and its location would have a long term impact. The socio-economic benefits of the project may be considered to outweigh the negative impacts of the project on the physical environment of the island as the island is located on a strategic location in the middle of high density of resorts.

Mitigation measures for these anticipated impacts have been identified and outlined in detail, including sedimentation control methods and other measures. These mitigation measures will have to be followed in order to minimize environmental damage. The proposed harbour details for Dhangethi has been prepared after considering the needs and requirements from the community by assessing and incorporating the outcomes from the extensive community consultations held during the data collection stage.

It is inevitable that there would be negative environmental impacts, especially when excavation is undertaken. Nevertheless, these negative impacts are not severe to the extent that the project should not be allowed to take place. As a result, a monitoring component has been suggested which takes in to consideration, the most important elements that require regular checks. This monitoring component will be adhered to and will allow the assessment of changes due to construction of harbour. Monitoring is specifically focussed on water quality changes.

Therefore, it appears justified from a technical and from an environmental point of view, to carry out the proposed project in light of the existing socio-economic developments and forecasts made on the harbour use and traffic increase.

1 Introduction

1.1 Introduction

This Environmental Impact Assessment (EIA) report has been prepared in order to meet the requirements of Clause 5 of the Environmental Protection and Preservation Act of the Maldives to assess the impacts of proposed project for the development of a harbour at AD. Dhangethi. This report will identify the potential impacts (both positive and negative) of proposed project. The report will look at the justifications for undertaking the proposed project components. Alternatives to proposed components or activities in terms of location, design and environmental considerations would be suggested. A mitigation plan and monitoring programme before, during and after the works would also be included. Monitoring would ensure that the proposed activities are undertaken with caution and appropriate care so as to protect and preserve the built environment of the areas in proximity to the site or those areas and environmental aspects affected by the development.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site visit during 27 February 2008. However, due to unavailability of long term site-specific data, the impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment. Available long term data were collected from available sources, such as long term data on meteorology and climate from global databases.

This EIA has been produced in accordance with the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water on preparing Environmental Impact Assessment studies.

1.2 Aims and Objectives of the EIA

This report addresses the environmental concerns of the proposed rehabilitation of the harbour in Dhangethi in Aalifu Dhaalu Atoll. It helps to achieve the following objectives.

- Allow better project planning
- Assist in mitigating impacts caused due to the rehabilitation without compromising environmental damage.
- Promote informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.

1.3 Methodologies

Internationally recognized and accepted methods have been used in this environmental evaluation and assessment. This EIA is based mainly on data collected during a field investigation mission from 27 February 2008 by a team from Water Solutions, Maldives. The data collection methods are described in detail under Section 4.

1.4 EIA Implementation

This EIA has been prepared by Water Solutions consisting a team of:

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- Abdul Aleem (Registration number: EIA 09 / 07)

- Ibrahim Naeem (Registration number: EIA 13/07)
- Abdulla Yamin, Survey Assistant
- Mohamed Riyaz, Survey Assistant

1.5 Terms of Reference

The terms of reference for this EIA have been attached as Appendix 1. This EIA has been prepared based on this term of reference.



Figure 2-2: Aerial View of Dhagethi Natural Harbour area

One of the key economic activities of Dhangethi is related to tourism, and island hopping being the major economic activity that brings revenue and income to the island. Every day several hundred tourists visit the island from nearby resorts to see the island life and do souvenir shopping. This has resulted in propagation of tourist shops throughout the island.



Figure 2-3: Jetty located on western side of the island accessing to the natural harbour.

As a result, the community is reluctant to develop the harbour on the western side. Furthermore, a harbour on the western side will require breakwaters that will be more expensive and with a greater liner length, due to the fact that this area is naturally deep and long.

In contrast, the eastern side of the island is generally calm throughout the year and the access channel that is on the north-eastern side of the reef seems to be the most stable to be used as an entrance channel. This channel has been in use for many years and this is also the area where currents are most stagnant (evidence obtained through consultation with local people). As a result, sedimentation of this channel occurs very rarely and the channel rarely gets filled by sediments. Therefore, from the experience of the islanders, especially the elderly, it does not seem that sedimentation would be an issue along this channel and generally this area. Development of the harbour on the east side will also have several advantages as most of the vital community infrastructure is being developed in close proximity to this side. Another advantage is that the eastern side has a considerable reef flat. If the breakwaters can be constructed inside the reef flat, it will provide additional further protection of the harbour. Therefore, a proper harbour was necessary.

2.4 The Project

This is harbour development project at Dhagethi under the access programme implemented by the MCPI. Details of the project are given in the following subsections..

2.4.1 Project duration

A summary schedule and detailed schedule is appended below. The design development, EIA and Tender Documents would take 4 months. The Tendering Process will also take similar time but with one month overlap between the two activities. Construction, including handing over, would be completed in eight months.

Table 2-1: Project Schedule

Project Summary Schedule														
#	Activity	Duration in Months	Months											
			1	2	3	4	5	6	7	8	9	10		
1	Design, EIA & Tender	2	█											
2	Tendering Process	2		█										
3	Construction & Handing Over	6					█	█	█	█	█	█		

2.4.2 Project Concept

The design concept for the proposed harbour has been derived based on the information gathered from the field visit. The assessment included various aspects of socio-economic and environmental condition of the site that included topography, bathymetric and socio economic surveys on the island.

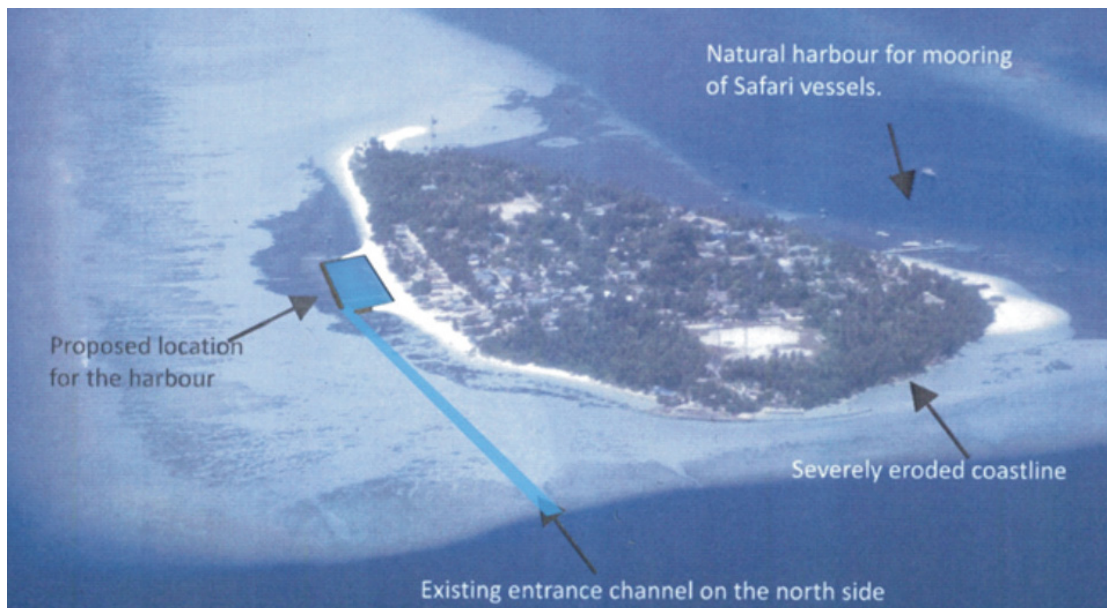


Figure 2-4: Concept layout for the proposed harbour and the island seen from the north side

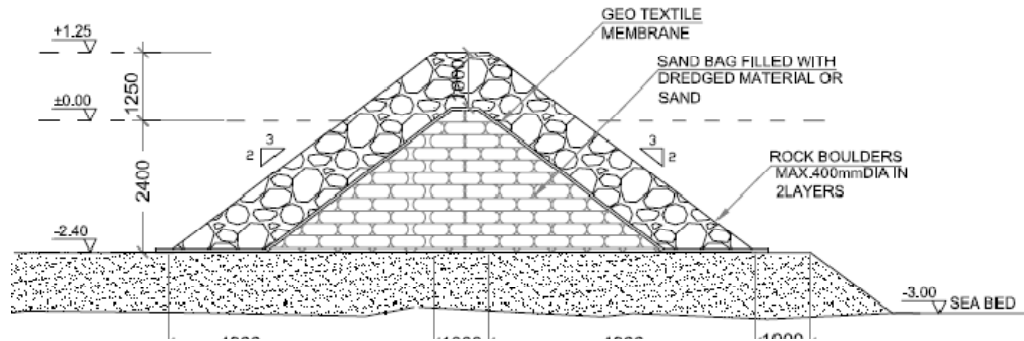


Figure 2-6: Proposed design for the breakwater

2.5.3 Entrance Channels

It is proposed to use the existing entrance channel which is located at north side of the island. The channel will be dredged to a depth of 3m below the low tide and will have a width of 20 meters.

2.5.4 Navigational Aids

Navigational aids are proposed to be installed on piled FRP pipes and block foundations with suitable lighting. Solar marine lights will be used to avoid laying of electrical cables.

2.6 Project Inputs and Outputs

2.6.1 Project Inputs

The project has inputs in terms of human resources, and natural resources and machinery. The main output of the project is a new harbour that would bring direct and indirect benefits to the local communities in terms of social and economic development. The inputs and outputs are summarised in Table 2-2 and Table 2-3.

Table 2-2: Main inputs of the proposed project

Input Resource(s)	Source/Type	How to obtain resource(s)
Construction workers (30+)	Maldivians and foreign (locals will be given preference)	Open bidding by advertising in local papers/other sources
Water supply (construction period)	Well water from the island	From community wells
Electricity/Energy (construction period)	Diesel-based electricity from island mains	Contractors to make provisions
Construction machinery	Excavators, dredgers, barges, general construction tools, lorries, cranes, loader.	Contractors to provide
Telecommunications	Mobile Phones, Fax Machines, E-mail and internet facilities	Already this services is available in the island
Transport (sea)	Materials to be transported in carrier vessels or large barges.	contractors
Food (during construction period)	Obtained from the island	Local purchase by the contractor
Fuel	Diesel, Petrol, Lubricants	Local purchase by the contractor

2.6.2 Project Outputs

The type of outputs (products and waste streams) and what is expected to happen to the outputs are given in Table 2-3.

Table 2-3: Matrix of major outputs of environmental significance during construction stage

Products and waste materials	Anticipated quantities	Method of disposal
Noise	Only localised to the island environment	Unavoidable during the construction stage but will be minimized.
Air pollution	Limited quantities of dust in the construction area (proposed harbour area).	Mainly arising as a result of dust emission from the construction work such as cement mixing, moving machinery and other processes. Only localised.
Dredged spoil	Over 45,000 cubic meters	About a third (15,000 m ³) will be disposed on the harbour front area behind the quaywall. The rest will be disposed at the southern end on the eastern side of the island.

2.7 Construction methodology

2.7.1 Construction strategy

The harbour development project will be undertaken in the planned time period to reduce cost and also reduce the environmental damage. Both coastal and marine based construction activities will be done in parallel to complete the work in the least possible time frame.

2.7.2 Work methods for coast-based activities

Coast-connected structures for this project include quay walls. Quay wall will also be constructed similarly using L-shaped reinforced precast concrete walls (see Figure 2-5). These L-shaped concrete walls will be placed along the quay wall section where it will be placed upright with a tie rod and concrete slab to stabilize the quay wall when it is loaded. Loading and unloading will be carried by excavators and cranes. Once they are in place and completed, backfilling will be done using part of the sand dredged from the entrance channel and harbour basin.

2.7.3 Work method for marine-based activities

Marine-based activities under the project include excavation and construction of breakwaters. Excavation of the harbour basin and access channels will be done by using excavators. Excavators placed on a barge or sand bund will be used to dredge the harbour basin. Breakwater construction will also be undertaken using excavators to remove the coral debris, placing and rearranging the boulders.

2.7.4 Management of dredged spoil and its disposal

The project will produce a combined volume of about 31,014m³ of sand or dredged spoil which has to be managed in an environmentally acceptable manner. In Dangethi, the dredged spoil from the proposed harbour basin and part of the entrance channel will be disposed in the area behind the

quaywalls on north and south side and behind on western side to create a wide harbour front and beach area for recreational needs of the community.

2.8 Operation and Maintenance

Harbour management in the Maldives is a responsibility of the government. The MCPI has a budget line allocated to investment and maintenance of the harbour. Harbour inspections are undertaken by the Ministry at regular intervals and condition of the harbours assessed regularly. Harbours requiring maintenance are then taken into consideration for public funding. In many islands, day-to-day management of harbours are undertaken by the island community. In most of the islands, such management is poor except where there is a Harbour Committee elected to manage harbours. In some islands, harbours are created by community finance. Therefore, in these islands, communities play a more important role in the management of harbours.

The Government currently has plans to form community cooperatives which will operate and maintain communal services such as water supply, sewerage, electricity, solid waste and may be harbours. It is envisaged that these cooperatives would be able to manage such services better and in a more-organised manner than the current setup.

2.9 Need and Justification

This project is vital for the island as there is lot of vessels operating in the island at present. At present, the natural harbour is being used for mooring of vessels, mainly safari and other tourist vessels. This harbour is also used for mooring of safari vessels. The primary justification to undertake this project is to provide easy access to the island community and to provide a safe mooring area for the island's vessels.

The project will directly benefit the local population by providing a suitable harbour and increasing standard of living through provision of safe and easy access to the island. The Project will also help to establish further facilities and opportunities to develop the fishing industry and other economic activities in the island.

2.9.1 Why a new harbour?

Dhangethi is blessed with a natural deep lagoon on western side which provides good mooring area in the north east monsoon. The western side of the island has been used as the face of the island. This side of the island has a large sand beach which reflects the characteristics of a typical Maldivian island.

Due to large lagoon on western side and the large distance between the reef and the island, the lagoon becomes difficult to be used as a mooring area in south west monsoon. The lagoon is located 80 meters from the shore line and the reef is more than five hundred meters from the shoreline. This makes it difficult to locate in the shallow area of the lagoon close to the island as there is not enough space. To provide a safe mooring condition in the southwest monsoon, then a breakwater need to be placed on the shallow area on western side which is located quite distance from the shoreline (see Figure 2-7).

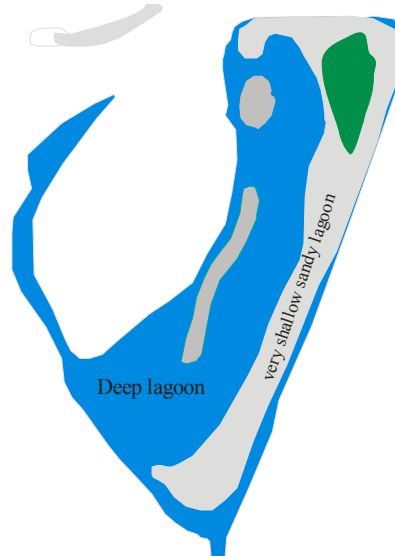


Figure 2-7: Reef system of the Dhangethi

The community of Dhangethi is united in their view regarding the location of a harbour. Consultations held with the community revealed good and reasonable facts that support the development of the harbour on the eastern side. While the community generally acknowledges that the issue of beach erosion would aggravate once the harbour is developed, they do not foresee this to be a reason why the harbour should not be developed. As with all other islands of Maldives, harbour construction is expected to interrupt the sediment movement around the island resulting in erosion.

The economical and social benefits of locating the harbour on eastern side weighs more than the environmental impacts at Dhangethi. It seems that eastern side is more calm throughout the year rather than the western side during the south-west monsoon.

Therefore, the consultant is in the opinion that if the harbour development is undertaken taking into following consideration, then the environmental impact could be mitigated.

1. Excavating the fine sands on the beach on eastern side and using the sand for beach replenishment on western side
2. Filling the northern side of the island where erosion is visible
3. Construct a groyne fields and breakwaters in areas where beach erosion is likely to become a problem.

It appears therefore justified to locate the harbour on the eastern side, mainly due to limited environmental impacts at the same time with significant socioeconomic benefits.

2.9.2 Why Proposed Design?

The proposed concrete quay walls are the new, third generation quay walls tried and tested in the Maldives. How the design concepts and construction methods for harbours have evolved will provide a better insight into why the proposed design was chosen.

The first generation quays were built with bags of sand and cement or coral materials and cement directly on the seabed. The basin is dredged at a distance of about 3 to 5m from the quaywall, because of which it is not possible for boats with a draught of more than 1 m to berth at the quayside. Also, the top of the quay is made of non-reinforced mortar, which is not strong enough and can easily crack.

In order to take into account the problems encountered with the first generation quays, designers then developed a second generation that could be founded at the level dredged in the basin and

with a crest beam strengthened by reinforced concrete cast in situ. This second generation of quays nevertheless still had two drawbacks:

- The structure built with the bags of sand and cement or coral was not completely watertight and the sand from the reclamation (behind the quaywall) tended to run through the quay, causing the reclamation area to subside and the harbour to be silted up
- This type of quay is designed in such a way that handling equipment such as cranes cannot be used, while storage and the use of lorries are limited.

To solve the problems encountered with the previous generation of quays and offer structures with a much longer working life, the designers decided to build prefabricated L-shaped quay walls tied with anchor bolts or tie rods to the reclaimed land. The concrete quaywall has also been considered for reasons of durability over the design period as well as the cost.

3 Policy, Legal and Administrative Framework

The project takes place in the Maldives Environment. Therefore, the extent to which the project conforms to existing plans, policies, guidelines, regulations and laws of the Maldives needs to be considered. Hence, this section will look at the context in which the project activities take place and the legal and policy aspects relevant to those activities. It is important to note that the project is of a local and regional scale and also has some bearing at a national context.

3.1 Applicable Policies, Laws and Regulations

3.1.1 Environmental Protection and Preservation Act

The Articles of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the following aspects of environmental management:

- Guidelines and advice on environmental protection shall be provided by the concerned government authorities.
- Formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions shall be carried out by MEEW.
- Identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.
- An EIA shall be submitted to MEEW before implementing any development project that may have a potential impact on the environment.
- Project that has any undesirable impact on the environment can be terminated without compensation.
- Disposal of waste, oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste shall be disposed only in the areas designated for the purpose by the government.
- Hazardous / Toxic or Nuclear Wastes shall not be disposed anywhere within the territory of the country. Permission should be obtained for any transboundary movement of such wastes through the territory of Maldives.
- The Penalty for Breaking the Law and Damaging the Environment are specified.
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

3.1.2 Second National Environment Action Plan (1999)

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

Main strategies of the NEAP II are:

- Continuous assessment of the state of the environment in the Maldives, including impacts of human activities on land, atmosphere, freshwater, lagoons, reefs and the ocean; and the effects of these activities on human well-being
- Development and implementation of management methods suitable for the natural and social environment of the Maldives, and maintain or enhance environmental quality and protect human health, while at the same time using resources on a sustainable basis
- Consultation and collaboration with all relevant sectors of society to ensure stakeholder participation in the decision making process
- Preparation and implementation of comprehensive national environmental legislation in order to provide for responsible and effective management of the environment
- Adhering to international and regional environmental conventions and agreements and implementation of commitments embodied in such conventions.
- NEAP II specifies priority actions in the following areas.
 - Climate change and sea level rise; coastal zone management;
 - biological diversity conservation; integrated reef resources management;
 - integrated water resources management;
 - management of solid waste and sewerage;
 - Pollution control and management of hazardous waste;
 - sustainable tourism development;
 - land resources management and sustainable agriculture
 - human settlement and urbanisation

NEAP II contains environmental policies and guidelines that should be adhered to in the implementation of the proposed project activities, especially impact assessment, stakeholder consultation, biodiversity conservation and human settlement and urbanisation.

3.1.3 National Biodiversity Strategy and Action Plan

The goals of the National Biodiversity Strategy and Action Plan are:

- Conserve biological diversity and sustainably utilize biological resources.
- Build capacity for biodiversity conservation through a strong governance framework, and improved knowledge and understanding.
- Foster community participation, ownership and support for biodiversity conservation.

In implementing the proposed project activities due care has to be taken to ensure that the national biodiversity strategies are adhered to. In fact, surveys were undertaken at the design stage to find out if biological resources of value and protected nature are affected by the proposed project.

3.1.4 Protected Areas and Sensitive Areas

Under Article 4 of the Environment Protection and Preservation Act, the Ministry of Environment is vested with the responsibility of identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation. At present there are no rules and regulations made available to the public on designation and protection of habitats and heritage areas.

In the project site or in the vicinity of the site, there are no protected areas or areas that are identified as sensitive areas.

3.1.5 Regulation on sand and aggregate mining

This regulation addresses sand mining from uninhabited islands that have been leased; sand mining from the coastal zone of other uninhabited islands; and aggregate mining from uninhabited islands that have been leased and from the coastal zone of other uninhabited islands.

This regulation will be strictly respected and there would not be any sand and aggregate mining except that which is required and approved under the terms of this Environmental Impact Assessment.

3.1.5.1 Ban on coral mining

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

- coral mining is not to be carried out on island house reefs;
- coral mining cannot be carried out on atoll rim reefs and common bait fishing reefs;
- coral or sand mining is only allowed from designated sites, and approval from the concerned Atoll Office is required prior to the commencement of any mining operation.
- requests for coral or sand mining from residents of inhabited islands are required to be submitted to the Atoll Office through their respective island office
- the island office is required to estimate the quantity of corals required for the applied construction work and hence this ensures that permission is granted to mine just the required amount;
- every island is required to keep a log book of the amount of corals mined.
- sand mining is not allowed on the beaches of inhabited islands, islands leased for industrial developments and tourist resorts and within the lagoons adjoining these islands.

This project does not involve sand or coral mining.

3.1.6 Consultation and public participation laws

In the Maldives public participation has been limited to the review stages of the EIS until recently with the EIA Regulation, which considers public consultation as an important and integral part of the EIA process. Hence, this EIA has also taken public views into consideration. In fact, public consultation was conducted in order to take public opinion, views, suggestions and expectations into consideration in the design of the project and not simply to fulfil the obligations under the EIA Regulation. A chapter on public consultation is dedicated to discuss the findings of public consultations held and natural interviews undertaken.

3.1.7 Population Policy

The objective of the Population Policy of Maldives is to contribute to improve standard of living and quality of life of the Maldivian people through socio-economic development with a sustainable balance between population and development. One important aspect of the Population Policy is the strategy of population and development consolidation, which focuses on organising human settlements in such a way that sustainable development is fostered and economies of scale are met. The proposed project in Dhagethi is expected to facilitate the strategy of population and development consolidation.

3.1.8 Regulation on Cutting Trees

The Regulation on cutting down, uprooting, digging out and export of trees and palms from one island to another was recently issued by the Ministry of Environment, Energy and Water. Clause 5 (a) of the regulations states that Prior to the commencement of any project(s) that would require the indiscriminate removal and export of trees/palms from one island to another for the purpose of agriculture, development/redevelopment, construction or any other purpose, it is mandatory under the Regulation to prepare and Environmental Impact Assessment Report stating clearly the details of the Project(s) with all necessary information and submit the same through the relevant Ministry to Ministry of Environment Energy and Water, and the project(s) can only commence upon the grant of written approval from the Ministry of Environment, Energy and Water.

Article 8 (a) requires permission be obtained from Ministry of Environment, Energy and Water, if more than 10 coconut palms that are of a six of 15 ft (from base of the palm to the tip of the palm frond) are cut, uprooted or relocated to another island. The regulation also ensures the replacement of the vegetation that is lost by imposing the planting of two palms for every palm tree that is cut or uprooted (Article 2 (d)). Logging on inhabited islands must be done under supervision of the islands chief or an official appointed by the island chief (Article 8 (c)).

The proposed harbour project does not involve clearing land. However, it involves creation or reclamation of land at the harbour front area. This area will be landscaped using only local species. No large trees would be transplanted in reclaimed areas.

3.1.9 Maritime and Port Legislation

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

3.1.10 Relevant Government Policies

The Ministry of Construction and Public Infrastructure has a harbour and jetties programme where there are minimal requirements for harbours and jetties in local inhabited islands. The Access Improvement Programme, which was initiated by the President in 2004, had a scope to provide a minimum access to all islands that had no means of a proper access. The revised scope is defined such that each island is to have a 300 feet long quay wall with a 300 feet long, 150 to 200 feet wide and 8 feet deep harbour basin that should provide a safe anchorage for the vessels. The basin should also have a 50 feet wide access channel. Depending on the environmental conditions of specific islands, breakwaters or side quay walls would be provided to make the harbour basin safe from adverse conditions

There are no other design criteria or considerations. There are also no environmental requirements for the design and location of harbours in the country. The environmental criteria for each project

are, however, defined according to the findings of the Environmental Impact Assessment, which is required to be undertaken for each and every harbour project.

3.2 International conventions, treaties and protocols

Some of the international conventions, treaties and protocols of relevance to the proposed project may be identified as follows:

3.2.1 *United Nations Convention on Biological Diversity (UNCBD)*

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

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

The proposed project involves dredging and filling beach areas which may have impacts on some biological resources. The creation of breakwaters may also impact reef resources. These impacts and mitigation measures have been dealt with in this report.

3.2.2 *Marpol Convention*

International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 and includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations - and currently includes Prevention of Pollution by Oil; Control of Pollution by Noxious Liquid Substances in Bulk; Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form; Prevention of Pollution by Sewage from Ships; Prevention of Pollution by Garbage from Ships; and Prevention of Air Pollution from Ships.

This Convention has little or no relevance to the proposed harbour development project in Dhagethi. However, it is worthy of mention since Maldives is a party to the MARPOL and any establishment of appropriate port side facilities in the harbour in Dhagethi will help ensure that the provisions in the MARPOL convention are fully enforced by ships and other vessels that travel in the territory of the Maldives and pollution of the Maldivian seas are prevented.

The Maldives has guidelines and regulations pertaining to pollution from ships and other vessels which may anchor at any harbour in the Maldives. Vessels requiring discharging slop from tank cleaning and dirty oil bilge should request local agent to provide reception facility. Port Authority does not have slop reception facilities. If any vessel discharges over board or in case any type of oil spill is found in port, the officer in charge of the vessel is required to report to Maldives Ports Authority and Coast Guard to take immediate action.

Furthermore, Government regulation states as follows:

1) It is expressly forbidden for any vessel to dump or discharge into any harbour, lagoon, or into any part of the waters of the Republic of Maldives, refuse, bunker oil, sewage, noxious substances or any materials or substances whatsoever.

2) The Master of any vessel and / or its agents will be held directly responsible for any nature or degree of pollution of the water, lagoons and Islands of the Republic of Maldives through the dumping or discharge of any refuse and / or substances.

3) In the event of any nature or degree of pollution of Territorial Water of the Republic of Maldives due to the dumping or discharge of refuse and / or substances, the master and / or the Agent of the offending vessel shall be subject to an immediate fine deemed by the Authority concerned according to Maldivian Law.

3.3 Relevant Environmental Standards and Guidelines

There are no relevant standards such as water quality criteria for dredging activities in the Maldives. Recently, the Maldives Water and Sanitation Authority in collaboration with World Health Organisation introduced some recreational water quality standards for the Maldives. However, there are some specific bio-indicators missing in these guidelines, which may be developed by the Marine Research Centre in cooperation with the Ministry of Environment, Energy and Water for Maldivian reef ecosystems. Table 3-1 provides a general indication of the parameters that will have to be measured in relation to the proposed harbour project. These have been drawn from the MWSA standards as well as international standards such as USEPA standards.

Table 3-1 – Water quality criteria for recreational areas near dredging projects

PARAMETER	GUIDELINE	METHODOLOGY
<i>Microbiological</i>		
Fecal coliforms	2,000 per 100ml	Minimum 5 samples collected over a month period. Counts according to MPN or membrane filtration on suitable culture. <i>Sampling must be in sterilised containers</i>
Tot. coliforms	10,000 per 100ml	
<i>Physico-Chemical</i>		
pH	< 0.2 pH unit change	Electrometry (calibration at pH 7 and 9)
Temperature	< 2°C increase	Thermometer
Dissolved Oxygen (DO)	> 6 mg/l or 80-90% saturation	Winkler's method or oxygen meter. Needs to be measured over at least one diurnal cycle. It is dependent on pH, temperature and salinity. In-situ measurements are preferable.
Turbidity	<10% of background	Spectrophotometry. In-situ measurements are preferable.
Phosphates (PO ₄) *	1-10 µg/l	Molecular Absorption Spectrophotometry
Nitrates (NO ₃) *	10-60 µg/l	Molecular Absorption Spectrophotometry
Chlorophyll-A *	< 1 µg/l	Spectrophotometry
<i>Toxic Substances (monitored annually, if required)</i>		
Ammonia (NH ₄)	< 5 µg/l	Nessler's Method or Indophenol blue method
Mercury	< 0.1 µg/l	Flameless Atomic Absorption Spectrophotometry
Phenol	< 50.0 µg/l	Verification of absence of odor or Absorption Spectrophotometry or Paranitraniline method. <i>Glass sampling container</i>
PAHs	< 3.0 µg/l	Measurement of fluorescence under UV after thin layer chromatography. <i>Glass or aluminium sampling container</i>

* The ranges of concentration values for these parameters are provided by the Australian Water Conservation Council as an indication of levels at which eutrophication related problems have been known to occur depending on a series of other factors (light, T°C, water circulation, zooplankton grazing etc.).

Furthermore, the dredging and/or disposal of sediments shall not cause:

- Floating, suspended, or deposited macroscopic particulate matter or foam in marine waters at any location more than 30 m (100 ft) from the project boundary or point of discharge, except unless authorized by the EIA/IEE Decision Statement.
- Visible floating, suspended, or deposited oil or other products of petroleum origin in marine waters in the vicinity of the dredging, which may be related to the dredging activity.
- No toxic or other deleterious substances shall be present in concentrations or quantities which may cause deleterious effects on aquatic biota, wildlife, or waterfowl, or which render any of these unfit for recreation either at levels created in recreational areas or as a result of biological concentrations within the harbour or reclaimed or dredged area.

Turbidity would be the main parameter that needs to be monitored in dredging/reclamation sites. Given that the water quality of the marine environment in the Maldives has very low levels of turbidity usually below 2 NTU, an increase in 1 NTU would be a considerable increase. However, in dredging operations, within an allowable zone of dilution turbidity may be taken to be less than 10 NTUs or 10% of the background level, whichever is greater.

3.4 Environmental Permit required for the Project

The most important environmental permit to initiate proposed harbour development works in Dhagethi would be a decision regarding this EIA from the Ministry of Environment, Energy and Water. The EIA Decision Statement, 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 Statement 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.

4 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental and socio-economic components of the project that were considered are physical environment, social and economic environment and coral reef areas as the marine environment.

Hence, data collection was undertaken for the above components. In order to study the existing environment of the island, the following data collection methodologies were used during the field visit to Dhagethi.

4.1 General Methodologies of data collection

Conditions of the existing environment were analyzed by using appropriate scientific methods. The environmental components of the study area were divided into marine and coastal zone. Although terrestrial component was not considered as important for this project, baseline environmental conditions were appraised. The marine environment of the island covered the house reef of, especially around the area expected to have the greatest impact as a result of the proposed project. The coastal environment covered the coastline within the project boundary and quay wall reconstruction.

The environmental conditions were assessed by dividing the tasks among different groups – marine, coastal and socioeconomics. The different methods used in assessing and reporting the conditions of the existing environment of the island are outlined in the following subsections.

4.1.1 Mapping and Location identification

The entire island, including reef line, shore line, vegetation line, coral patches and marine survey locations (in the project boundary), existing breakwaters and access channel/s were mapped for the assessment. Mapping was undertaken using hand held differential GPS. The location of data collection sites were marked using handheld GPS. These data collection points include water sampling locations, marine survey areas and proposed dredging areas and access channels.

4.1.2 Marine Environment

Marine environment was surveyed to assess and obtain baseline data of the existing environmental conditions. Major components of the marine ecosystems surveyed are the reef-flat, the coral thickets, other benthic communities, the fish communities, and the seagrass habitats. The findings of the surveys were used for impact evaluation and mitigation during the proposed development. The survey methods used here are easily replicable and involve in-expansive techniques. Theses surveys will be repeated through out the life of the project and there after to monitor the changes occurring in the biotic and abiotic components of the environment.

4.1.2.1 The photo-quadrat and point intercept method

Underwater cameras were used to take a series of random photographs for assessing reef benthic substrate at a constant distance from the substrate. Photo quadrats were taken along a 100m line on every 5 fin-kicks. Randomly selected 20 photographs were then assessed for major benthic cover types. Two sites were selected for reef benthic community assessment. Coral point count with excel extension (CPCe) was used to assess the benthic substrate cover (see Figure 8). This method allows rapid collection of data in the field at the same time providing a permanent and reliable record of the data.

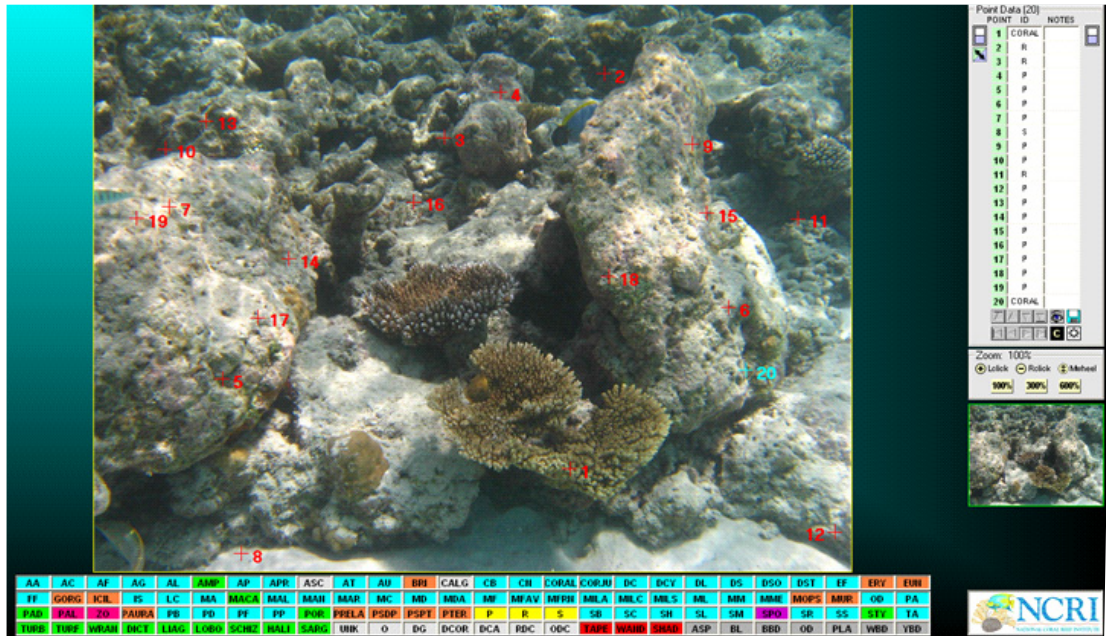


Figure 8: Screen shot of CPCe.

Timed-Swim Surveys

These surveys were carried out using snorkelling gear for both fish and benthic communities including live coral, dead coral, algae and other sessile organisms. Three swims on a straight path were done on the six selected sites. The duration of each swim was 15 minutes for benthic cover and an additional 15 minutes for assessing mobile organism such as fish that are conspicuous. The abundance is given in relation to the occurrence of particular taxa in other similar habitats of the Maldives. There is a tendency to underestimate fish when using this method of fish senses. This results due to rare species not being effectively sampled and failure to observe all the fish present. However, this method represents a quick and easy way of obtaining data in a limited time frame. The data obtained is valid and dependable and can be replicated.

4.1.3 Marine Water Quality

Seawater samples were collected from two locations on the reef at the proposed harbour locations in order to identify the extent of pollution and as baseline for future project monitoring and evaluation.

4.1.4 Bathymetric survey

A detailed bathymetric survey was undertaken to assess the baseline condition of the harbour basin and also calculate the wave strength approaching the harbour. Bathymetric surveys were also used to determine the volume of dredging required for the basin and access channels. Salinity was tested on site but sample was collected in appropriate sampling bottles for testing nitrates, phosphates and turbidity at the National Health Laboratory.

4.1.5 Socio-economic data collection

A participatory approach based on the following methods was applied during the assessment:

1. Series of community consultation based on focus group discussions

2. Key informant interviews
3. Data collected from secondary sources
4. Natural Interviews
5. Personal observation

4.1.5.1 Focus group discussions

In each island focus group discussions were held separately with Island Development Committee, Women's Development Committee and the Non-Governmental Organizations, Fishermen and Traders registered in the 3 islands. Together, these groups encompass a wide age range, as well as both genders, and people from the entire communal spectrum. Their views would represent a substantial and sizeable cross-section of the island population.

4.1.5.2 Natural Interviews

Wherever possible, natural group discussions were also conducted. Natural group discussions are interviews conducted with 'naturally' occurring groups. The method has the advantage of being interviewed at a time and place of their convenience, and is suitable from the point of view of the interviewee. The result is frank and open discussion in a more relaxed and informal manner.

4.1.5.3 Key informant interviews

To verify and cross check the information collected from the focus group discussions interviews were also held with key informants such as island chief, staff of the Island Office and Atoll Office and community members who were interested in providing information. For some of these interviews household visits were made to visually observe the system when collecting information.

4.1.5.4 Secondary sources

Secondary sources of data, including island office records forms an integral part of the assessment. Socio-economic data relating to the population, literacy rate, housing, economic activities, educational status, health services, electricity and other infrastructure existing in the island were collected.

4.1.5.5 Observation

During the field visit personal observation were made which harmonized the information collected through other sources.

5 Existing Environment

5.1 Existing Coastal Environment

The island of Dhangethi lies on its own reef system on the eastern rim of Aalifu Dhaalu Atoll. The reef is about 161.1 hectares. The island has a peculiar shaped reef with wide reef extent on the western side varying from 1,346 m on the west corner to 287 m on the southern side of the island. The reef extent on the western side, where the existing natural harbour is located.

There is an extensive lagoon on the western and southern side of the island covering a reef extent of about 2000m. sea grass is found on southern side of the island covering an area of 35,000 square meters of area. The seagrass of predominantly thalassia hemprichi species. The lagoon also has shallow depths varying from 0.3 to 0.8m on average which is found all around the island. Some areas on the southern shoreline get dry during low tide. The area in which the proposed harbour is located have clear lagoon which has constant depth all the way to the reef slope. The reef extent on the eastern and southeastern side, where the existing harbour and proposed harbour is located is about 50 to 100m from the shore.



Figure 5-1: Recent aerial photo of Dhangethi

The north side of the island is prone to high energy swells from Alihuras Kanduu, the north western corner and the southern corner being the most dynamic and with the greatest reef extents. The northeast side of the reef, which is usually calmer than the other areas of the reef, has an entrance channel which was previously used even before 1969. A harbour was also created on this side, however, is not used except during rough southwest monsoon.

The lagoon all around the island has somewhat constant depths and the reef flat is less obvious on the lagoon ward (leeward) reef on the west than the rim reef on the east. The reef has a gentle slope, especially on the eastern side and southeast side where the existing and proposed harbour is located. The island lagoon is clearer on the western side than the eastern side possibly due greater depths than the west.

The island's coastline is properly managed with no visible solid waste dumped in any all locations around the periphery of the island.

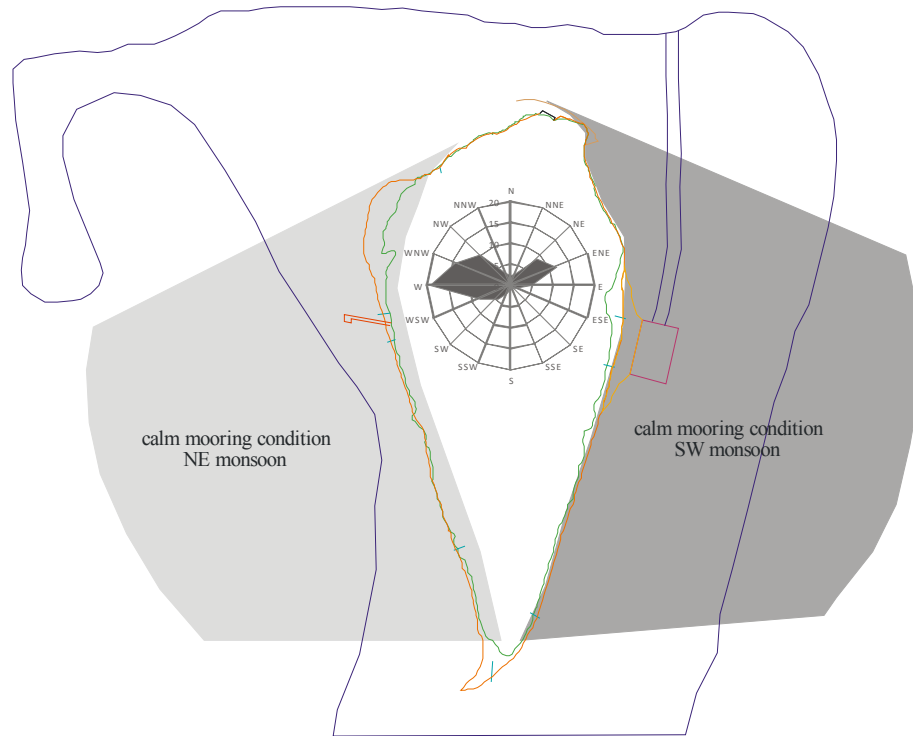


Figure 5-2: Wave condition at Dhagethi

The jetty which has been located in the western of the island provides good access to the island during the north east monsoon. Figure 5-2 shows an interpretation of the wind climate around the island of Dhagethi based on the wind data collected at the National Meteorological Centre at Hulhule. The wind rose for Hulhule shows that predominant wind direction in the NE monsoon from NE and the island protection for the western side of the island. This makes the existing jetty and the natural harbour on the western side a good place for mooring in this monsoon.

In the south west monsoon, the predominant wind is from north west to south west and this makes the proposed harbour location a good place mooring in this period. SW monsoon is the longest period and provide most sever weather events that the boats and dhonies need secure harbour for protection.

5.2 General meteorological conditions

5.2.1 Climate and weather

The Maldives has a warm and humid tropical climate. The weather is dominated by two monsoon periods: the South-West (SW) monsoon from May to November (rainy period) and the north-east (NE) monsoon from January to March (dry period), when winds blow predominantly from either of these two directions.

The relative humidity ranges from 73% to 85%. Daily temperatures in the country vary very little throughout the year with a mean annual temperature of 28°C.

5.2.2 Wind conditions

Winds affect sedimentation process both during the formation and development of islands. Winds help regenerate waves that are weakened by travelling over reefs and also cause locally generated waves over lagoons. Figure 5-3 shows the wind direction pattern for Malé International Airport from National Meteorological Centre. Winds from the north-east and the east-north-east are predominant during December to February. During March to April the direction varies with the general direction being westerly. Strong winds are associated with the southwest monsoon season. Gales are uncommon, and cyclones very rare in the Maldives. The stormiest months are typically May, June and July. Storms and squalls producing wind gusts of 50-60 knots have been recorded at Malé.

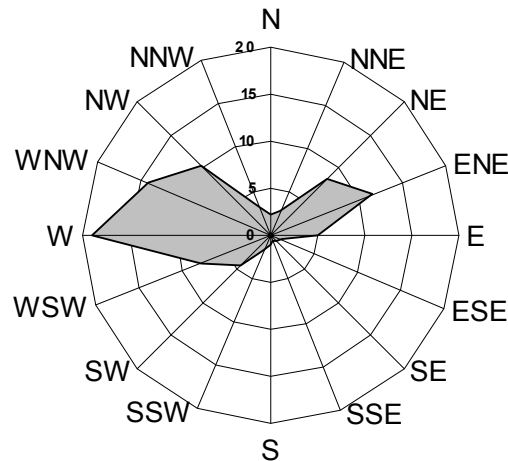


Figure 5-3: Percentage of average wind direction for Malé (1980-2006)

5.2.3 Tide levels

The tidal regime is semi-diurnal with diurnal inequalities (twice daily). That means 2 high tides and 2 low tides per day, with different heights. Typical spring and neap tidal ranges are approximately 1.0 m and 0.3 m, respectively.

5.2.4 Currents

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

5.3 Hazards and Disasters

5.3.1 Vulnerability to Natural Disasters

The islands of the Maldives are less prone to tropical cyclones and are only impacted in the northern part of the country by weak cyclones that formed in the southern part of the Bay of Bengal and the Arabian Sea. Since 1877, only 11 cyclones crossed the archipelago (Maniku, 1990). Most of the cyclones crossed Maldives north of 6.0° N and none of them crossed south of 2.7° N during the

period. All the cyclones that affected Maldives were formed during the months of October to January except one, which formed in April (UNDP, 2006).



Map 1: Cyclonic Wind Hazard Map (source: UNDP, 2006)

The northern atolls have a greater risk of cyclonic winds and storm surges. This reduces gradually to very low hazard risk in the southern atolls (see Map 1). The maximum probable wind speed in Zone 5 is 96.8 knots (180 kilometers per hour) and the cyclonic storm category is a lower Category 3 on Suffir-Simpson scale. At this speed, high damage is expected from wind, rain and storm surge hazards (UNDP, 2006).

Figure 5-4 shows historical earthquakes around Maldives; and three events of magnitude above 7.0 struck the region which had their sources in the Indian Ocean (UNDP, 2006).

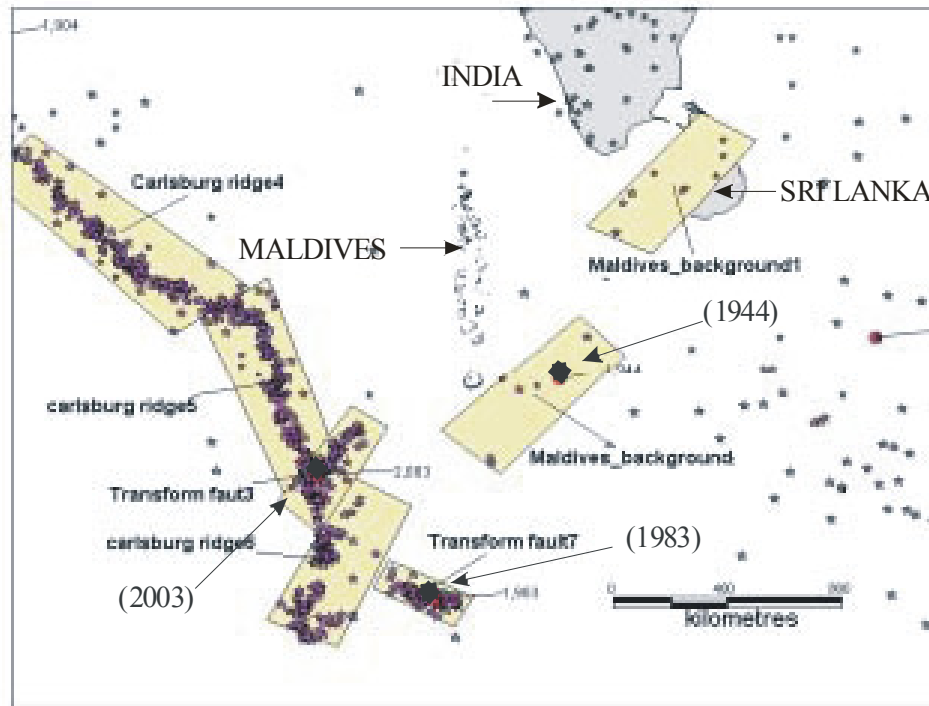


Figure 5-4: Earthquake Epicentres around Maldives (Source: UNDP, 2006)

UNDP (2006) identified that hazard risk from earthquake is low for the Maldives and considered as a disaster risk for only islands located in the south of the country. See Map 2.



Map 2: Earthquake Hazard Zone (source: UNDP, 2006)

Maldives faces tsunami threat largely from the east, and lower threat from the north and south. Islands along the eastern fringe of the atolls are more prone to tsunami hazard than those along the northern and southern fringes. Islands along the western fringe experience a relatively low tsunami hazard. Historically, Maldives has been affected by three earthquakes which had their sources in the Indian Ocean. Of the 85 tsunamis generated since 1816, 67 originated from the Sumatra Subduction zone in the east and 13 from the Makran Coast Zone in the north and Carlsburg Transform Fault Zone in the south. The probable maximum tsunami wave height is estimated at 4.5 metres.

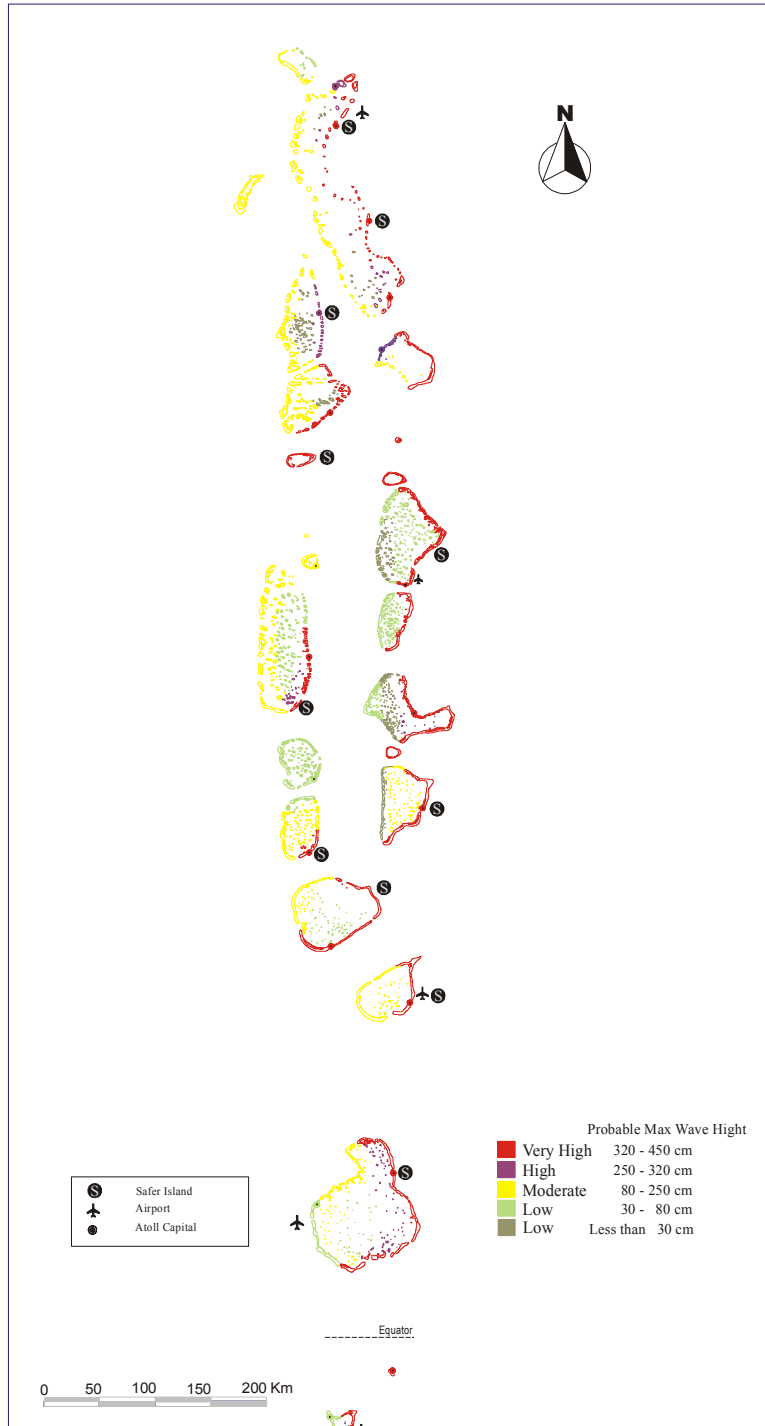


Figure 5-5: Tsunami Hazard Zones (adopted from UNDP, 2006)

5.3.2 The Impact of Indian Ocean Tsunami

Following information for Dhangehti has been produced based on the reports that the National Disaster Management Centre received in December 2004 following the Indian Ocean Tsunami.

Table 5-1: information recorded for Dhangethi at the National Disaster Management Centre following the Indian Ocean Tsunami on 26 December 2007.

Island	Dhagethi
Impact Sequence	limited
Displaced population in the island	0
Island evacuated	No
Groundwater condition	Usable
Drinking water availability	Required
Solid waste generated	Not too much
Damaged breakwaters length (m)	0
Damaged seawall length (m)	0
Area of the harbour basin become shallow (m2)	0
Houses damaged	No damage
Jetties damaged	damaged
Length of the jetties damaged (m)	0
Impact on harbour entrance	Did not became shallow
Impact on beach	No
Area of beach eroded	0
Impact on roads	No
Length of road damaged (m)	0

5.3.3 Natural Vulnerability of the Island of Dhagethi

The islands of the Maldives have natural characteristics which make them vulnerable to disasters such as tsunamis. An island's Natural Vulnerability depends on geographic and geomorphologic characteristics of the island. These include geographic features of the island like the side of the country where the island is located, the formation of the island, location of the island respect to the atoll, orientation of the island, region of the country where island is located, level of shadow to the island from the reefs and other islands; area of the inland lake found on the island, width of the island's house reef, coastal defence structures on the island, shape of the island and the area of the island. A Model to Integrate the Management of Hazards and Disasters in the National Sustainable Development Planning of the Maldives which was developed as part of the Masters of Science (Hazard and Disaster Management) thesis at the University of Canterbury (2007) identified the relationship between natural characteristics of the island and the *natural vulnerability* of the islands using the data that was collected following the Indian Ocean Tsunami.

Based on this research, the natural vulnerability of the Dhagethi was found to be MODERATE for flooding disasters such as caused by tsunami or high waves incident approaching the island from the east.

5.4 Features of the Coastal Environment

The coastal environment of the island and in general the project area can be described as having four major characteristics as illustrated in

Figure 5-12. They are:

1. The natural harbour on the western side
2. Jetty extending to deepwater at the western side
3. A coastline characterised by white sandy beach along around the island except the northern side.
4. Eroding beach no north side of the island

The coastline on the proposed harbour area mainly consists of fine sand. The condition of the coastal environment of the island is illustrated in

Figure 5-12 and a pictorial representation given in Figure 5-12.

In order to assess the coastline, beach profiles were taken from selected locations within the project boundary illustrated in Figure 5-6. The beach profiles is presented in the appendix.

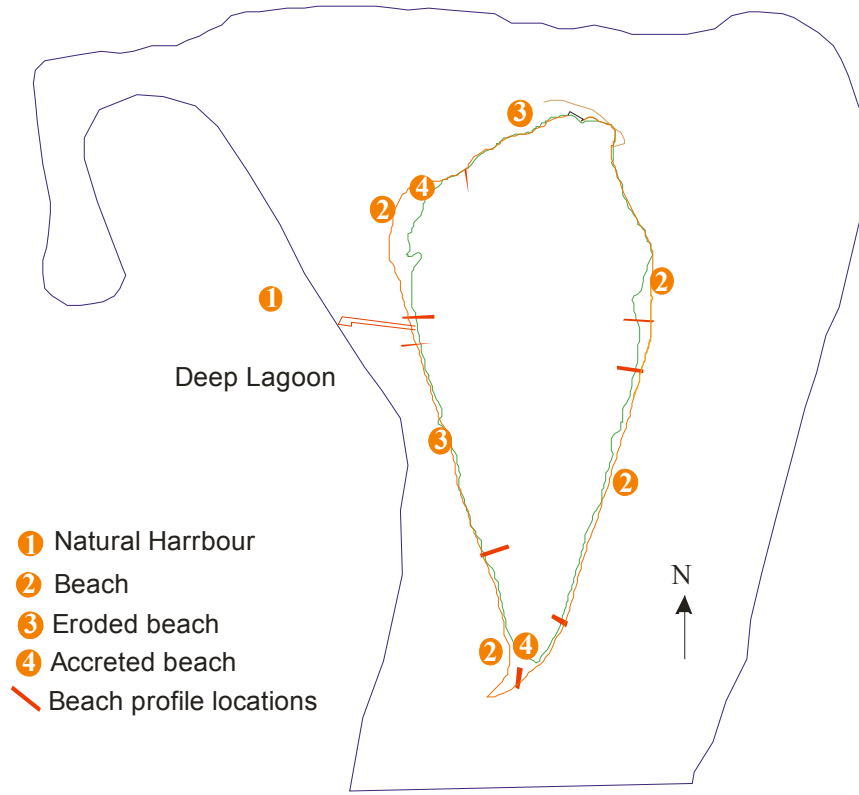


Figure 5-6: Illustration of coastal environment and the project boundary.

5.4.1 Lagoon

The project takes place on the eastern side of the island. The eastern lagoon where the harbour basin would be dredged has clear water and has a shallow lagoon. The lagoon in the area has shallow depths close to the shore varying from 0.5m to 1m to the reef flat which is located around 200 meters from the shoreline. In comparison, the lagoon on the west has a wide reef extent and shallow water with extensive growth of seagrass.

5.4.2 Proposed Harbour Area

The proposed harbour area is a clear lagoon area with sandy seabed conditions. Borehole tests have not been done for the dredge area. However, the area is believed to consist of sand and coral rubble and is not considered to be difficult to excavate.

5.4.3 Dredged Material Disposal Areas

The dredged material disposal sites of dhagethi are between the land and quay-walls of the harbour. Additional materials will be disposed at the northern shoreline behind the existing seawall that has

been constructed. This area has been eroded from the island. The seabed of these areas consists of mainly fine sand and rubble. No significant benthic life was encountered during the visual observation.

5.5 Marine Environment

The marine environment of the island was studied by surveying coral cover and fish populations in two locations; one close to the proposed harbour and the other at the existing harbour entrance on northern side. The findings for these two locations are given in the subsections below.



Figure 5-7: The proposed development area and the survey sites.

The reef around Dhangethi is has about 13 and 7 percent live coral cover at the two surveyed lagoon sites (site 1 and 2 respectively). The bottom of reef-flat was dominated by rock, rubble, dead coral remnants and un-consolidated rock. The reef slope on the eastern side forms a steep slope. The reef-flat on both sides of the island is wide and was covered with seagrass – mainly *Thalassia heprichii*.

The western side reef-slope was very far from the proposed development area and was separated by a deep lagoon (*vilu*). Therefore no surveys were conducted at this area. It is also worth noting that the predominant monsoonal current is from the west to east, therefore the proposed development work will have very little impact on reef-slope on the inner reef-slope.

The coral reef system of Dhangethi is in a good condition in terms of diversity and percentage live coral cover (see Figure 5-8). The two sites observed at the lagoon for reef status was presented below graphically. The live coral cover varied significantly at these two sites. Percentage of rock was higher at site 1. The percentage cover of rubble and sand was higher at the site 2. The dominant forms of benthic cover are rock, rubble and sand. Branching forms of *Acropora* spp. (staghorn) and *Pocillopora*, *Porites*, *Astreopora*, *Astreopora*, corals predominates the live benthic cover. Massive types corals namely *Porites*, *Favites*, *Goniastrea*, and encrusting type *Montipora*, *Pavona* were also present. Solitary corals namely *Fungia* and blue corals *Heliopora* are present at the site 2.

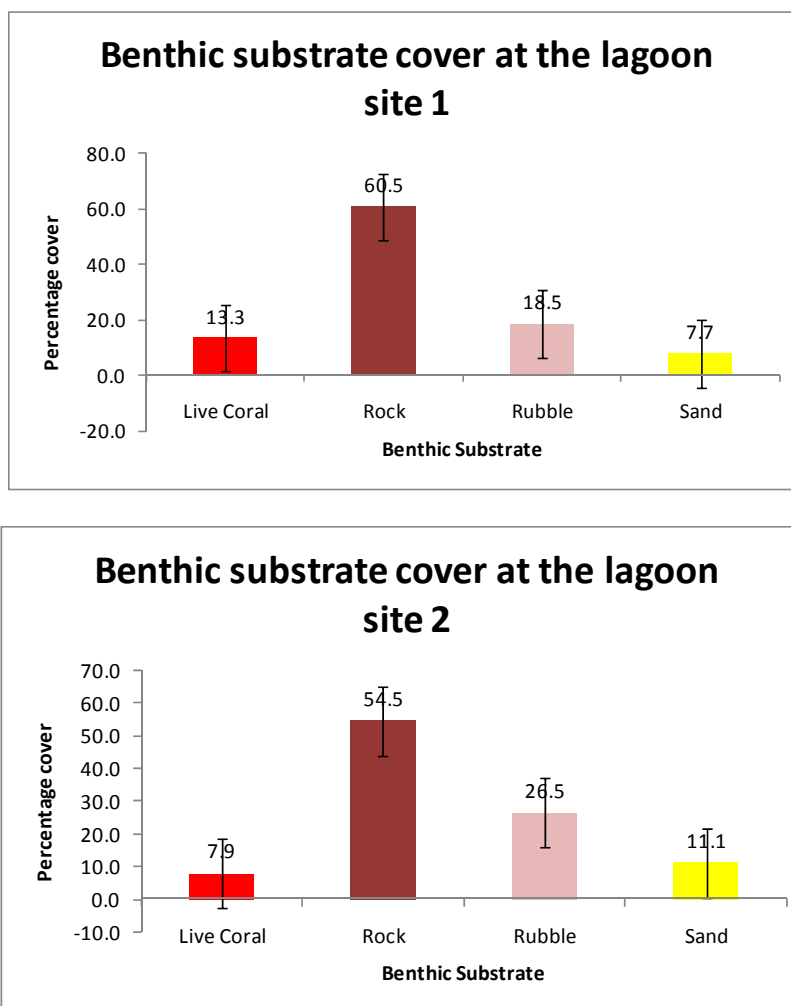


Figure 5-8: Percentage cover of benthic substrate present at the eastern side lagoon sites. The benthic covers are given in percentages of the bottom area surveyed LC = live coral, RK = rock, RL = rubble, and S = sand

Based on the survey data of the two fore lagoon sites, rocky and rubble areas were found to be dominant. The photographs below shows provide an idea of benthic cover present at the survey sites.

5.5.1 Reef Invertebrates

One species of mollusks and three species of echinoderms were encountered during the invertebrate assessment. It is worth mentioning that due to the nocturnal nature of mollusks they are hardly seen during the day. What is observed during the timed swims are:

- *Tridacna* sp.
- Common star fish
- *Diadema* urchin
- Black sea cucumber

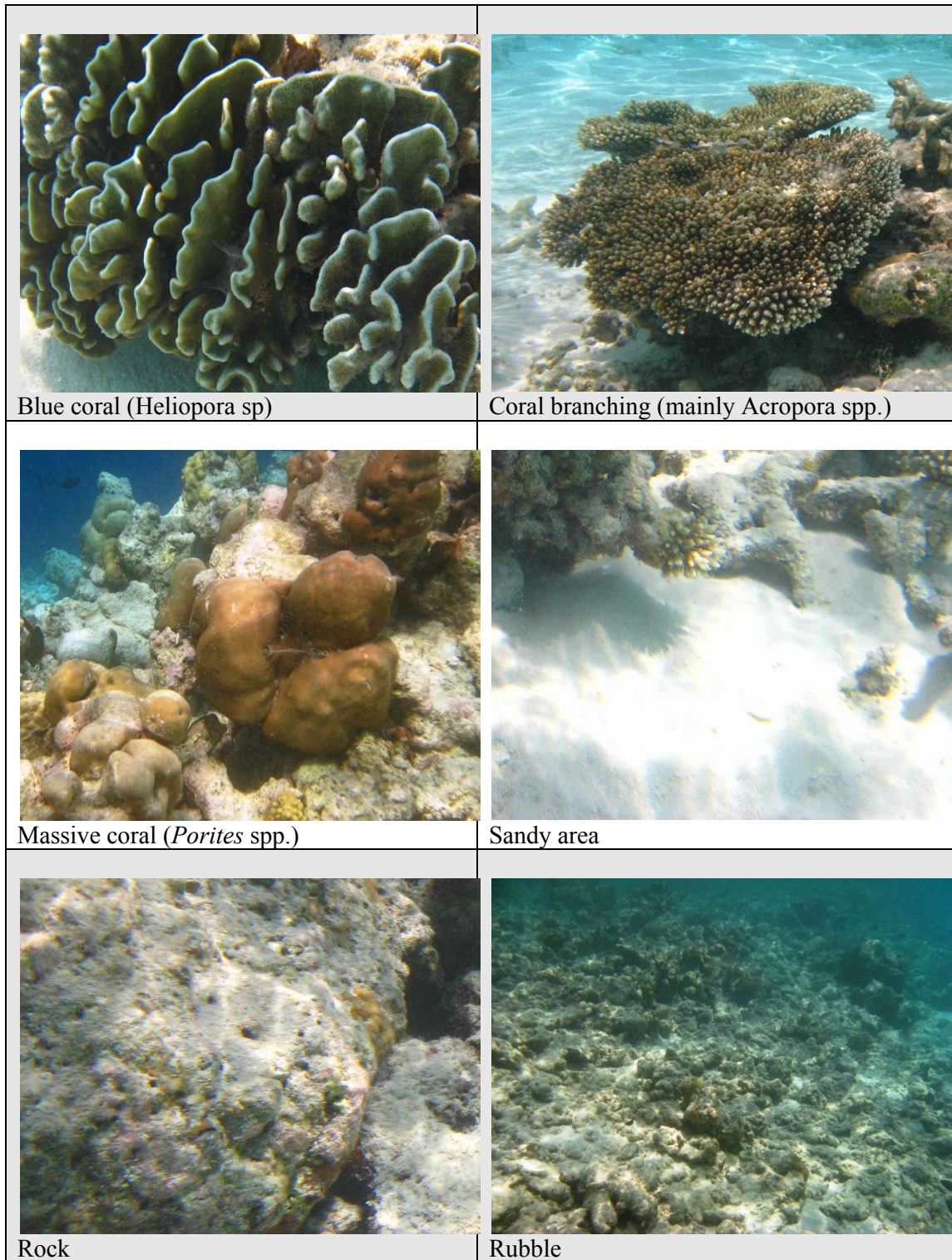


Figure 9: Some of the benthic substrates observed at the surveyed areas.

5.5.2 Assessment Fish Communities

The result of 15 minutes swim for fish count around each site (Site 1 and Site 2) reveals that the abundance and diversity of fish is not so good around the proposed development area. Since most of the area was covered with rock and rubble, fishes associated with this type of environment were encountered. The dominant fish taxa observed in the surveyed area included surgeon fishes (Acanthuridae), wrasses (Labridae) and damselfishes (Pomacentridae) (see Table 2). The presence of *Acropora* coral colonies was associated with the occurrence of butterfly fishes. These fishes are an indicator of reef health. Some of the conspicuous fish encountered are shown in Figure 10.

Table 2: Results of the fish encounter survey at lagoon sites 1 & 2

Family	Species	S 1	S 2
Acanthuridae	<i>Acanthurus lineatus</i>	A	-
Acanthuridae	<i>Acanthurus leucosternon</i>	C	-
Acanthuridae	<i>Acanthurus triostegus</i>	R	C
Acanthuridae	<i>Ctenochaetus</i> sp.	C	-
Balistidae	<i>Balistapus undulatus</i>	R	-
Balistidae	<i>Melichthys indicus</i>	R	-
Balistidae	<i>Odonus niger</i>	A	-
Chaetodontidae	<i>Chaetodon citrinellus</i>	R	-
Chaetodontidae	<i>Chaetodon trifasciatus</i>	R	R
Chaetodontidae	<i>Hemitaurichthys zoster</i>	R	-
Labridae	<i>Gomphosus caeruleus</i>	-	R
Labridae	<i>Helichoeres hortulanus</i>	R	R
Labridae	<i>Labroides dimidiatus</i>	C	C
Labridae	<i>Thalassoma hardwicke</i>	C	C
Lethrinidae	<i>Monotaxis grandoculis</i>	R	-
Lutjanidae	<i>Lutjanus kasmira</i>	C	-
Lutjanidae	<i>Lutjanus gibbus</i>	C	-
Mullidae	<i>Parupeneus barberinus</i>	R	-
Nemipteridae	<i>Scolopsis bilineatus</i>	R	R
Pomacanthidae	<i>Pomacanthus imperator</i>	R	-
Pomacentridae	<i>Abudefduf sordidus</i>	-	R
Pomacentridae	<i>Dascyllus aruanus</i>	-	R
Scaridae	<i>Cetoscarus bicolor</i>	R	-
Scaridae	<i>Chorurus stronglycephalus</i>	R	-
Scaridae	<i>Hipposcarus harid</i>	R	-
Scaridae	<i>Scarus frenatus</i>	C	-
Scaridae	<i>Scarus sordidus</i>	A	A
Serranidae	<i>Epinephelus spilotoceps</i>	R	-
Zanclidae	<i>Zanclus cornutus</i>	R	-

The abundance of fish was given in abundance categories. A = Abundant, C = Common, R = Rare. Commercial fishes belonging to the families Lethrinidae, Lutjanidae, and Serranidae were observed at the survey sites.

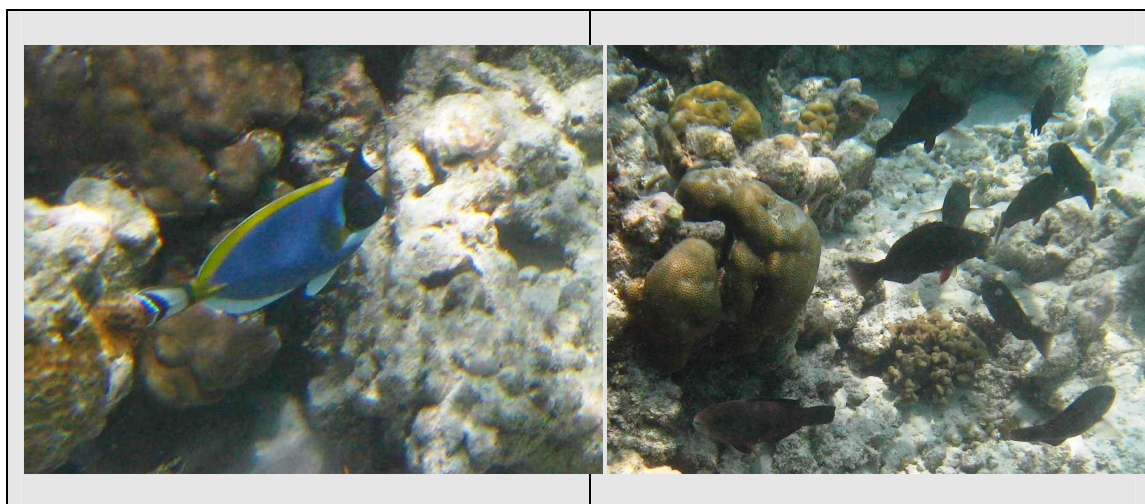


Figure 10: Some of the fishes encountered at the survey. Left – *Acanthurus leucosternon*, Right - School of parrotfish *Scarus sordidus*.

5.5.3 The Seagrass Ecosystems

Seagrass beds are known to have high ecological value as they provide important food resources to a wide 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 number 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.

The proposed harbour basin is completely covered by seagrass and other marine flora (*Dictyota* spp, filamentous algae, macro algae, brown algae, blue green algae, which was colonizing on the filamentous wafer like algae) and sea weed. The density of the seagrass varied depending on the locality. The density of the seagrass is controlled by wave energy and strong current in some areas. Two species of sea grass was observed on the seagrass bed, *Thalassia hemprichii* and *Thalassia* sp. (long thin blades). *Halimeda* was also present at a lower percentage. Sand present there was also of *Halimeda* origin on top and fine sand underneath.

It has been evident based on aerial photo interpretations that the growth of seagrass is in the increasing trend. This growth of sea grass is related to nutrient discharge (sewage and fish waste). The dominant species of seagrass was *Thalassia hemprichii*.

During extreme low tides the large portions of seagrass bed is exposed. The average depth during mean tide is around 0.8m. At present the only use of seagrass bed is for collecting cowry shells which are of no significant commercial value.

Visual surveys were conducted on the eastward lagoon site. The observations show that the coverage of seagrass decline as we moved away from the shoreline of the island. The seagrass was grown in isolated dense patches on this side. Areas other than seagrass was covered mostly with sand and rubble (see Figure 11). No rock areas were recorded encountered within the seagrass habitats.

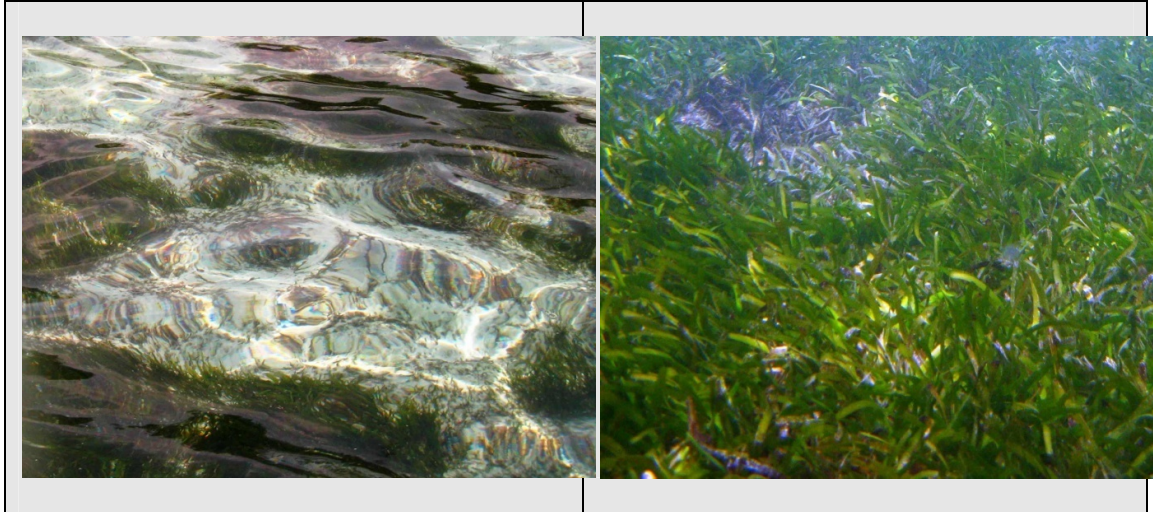


Figure 11: Benthic substrate cover at the reef flat (seagrass sites). Left = patches of Seagrass; Right = Seagrass *Thalassia hemprichii*.

A 15 minute encounter survey was conducted for fish, molluscs and echinoderms at the area. Diversity and abundance of fish life was very low at the reef flat seagrass area. The table below summarises the results of fish abundance survey.

Table 3: List of fish species (and their families) encountered on seagrass beds.

Family	Species	SG
Gerreidae	<i>Gerres</i> sp.	R
Gobiidae	<i>Amblygobius semicinctus</i>	R
Lethrinidae	<i>Lethrinus harak</i>	R
Labridae	<i>Helichoeres scapularis</i>	C
Labridae	<i>Labroides dimedius</i>	R
Labridae	<i>Cheilinus fasciatus</i>	R
Labridae	<i>Cheilio inermis</i>	R
Mugillidae	<i>Mugil</i> sp.	R
Acanthuridae	<i>Acanthurus triostegus</i>	C
Acanthuridae	<i>Ctenochaetus</i> sp.	R
Pomacentridae	<i>Abudefduf biocellatus</i>	R
Pomacentridae	<i>Pomacentrus chrysurus</i>	R
Pomacentridae	<i>Stegastes fasciloatus</i>	R
Tetraodontidae	<i>Canthigaster benetti</i>	R

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.

Apart from a few sea cucumbers and sea urchins no other conspicuous invertebrates were observed at this seagrass area.

5.5.4 Rare or Endangered Species

During the course of the baseline survey not a single individual of rare or endangered species was encountered. Therefore, the impacts from the proposed project on the rare and endangered species are not clear. Since the area is a population centre, the likelihood of getting encountered with such species is relatively low.

5.5.5 Potential Nuisance Species

The dredging of harbors is associated with a shift in the bottom conditions of the harbor basin. The accumulation of silt at the bottom of the harbor may attract fishes and other living things that prefer such a habitat. It has been known that the striped eel cat fish (*Plotosus lineatus*) has infested some of the dredged harbor basins. One such occasion was seen in Th. Kibidhoo where dense schools of *P. lineatus* infested the harbor basin. This species has got deadly poisonous spines which makes this a potentially dangerous species. The small size (max 30cm) and rarity of the fish makes it potentially worthless economically. It is not clear that whether this species will infest the harbor basin. Based on the past experience with the harbors, there seemed to be no major problems associated with potential nuisance species.

5.5.6 Environmental Condition of the Dredged Material Disposal Sites

The dredged material disposal sites of Dhangethi are between the land and quay-walls of the harbor. The bottom of this areas consisted of seagrass, fine sand and rubble. No significantly important benthic life was encountered during the visual observation. The nektonic life consisted of few sand associated species of fish belonging to the families Mullidae, Acanthuridae, and Pinguipedidae and Gerreidae. Total number of fish encountered was only 17 during the fifteen minutes visual observation.

5.5.7 Marine Water Quality

The marine water quality samples were tested at the National Health Laboratory. Water samples were taken from the proposed harbour entrance area. The GPS location of the sampled location is 3°42'55"N and 72°58'45"E.

The water quality tests, the results of which are given in

Table 5-4, indicate that the marine water quality in the harbour area is similar to that at the other location. Also, there is no visual change in turbidity. Water quality test results for turbidity indicate no turbidity, which is expected to be due to instrument calibration at the Public Health Laboratory. The onsite water quality logger at Water Solutions could not be used since calibration solutions had run out and instrument could not be calibrated.

Table 5-4: Water quality results

PARAMETER TESTED	S1 (harbour entrance)
Physical appearance	clear
Nitrate	0.0 mg/L
Dissolved oxygen	5.4 mg/L
Phosphate	0.06 mg/L
BOD/COD	#
Turbidity	1 NTU
pH	7.4

These tests are not possible to be done from National Health Laboratory, Maldives

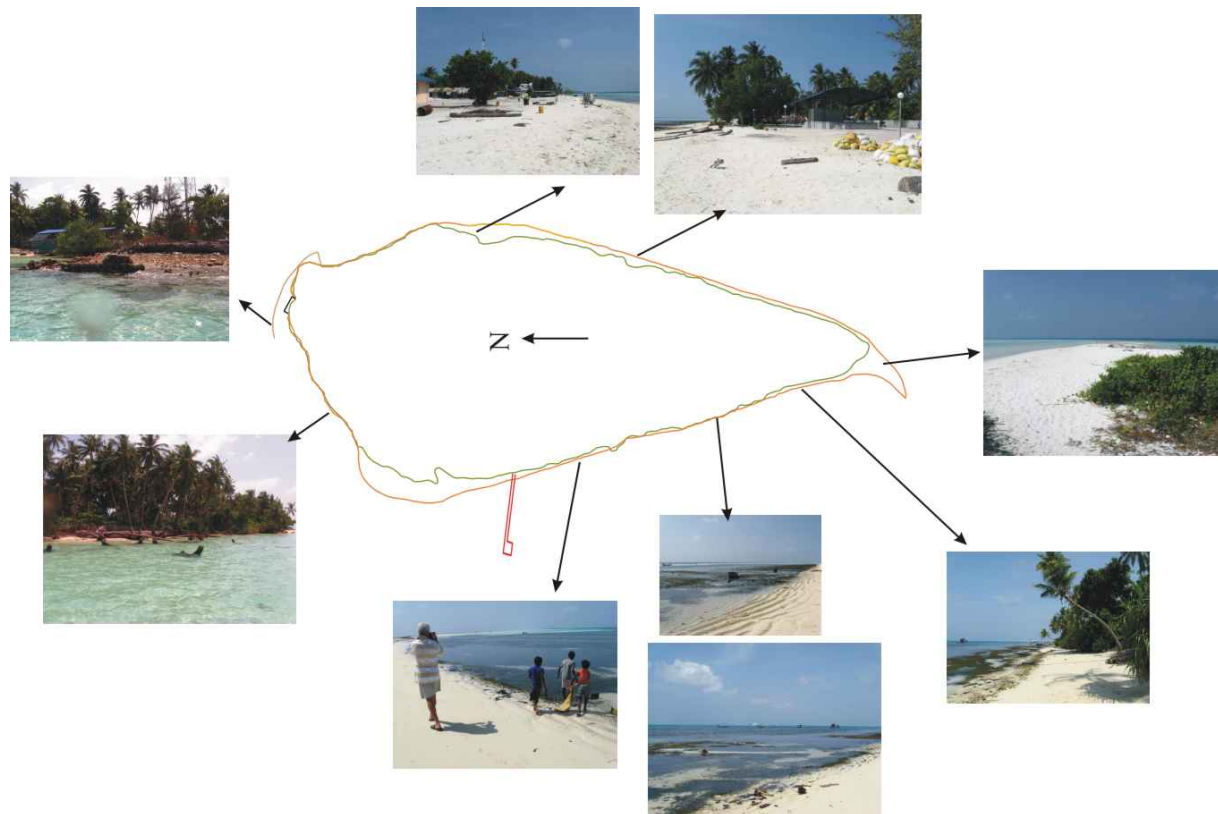


Figure 5-12: Photo representation of the coastal and marine environment of Dhagethi

5.6 Existing Socio-economic environment

Over the years a significant number of infrastructure facilities have been established to cater for the island population. In this respect in addition to island office, school, pre school, tuition class, Health Centre, Power House and Cybercafé (private company) has been in operation are of significant importance in terms employment and service providers. Important island infrastructure also includes the jetty paving way for trade related activities.

5.6.1 Vulnerability and Poverty of Dhagethi

In order to place Dhangethi in national context in terms of vulnerability and poverty, the income poverty outlined in the Poverty and Vulnerability Assessment of 2004 were reviewed. Dhagethi's income poverty index is 0.01 where as the national average is 0.1 while all the atoll average (excluding Male') is 0.14. Aalifu Dhaalu Atolls income poverty index stands at 0.12.(Ministry of Planning and Development,2005) The income poverty figures illustrate Dhagethi's position in terms of poverty and vulnerability compared to the atoll average and national average. The indexes are based on other dimensions and is measured on scale of 0-1, where the higher the score the higher the vulnerability.

5.6.2 Population and Literacy rate

Population of Dhagethi is recorded at 826 in February 2008(Island Office Records).

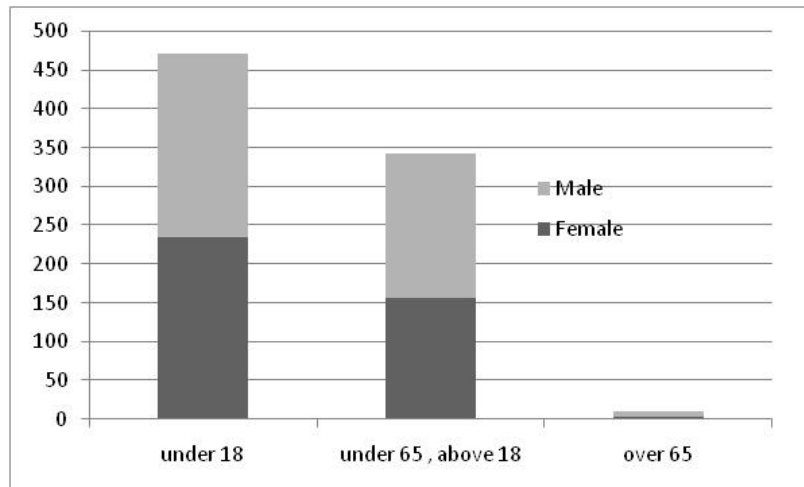


Figure 5-13: Population of Dhagethi, Septemeber 2007 (source: Island Office)

As illustrated in Figure 5-13 the population by major age groups reveals that 33% of the population is less than 18 years while 62% of the population is between 18 years and 65 years and the rest (5%) is above 65 years.

5.6.3 Employment

Major economic activities of the people living in Dhagethi are tourism related trade, fishing, retail trade, carpentry, construction work, fixed salary jobs in the resorts, engineering workshops. It is observed that due to the scarcity of employment in home island considerable number of males in the island are working

away from Home Island. The working away population of Dhagethi is 35 of which 28 are males and 7 are females. They work either in Male or tourist resort.

In terms of fishing Dhagethi has 25 mechanized vessel 25 trolling vessels operating in the island. In addition fishing vessels from other islands are operating in the Island. Major type of fishing is tuna fishing and the fish caught is sold to Malé and resorts

Other service related income earning activities such as retail trade, carpentry and construction work has increased significantly over the years. Dhagethi has 17 retail outlets operated by private people. These shops are stored with food and other items of every day use facilitating the community to get the necessary items from the island.

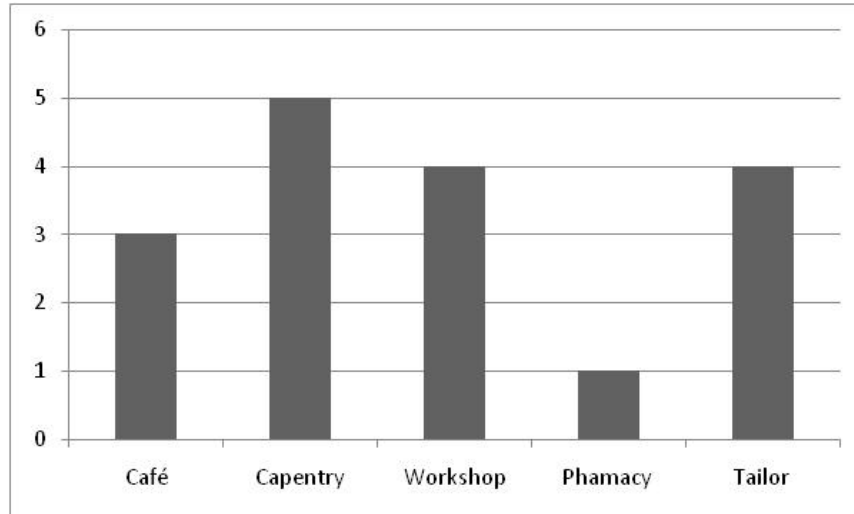


Figure 5-14: Service facilities operating in Dhagethi

With an adequate health services being available from the Health Centre one pharmacies are being in privately operated selling necessary pharmaceutical products such as common medicine and other items.

To cater of the population 4 cafes are registered and in operation while 4 carpentry and 4 tailor shops provides a source of income to few people of the island. In addition common to other islands of the country the informal sector such as tailors, short eats makers, play a minor major role towards the economy of the island.

5.6.4 Health

The number of health staff and the quality of healthcare can have a dramatic impact on the quality of life. Dhagethi Health Centre is staffed with 1 expatriate doctors and 1 expatriate nurse along with 2 family health worker and 1 midwife. Additional Health workforce includes 2 pharmacists and 1 local medical worker indicating that adequate health facilities are available in Dhagethi

5.6.5 Education

While the nation has achieved near universal primary school enrolment, the quality of teaching and the level of education on offer differ considerably from island to island.

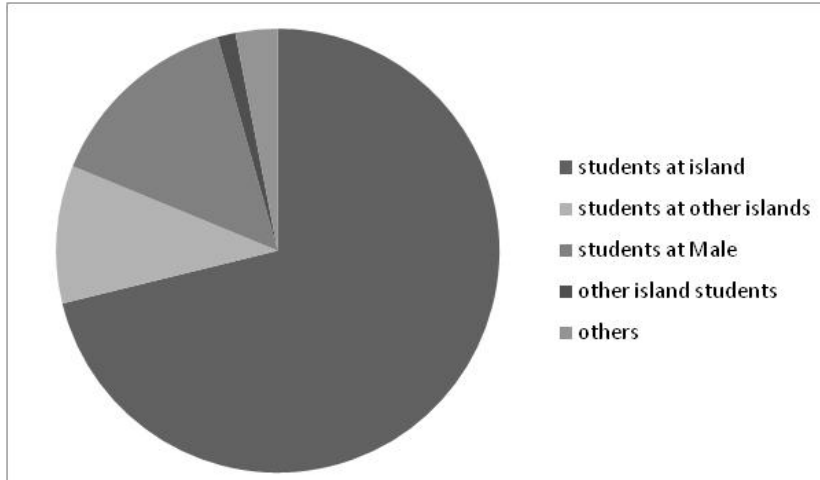


Figure 5-15: Students of Dhagethi

The Atoll Education Centre teaches up to Grade 10 is staffed by 22 teachers of which 36% are expatriates.

As Graph 3 illustrates, typical to other islands, even Dhagethi a considerable number of students (14.4%) are studying away from the island in Male offering better education. In addition around some students (10%) study in other islands other than Male' and some (7) are studying abroad.

Additional education establishment in the island includes a pre-school, a tuition class teaching up to Grade 10, and school for teaching Quran.

5.6.6 Housing

Dhagethi has given out 264 plots of land for housing purposes out of which in 167 plots house have been constructed of which almost all houses appear in general having good housing condition built with cement brick /or coral and limestone replacing the thatch huts of the past. Also majority of these houses have boundary wall built round them. Records indicate that space for additional land is limited and only 27 plots of lands can be given out taking into consideration the existing land area

6 Stakeholder Consultations

This project involves various stakeholders at different levels. From the initial project planning stage, stakeholder consultations have taken place at various levels. For this EIA, stakeholder consultations were undertaken with the client and the community. During the consultations with the client, their plans and expectations were noted while at the same time, the community consultations were used as a mechanism to gather information for the proposed project. As the harbour comes under the jurisdiction of MCPI, the formal channel of communication is directly between the MCPI and the island community.

6.1 Consultation with the proponent

The proponent for this project is Ministry of Construction and Public Infrastructure. Consultations were undertaken at various stages of the project. Initial consultations were conducted with the client in February 2008. Discussions were focused on gathering preliminary data and information from the client before the field visit. The client was also briefed about the environmental components and how the data would be collected. The client briefed about the present policies and construction practice of the government for harbour projects.

6.2 Consultations with the local community

Comprehensive informal and formal consultations and discussions were held with the community through randomly discussing with the islanders, fisherman and also by means of a formal community meeting. Generally, consultations were held to assess and identify the different socio-economical aspects of the project. The discussions were also used as a means to identify what the community / local fisherman considered as the most significant difficulties, constraints and what aspirations they have regarding the project. These consultations also helped to gather other information that were usually not documented in the island office such as harbour traffic at different periods of the year.

More details of the socio-economic aspects have been presented in the “Socio-economic” section of the report.

6.2.1 *List of persons consulted*

Following are the names and designation of persons consulted.

<u>Name</u>	<u>Stakeholder Group</u>
1. .Ahmed Abdu Samad	IDC
2. Ahmed Adam	Vice Chairman
3. Ahmed Imad	IDC
4. Ibrahim Aboobakuru	IDC
5. .Ali Mohamed	Harbour Committe
6. Hussain Hassan	Harbour Committe
7. Mohamed Ahmed	Harbour Committe

6.2.2 Perceptions of the Community

Dhangethi has the natural characteristics of a typical island of the Maldives. The western side of the island has a deep lagoon which provides a natural harbour for mooring of safari boats in north east monsoon and calmer days in south west monsoon. The western side of the island has a large beach which is typical of the kind of beach that is found in most of the resorts of the Maldives. The southern end of the island has a large sand pit which moves with the monsoon.

One of the key economic activities of Dhangethi is related to tourism, and island hopping being the major economic activity that brings revenue and income to the island. Every day several hundred tourists visit the island from nearby resorts visit the island to see the island life and do souvenir shopping. This has resulted in propagation of tourist shops throughout the island.

Through the community consultation it was found that it is the wish of the islanders to retain the natural characteristics of the western side and maintain its beauty. As a result, the community is reluctant to develop the harbour on the western side. Furthermore, a harbour on the western side will require breakwaters that will be more expensive and with a greater liner length, due to the fact that this are is naturally deep and long.

6.2.3 Community Support and participation in terms of maintaining and managing the harbour

During the focus group discussions the community members were asked about the willingness of the community to support and participate in terms of maintaining and managing the harbour. The response for this was positive stating that in the past, funds have been raised and community has been mobilized to repair and construct the community infrastructure and the jetty which has been built to get access to the deep lagoon on western side of the island. They emphasized priority should be to construct basic harbour at this stage.

6.2.4 Conclusions

From the community discussions it is very clear that construction of an appropriate harbour is one of the major priority areas of Dhagethi. At present the community in general and especially the fishermen and traders are undergoing immense difficulties due to the lack of a proper harbour. Review of the discussions revealed that an appropriate harbour will increase the traffic of vessels to and from the island and within the atoll. This will bring increased access to goods and services providing opportunities for diversification of the economic base providing more employment opportunities and income. In the long term this will have the potential of reducing the economic disparity between Malé and the islands.

7 Impacts and Mitigation measures

This section will look at the impacts of the proposed harbour development project on the coastal, marine and socio economic environment of Dhagethi. Furthermore, measures to mitigate impacts would be suggested so that overall environmental improvements and damage could be minimized. The impacts have been identified for both the construction and operational stage.

7.1 Methods of Impact Prediction

7.1.1 Coastal and Marine Environment

Impacts on the marine environment from the proposed dredging and reclamation as well as other coastal infrastructure have been predicted through analysis of the proposed project, discussions with the project proponent, field surveys, observations and assessment as well as based on field experience of similar works in the country. Data collected from field work were analyzed to predict the extent and significance of the impacts that may arise from the proposed harbour development project's activities. The assessment was also based on area calculations of the coastline that fall within the project boundary and anticipated to be impacted.

7.1.2 Socioeconomic environment

Impacts on the socio economic environment from the proposed project have been predicted through, series of community consultation based on focus group discussions, key informant interviews, data collected from secondary sources, natural Interviews and personal observation.

Focus group discussions were held with Island Development Committee, Women's Development Committee and the local Non-Governmental Organizations registered in the island in addition to the fishermen and the traders.

Natural interviews conducted with 'naturally' occurring groups. The method has the advantage of being interviewed at a time and place of their convenience, and is suitable from the point of view of the interviewee. The result is frank and open discussion in a more relaxed and informal manner.

To verify and cross check the information collected from the focus group discussions, interviews were also held with key informants such as island chief, staff of the Island Office and the staff of the Island Health Centre and community members who were interested in providing information.

Secondary sources of data, including island office records forms an integral part of the assessment. Socio-economic data relating to the population, literacy rate, housing, economic activities, educational status, health services, electricity and other infrastructure existing in the island were collected.

Quantitative and qualitative data collected from field work were analyzed to predict the extent and significance of the impacts that may arise from the proposed project activities.

7.2 Uncertainties in Impacts Identification

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

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

7.3 Impacts on the Marine and Coastal Environment

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

Four components of the marine environment that will be impacted are identified as the lagoon, the reef-flat, the seagrass beds and the coral reef system. Quantitative assessment of potential direct and indirect impacts due to the proposed development was based on area calculation of the lagoon and coral reef.

Impacts from these activities will be due to disturbance to the lagoon, seagrass and reef-flat bottom in construction activities and release of fine sediment to the water column.

Indirect impacts will be felt to the pelagic organisms inhabiting these areas that are close to the development zone. Indirect and long term impacts on the marine environment will be more accurately assessed by long term monitoring and assessment as part of this environmental assessment.

7.3.1 *Impact on the Coastal Environment*

7.3.1.1 Mobilization Impacts

The transport and supply of construction material, the excavator and other heavy duty equipment to the project site is not expected to have a direct impact on the coastal environment.

7.3.1.2 Impacts of Sedimentation

Dredging of harbour basin and reclamation of land will be carried out using excavators, loaders and lorries. The negative impact of sedimentation is unavoidable even with the construction of sand bund walls. However, the impacts of sedimentation are short term impacts since the monsoonal currents will aid in the dispersal and removal of fine suspended materials.

7.3.1.3 Impact of Breakwaters and Quay walls

Construction of quay walls is expected to have significant impact on the coastal environment. As this would have an irreversible change to the natural shoreline and sediment movement around the island.

7.3.1.4 Impacts of Land Reclamation

Land reclamation under this project for Dhangehi may be considered a positive and indirect impact of the project. Dhagethi has a high population density with its houses on the edge of the greenbelt of the island. These houses will benefit from the reclamation in that their property would be shielded from waves as well as high winds provided appropriate landscaping takes place in the harbour front area. The additional land to the island would facilitate to develop public spaces on the island.

7.3.1.5 Impacts due to Harbour Operation

Impacts associated with the harbour operation can be considered as minor to moderate and short to long term. These impacts include: Impacts due to accidental spillage of oils, other chemicals and waste and hydrodynamic changes forming dead zones in the inner harbour where litter may accumulate

7.3.1.6 Solid waste disposal

Inappropriate handling of solid waste and garbage, and its disposal into the surrounding environment can have impacts on the marine environment including pollution of coastal waters and consequential effects on coral reefs and associated reef organisms. The types of solid waste generated during the operation will mainly consist of plastic bags, glass and plastic bottles, cans, tins, paper, wrappings, other discarded litter and human faeces. Such items can have adverse impacts on the marine environment ranging from reduced aesthetic beauty of the surrounding area to degraded harbour water quality from marine pollution as well as potential ecological disturbances. Ecological impacts associated with solid waste disposal into the marine environment include reductions in fish populations due to water pollution, as well as killing corals and other marine organisms by smothering and certain items such as plastic bags.

7.3.1.7 Impacts on the Marine Environment from the Proposed Harbor Project

Harbor dredging and land reclamation projects have both construction and operational impacts on the marine and coastal environment. These impacts may be either short term reversible or long term irreversible damage or alteration to the marine and coastal environment. The impacts identified here will be according its location and magnitude. The intensity or severity of the impacts is further grouped into negligible, minor, moderate and major. This will help in identifying and carrying out remedial and mitigation measures. A description of the impact categories are presented below (LaMer 2006).

- Negligible: no significant impact on environment
- Minor: the impact is short term and cause little impact on the environment which may be reversible on the long run.
- Moderate: Impacts significant, may cause long term environmental concerns but are likely short term, acceptable and justifiable
- Major: long term impact, large scale environmental alterations

Potential environmental impacts predicted for the development will be the impacts during construction and irreversible modifications as a result of dredging and excavation. These impacts are presented together with mitigation measures in the (Table 6).

Excavation and reclamation generally lead to major impacts on reef habitats, lagoon and coastal hydrodynamics. The Impacts of excavation and dredging may range from smothering of live corals and other flora and fauna. Coastal modification involved in the construction of the harbor can have short to long term impacts on the coastal processes and beach profiles of the island. Specific impacts on the marine environment arising from the proposed project will be mainly an alteration of the bottom of reef-flat where dredging is done and a moderate impact on the sediment movement along the shoreline, and a major impact on the benthic and nektonic communities that inhabit in the possible impact area. The predicted impacts are moderate because the proposed location of the harbor has been used for mooring and channel is in existence since 1969.

7.3.1.8 Mobilization Impacts

The transport and supply of construction material, the excavators and other heavy duty equipments may have an impact as a result of increased traffic with barges and other large vessels. The impacts may arise from:

- Accidental spillage of construction materials (cement bags, timber, iron bars).
- Accidental oils and other chemical spills.
- Accidental grounding of large vessels.
- Propellers' wake can break fragile corals.
- Anchor damage from the vessels.

7.3.1.9 Impacts from Construction Materials and Other Waste

Construction materials such as cement, timber, and fuel for excavators and trucks have the potential to damage the marine environment. Pollution of the lagoon and reef system can be caused by waterborne and windblown debris escaping from the construction.

The dredge material will be disposed at the area located at the map (see Figure 16). Disposing dredge material at the shoreline would have major irreversible impacts on the near shore habitat since the project will dispose materials on the new disposal sites. However, disposal of dredge material at these sites may have positive socioeconomic impacts. This can increase the available land for various purposes. The long term possible alterations in coastal processes of the area will not be clear only after carrying out long term monitoring.

7.3.1.10 Impacts due to Construction Work

Deepening work of the entrance channel and harbor basin will be carried out using excavators. Therefore the negative impact of sedimentation is unavoidable even with the construction of sandy bund walls. The impacts of sedimentation are short termed since the monsoonal currents will aid in the dispersal and removal of fine suspended materials. Growth and recruitment of live corals may have moderate short term impact due to sedimentation.

The impacts of excessive sedimentation on corals include:

- Direct physical impacts like smothering of corals and other benthic organisms,
- Reduced light penetration reducing the productivity of corals.
- Formation of false bottoms due to unstable shifting of sediments.
- Eutrophication due to increased fine sediments leading to algal blooms.
- Formation of anoxic (black) bottoms under the fine sediments.

Construction of wharfs and protection walls may have impacts on the reef-flat habitat by seepage of cement material. Construction of protection wall include a lot of manual transport of cement bags and other materials, trampling and breakage of live coral is possible at the seaward side of the harbor basin and the sides of the entrance channel.

7.3.1.11 Impacts of Built Coastal Structures

The impact of anthropogenic physical structures such as breakwaters, access channels and harbors on the coastal processes and marine flora and fauna, can be quite significant and often permanent. Some of these include:

- Change in near shore hydrodynamics.
- Erosion and loss of vegetation at the low energy areas during either monsoons.

- Sedimentation and turbidity resulting poor water quality which negatively impacts vitality of marine organisms.
- Alteration of bottom substrate
- Degradation of sea water quality due to turbidity

7.3.1.12 Impacts due to Harbour Operation

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

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

7.3.1.13 Significance of the Impacts

Impacts that may arise from activities of the proposed harbor rehabilitation project were categorized into the characteristics mentioned in the The magnitude of the impact was represented by color. The darker the red color the higher the predicted impact will be.

Table 9. The significance of impacts was determined based on these characteristics and analysis of the impacts from this project and other analogous projects. These impacts correspond in the worst case scenario and after mitigation measures were taken. The The magnitude of the impact was represented by color. The darker the red color the higher the predicted impact will be.

Table 9 shows the main impacts that will arise from the proposed project activities and their significance based on impact characteristics.

Magnitude of impact is calculated in relation to the total area of the lagoon and the coral reef (see Figure 16). Direct geographic range of impact felt will be the immediate proposed development area and indirect impacts will be felt on a larger area due spreading of fine sediment. Duration of the impact is predicted in terms of severity of impacts. The impacts are likely to be felt on an estimated 5% of the lagoon and reef-flat of that extensive reef system. Estimated error of these predictions may vary significantly due to uncertain weather conditions.

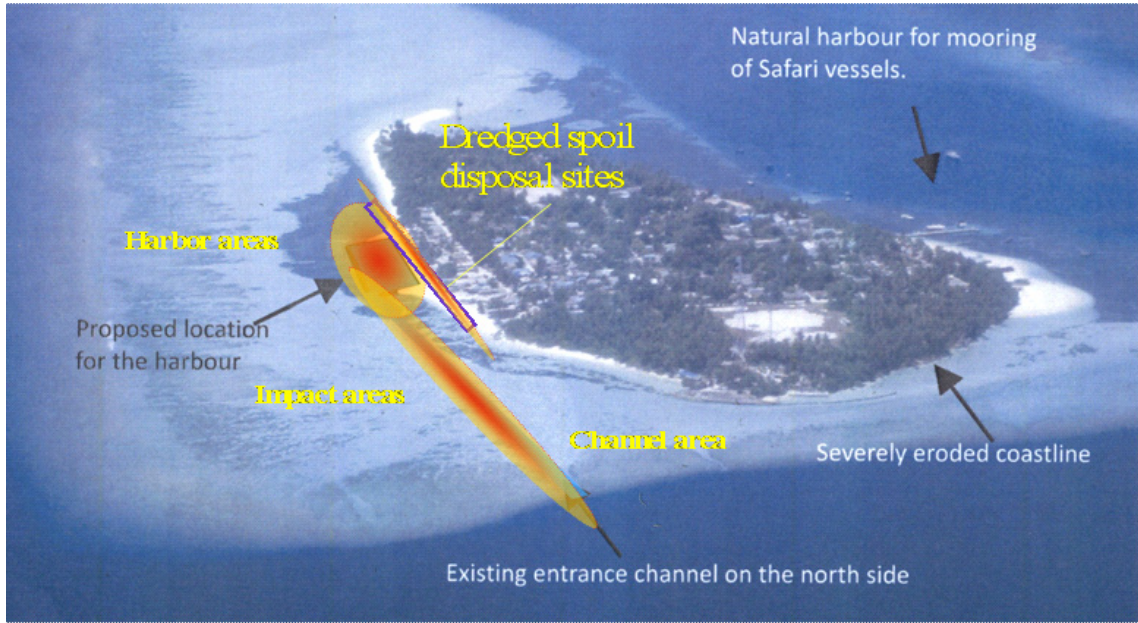


Figure 16: Possible impact areas of the proposed harbor development project

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

Table 9: Significant impacts of the proposed harbor rehabilitation project

Impact characteristics	Harbor basin dredging	Reclamation	Channel dredging
Nature of impacts	Cumulative, long term	Cumulative, long term	Cumulative, long term
Magnitude of impacts	Moderate- negative	Minor- negative on coastal ecosystems. Minor +ve on socioeconomic aspects: more land	Minor-negative
Geographical range and environmental attributes	Direct impact on 1000m ² of reef-flat and lagoon Direct impact on coral reef on 400m ² Direct impact on seagrass bed 500m ² Indirect impact on 4000m ² of reef-flat and lagoon	Direct impact on 500m ² of reef-flat and lagoon Direct impact on coral reef on 200m ² Indirect impact on 1000m ² of reef-flat and lagoon	Direct impact on 8000m ² of reef-flat and lagoon Direct impact on coral reef on 300m ² Direct impact on seagrass bed 200m ² Indirect impact on 3000m ² of reef-flat and lagoon

Impact characteristics	Harbor basin dredging	Reclamation	Channel dredging
Duration of impacts	Short term on coral reef and lagoon and long term on reef-flat, seagrass beds and beach	Permanent alteration of physical and biological system of the sea bed and marine life	Short term on coral reef and lagoon and long term on reef-flat and seagrass beds.
Reversibility of impacts	Permanent alteration of physical and biological system of the harbor basin, Short term reversible impacts on coral reefs, lagoon and reef-flat and seagrass beds adjacent to the harbor basin	Irreversible impact on the benthic life of the filled area	Permanent alteration of physical and biological system of the entrance channel basin and sand dumping site, short term reversible impacts on coral reefs, lagoon and reef-flat and seagrass beds adjacent to the entrance channel basin
Significance of the impacts	Minor impacts on the harbor basin, shore-line and beach, moderate impacts on the adjacent areas of reef-flat and other environmental attributes	Moderate impact on benthic communities. Impacts to hydrodynamic process unclear.	Minor impacts on the entrance channel basin and sand dumping site, moderate impacts on the adjacent areas of reef-flat and other environmental attributes

7.3.2 Mitigating the Impacts

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

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

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

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

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

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

The monitoring programme specified in this report will be followed and reported in both work phase and operation phase.

Table 6 below provides more information on potential impacts during construction and operation of the harbor rehabilitation project and mitigation measures (LaMer 2006).

Table 6: Potential impacts during construction and operation of the harbor rehabilitation project and mitigation measures identified to minimize the impacts

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Littering on and marine environment	Avoided by proper planning in ways transportation and disposal. Use 3R- reduce, re-use, recycle. Proper disposal	Reef-flat, lagoon, seagrass and land	During construction	Minor to moderate, short term -ve impact. Reversible	Contractor, Island authorities	35,000 (included in the contract of the contractor)
Damage to reef by Loading/unloading works	Raising awareness and utilizing environmental best practice, careful planning	Reef-flat and reef-slope, seagrass and lagoon	During construction	Minor, short term -ve impact. Reversible over long run	Contractor, Island authorities	5,000 (included in the contract of the contractor)
Sedimentation and siltation on the reef and lagoon due to excavation works	Creation of a sand bund to reduce the sedimentation impact, carried out in low tides	Reef-flat and reef slope lagoon	During construction	Moderate, short term -ve impact. Reversible over long run	Contractor, Island authorities	75,000 (included in the contract of the contractor)
Loss of habitat, damage or death of coral at the entrance area, harbor basin and protection wall area	Clearly marking the areas to be excavated	Reef-flat, seagrass and lagoon	During construction	Moderate, short term -ve impact since these are new dredging sites	Contractor, Island authorities	5,000 (included in the contract of the contractor)
Loss of habitat at the spoil disposal site.	Clearly marking the areas to be filled	Reef-flat, seagrass and lagoon	During construction and Operational phase	Minor, long term -ve impact. Most likely irreversible.	Contractor	5,000 (included in the contract of the contractor)
Habitat modification at the spoil disposal site.	The material will be disposed at the seagrass bed with strictly marking the areas to be filled.	Reef-flat, and beach	During construction and Operational phase	Moderate, long term -ve impact. Most likely irreversible. Positive impacts	Contractor, Island authorities	5,000 (included in the contract of the contractor)

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Impacts on commercial species	Shortening the duration of the project; minimizing the spread of sediment by containing the sediment using sandy bund walls; creating awareness about the importance of these species.	Reef-flat and reef-slope, seagrass and lagoon	During construction	Minor -ve; impacts not fully clear. Most likely little change.	Contractor, Island authorities	N/A
Impacts of storm-water drainage and coastal flooding.	The spoil will be disposed at sites adjacent to the beach. The elevation will be maintained at the same level of the adjacent areas.	Coastal area	During construction and Operational phase	Minor, impacts not fully clear. Most likely no change.	Contractor, Island authorities	20,000 (included in the contract of the contractor)
Impact of dredging works on the existing operations of the lagoon	Dredging will be carried in a manner that will not interfere with the operation of the harbor	Entrance channel and harbor	During construction	Minor, -ve impacts on the operation of the harbor	Contractor, Island authorities	N/A
Air pollution	Completing the excavation works as soon as possible.	Air	During construction	Minor, short term -ve impact. Reversible	Contractor	N/A
Noise pollution	Completing the excavation works as soon as possible, avoid working at night	Land	During construction	Minor, short -ve term impact. Reversible	Contractor	N/A
Possible erosion due to obstruction of littoral sediment movement	Keep part of the dredge material on the island to supplement areas showing erosion	Beach	Operational phase	Minor and unpredictable impact. Most likely no change	Island authorities	Cost is difficult to estimate since the timing of impact unpredictable
Solid waste	Employ a staff for monitoring and cleaning the harbor	harbor	Operational phase	Minor, long term -ve impact Reversible	Contractor	monthly salary equivalent to 3000
Accidental spillage	Put up sign boards	harbor	Operational phase	Minor, short term -ve impact reversible	Island authorities	5000 - 9000

7.3.3 Uncertainties in Impacts Identification

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

8 Alternatives

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

8.1 No Project Option

The no project option takes the following into account.

- The existing natural harbour continues to be used via the jetty on the western side of the island
- Development of the island would be affected

The main advantages and disadvantages of these are given below.

Strategy	Advantages	Disadvantages
Allow to use the existing natural harbour on the western side of the island	Environmental problems related to developing a new harbour can be avoided No costs to the proponent and hence there is a short term benefit	Economic burden may increase Long term socio-political problems may arise Higher long term costs Sedimentation of the access channel will increase Economic expansion would be limited.
Allow public frustration and anger to continue	Short term costs of dealing with the problem can be avoided	Political unrest Stability and peace in the island affected Economic activities and social fabric weakened Lives and livelihoods may be affected

Table 8-1: Advantages and disadvantages of the no project option

8.2 Design Alternatives

8.2.1 *Sheet piling the quay wall.*

Sheet piling the quay wall will allow greater live load carrying capacity. This option, although it was considered has been rejected as it is not predicted that the island will have traffic and cargo that require sheet piling in the near future. If it is required, then the harbour will have to be upgraded with more facilities. Sheet piling will also be environmentally more damaging and more costly. Therefore, this option was rejected.

8.2.2 *Alternatives Breakwater*

8.2.2.1 Rubble-mound breakwater

Rubble-mound breakwaters are ineffective for harbours because they collapse during storm conditions. Even with a wire mesh (or gabion box) around the structure, the structure is bound to collapse. Therefore, the use of rubble mound breakwaters has been discontinued, especially with the regulations banning the mining of sand and coral from house reefs.

8.2.2.2 Vegetated breakwater

There are very few vegetated breakwaters in harbours in the Maldives. However, these structures have been seen to be quite effective in reducing wave action inside the harbour basin during rough weather, especially wind-generated harbour waves. Vegetated breakwaters also provide better wave-overtopping control than plain breakwaters. Vegetated breakwaters are made by placing dredged material on the breakwater area and salt-resistant trees such as *Pemphis acidula* (*kuredhi*), *Hibiscus tiliaceous* (*dhiggaa*), *Calophyllum innophyllum* (*funa*) or *Scaevola taccada* (*magoo*). Vegetated breakwaters are also aesthetically pleasant. Nevertheless, vegetated structures take time to form and would still require a seawall or similar structure on the harbour side of the structure. Therefore, these may not be that suitable for Dhagethi. However, placing appropriate amount of dredge material behind the proposed breakwater to create such a vegetated area may prove to be useful in the long term. However, the area behind the proposed breakwater would be shallow and reef flat would be in proximity. Also, community initiative and involvement would be necessary for maintaining a vegetated breakwater.

8.2.2.3 Other Breakwater Structures

Timber pile, cellular sheet pile and floating structures may be considered. These structures have not been tried in the Maldives so far. Floating breakwaters may be designed to either prevent overtopping or allow some overtopping for harbour flushing. They are cost-prohibitive and therefore, are suited for deepwater and sites with poor foundations and/or where water circulation is desirable.

8.3 Alternative locations

The alternate location for the harbour is on the western side. However due to the deep lagoon proximity to the island, it is not possible to develop a harbour on this side of the island as the harbour is too deep to construct a breakwater on the western side of the island.

9 Environmental Monitoring

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

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

The objectives of the monitoring plan are to measure:

- live coral cover and nektonic fauna
- the amount of sedimentation on the reef
- water quality and visibility
- beach profile and hydrodynamic changes
- impacts are accurate and mitigation measures taken are effective and
- the thresholds are kept within the baseline limits predicted.

The Table 2 below summarizes the various aspects of the monitoring program.

Table 2: Aspects of the monitoring program

Monitoring Attribute	Indicator	Methodology	Monitoring Frequency	Estimated Cost
Coral and other benthic cover.	Percent cover	LIT	Upon completion of the project and once a year there after.	US\$ 350 per survey
Diversity and abundance of fish communities	Number of fish present	Visual fish census	Upon completion of the project and once a year there after.	US\$ 350 per survey
Seawater quality	DO and turbidity	Lab analysis	Twice during the project, 2 months after the completion, there after once a year	US\$ 50 per test performed
Beach profile	Beach dynamics	D-GPS tracks along the beach	Once during the project, 2 months after the completion, there after once a year	US\$ 100 per survey

9.1 Monitoring Report

A detail monitoring report will be compiled, if required, after the completion of the civil works based on the data collected for monitoring the parameters included in the monitoring program. This report will be submitted to the relevant government agencies for compliance.

The report will include details of the site, data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

9.2 Cost and Commitment for Monitoring

The proponent committed fully for the monitoring programme outlined in this report, with the assistance from Environment Research Centre. The cost indicated is for monitoring the project during the construction stage only as experience has shown that monitoring during the operational phase has not worked in any projects as there is no social or economic incentive driving such a monitoring programme forward.

During the construction stage, the Proponent will ensure that the contractor undertakes monitoring and the cost of such monitoring is included in their proposal. The total cost of monitoring the parameters listed above would be approximately 45,000 Rufiyaa including transport costs.

9.3 Monitoring responsibility

Monitoring responsibility will be with the Ministry of Environment, Energy and Water. The Proponent shall make monitoring part of the requirements of the Contractor's obligations. The Contractor may obtain the services of qualified environmental consultants to undertake the monitoring or undertake monitoring on their own.

9.4 Monitoring Report

A detailed monitoring report will be compiled after the completion of the civil works based on the data collected for monitoring the parameters included in the monitoring program. This report will be submitted to the relevant government agencies for compliance.

The report will include details of the site, data collection and analysis, quality control measures, sampling frequency and monitoring analysis and details of methodologies and protocols followed.

10 Conclusion

This EIA report has identified the major impacts of the proposed harbour project in Dhagethi. The main negative impacts of the project would be related to the disruption of the sediment movement around the island and the dredging or excavation process. Dredge material disposal would also have impacts on the environment and positive impacts to economy and aesthetic and recreational amenities. The assessment has indicated that the impacts are likely to be felt on five percent of the lagoon and reef areas. Socioeconomic impacts have also been assessed in depth and it is evident that there would be several positive socioeconomic impacts.

During the dredging, care should be taken to allow only minimal amount of suspended sediments to escape from the working areas. The harbour basin to be dredged shall be initially enclosed by creating a bund using initially dredged material. Areas to be filled would have to be banded in the same way except the area behind the proposed harbour/quaywall, which would be inside the bund created for the harbour dredging.

Although several alternatives have been considered, these alternatives cannot be implemented for various reasons. Alternative locations cannot be considered for this project, as the harbour is proposed in the most appropriate location in terms of acceptability by the community who is the main beneficiary of the project. This location is also the preferred location by the community.

The monitoring programme for this project will focus on water quality during dredging works and for this reason, turbidity and dissolved oxygen monitoring has been considered in the monitoring programme.

It appears justified from a technical and from a developmental point of view, to carry out the proposed project in light of the existing socio-economic developments and forecasts made on the harbour use and traffic increase. There are good reasons from an economic and social point of views to undertake the project. There would definitely be environmental impacts, but they are also unavoidable and achieved by social acceptability of the project and economic gains on the other hand. The adverse environmental effects of the project therefore appear to be limited and acceptable, including the effects of dredging the basin on eastern side and disposing the dredged spoil to fill the eastern side lagoon, assuming that the mitigation measures proposed are implemented.

11 Declaration of the consultants

This EIA has been prepared according to the EIA Regulations 2007, issued by the Ministry of Environment, Energy and Water. The EIA was carried out by a multidisciplinary consulting team representing Water Solutions.

We certify that the statements in this Environmental Impact Assessment study are true, complete and correct to the best of our knowledge and our abilities.

Name: Abdul Aleem (EIA 09/07)

Signature:

Date:

Name: Ahmed Jameel (EIA 07/07)

Signature:



Date: 20 April 2008

Name: Ahmed Zahid (EIA 08/07)

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Name: Hassan Shah (EIA 02/07)

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Date:

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Appendix 1: Terms of Reference



Environment Research Centre
Ministry of Environment, Energy & Water
Male', Republic of Maldives

Terms of Reference for Environmental Impact Assessment

The following is the TOR based on the points discussed in the scoping meeting held on 1st April 2008 for undertaking the EIA of the proposed Harbour Construction in Dhagethi, Alif Dhaal, Atoll.

1. Introduction - Identify the development project to be assessed
2. Study Area - Specify the boundaries of the study area for the assessment as well as any adjacent or remote areas that should be considered with respect to the project (e.g. dredged material disposal site/s).
3. Scope of Work - The following tasks will be performed:

Task 1. Description of the Proposed Project - Provide a full description of the relevant parts of the project using maps at appropriate scales where necessary. This is to include: quality and volume of sediments to be excavated in each area to be dredged; type of dredging equipment to be used and the manner of deployment including handling, transportation, and disposal of dredged material; sediment containment settling and turbidity control measures; considered; project schedule; and life span. Justify the proposed location for the harbor is most appropriate.

Task 2. Description of the Environment - Where baseline data is to be collected, careful consideration must be given to the design of the survey and sampling programme. Data collection must focus on key issues needing to be examined for the EIA. Consideration of likely monitoring requirements should be borne in mind during survey planning, so that the data collected is suitable for use as a baseline to monitoring impacts.

Assemble, evaluate and present baseline data on the relevant environmental characteristics of the study area (and disposal sites), including the following:

- a) Physical environment: marine water quality; BOD, COD Dissolved oxygen, Salinity, turbidity, salinity, suspended solids, pH, Nitrate and phosphate.
- b) Biological environment: lagoon and reef system.
- c) Socio-cultural environment: boating activities and use of the harbour, population, land use, planned development activities, employment, and community perception of the development.
- d) At least four beach profiles at different locations should be provided to establish the baseline statistics giving GPS positions of each site.

Characterize the extent and quality of the available data, indicating significant information deficiencies and any uncertainties associated with the prediction of impacts.

All survey locations shall be referenced with Geographic Positioning System (GPS) including sampling points, reef transects, vegetation transects, manta tows and soil sampling sites. All water samples shall be taken at a depth of 1m from the mean sea level or mid water depth for shallow areas. The report should



outline the detailed methodology of data collection utilized to describe the existing environment

Task 4. Determine the Potential Impacts of the Proposed Project – Identify impacts related to dredging, spoil disposal and possible land filling. Distinguish between significant impacts during construction and operational phase that are positive and negative, direct, indirect, short and long term. Identify impacts that are cumulative, unavoidable or irreversible. Identify any information gaps and evaluate their importance for decision-making. Special attention will be paid to:

Effects of the project (dredging and spoil disposal) on water quality and existing coastal ecosystems and resources,

- Effects of dredging on the coastal stability of the shorelines, potential erosion prone areas that may arise due to this project.
- Effects of dredging works on the existing operations of the lagoon.
- Effects of storm water drainage from proposed spoil disposal sites, including potential for off-site flooding.
- Possible impacts on vegetation.

Task 5. Analysis of Alternatives to the Proposed Project. – Describe the alternatives examined for the proposed project that would achieve the same objective including the "no action alternative, harbour location and dredge spoil and also the disposal sites. Determine the best practical environmental options.

Task 6. Mitigation and Management of Negative Impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels with particular attention paid to dredge spoil disposal and dispersal/sedimentation control. Cost of the mitigation measures, equipment and resources required to implement those measures.

Task 7. Development of a Monitoring Plan – Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for dredging/disposal operations. Detail of the monitoring programme including the physical and biological parameters for monitoring, frequency, duration and cost commitment from responsible person, detailed reporting time table and ways and means of undertaking the monitoring programme must be provided

Task 8. Public/NGO Participation- Identify appropriate mechanisms for providing information on dredging activities and progress of project to stakeholders. Assist in coordinating the EIA with the relevant government agencies and in obtaining the views of local stakeholders and affected groups (It is anticipated that there will be considerable public interest concerning issues of location of the harbor, spoil disposal and turbidity with and the economic benefits to be derived from the project.)

Presentation - The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations for any references used in interpreting those data. The environmental assessment report will be organized according to the outline given in the Environmental Impact Assessment Regulations, 2007.

2nd April 2008

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Appendix 2: Names and Registration Certificate numbers of the EIA consultants

Abdul Aleem – EIA Registration no: EIA09/07

Ahmed Jameel – EIA Registration no: EIA07/07

Ahmed Zahid – EIA Registration no: EIA08/07

Hassan Shah – EIA Registration no: EIA02/07

Appendix 3: Beach Profiles

