Ministry of Construction and Public Infrastructure

Environmental Impact Assessment Notes for
H.A. Uligamu
Harbor Construction Project

Uligamu, Thiladhunmathee Uthuruburi, Maldives

January 2008

  

Prepared by

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For the Ministry of Construction and Public Infrastructure (MCPI)

Consultant’s Declaration

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

Name: Ibrahim Naeem **(M Env. Mgt.)** – EIA 13/2007

Signature

Date: 25 January 2008

Environmental Impact Assessment Note for H.A. Uligamu Harbor Construction Project

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1 Summary

This impact note deals with the construction of a harbor at Uligamu in Haa-Alifu Atoll.

1. The implementing agency for this project is Ministry of Construction and Public Infrastructure (MCPI). The project will be executed under the Access Improvement Program of the government. The project was awarded to RKL Group, Maldives.

2. The proposed site for the project on the western side of the Island appears to be the most appropriate location for the harbor development taking into account environment, construction feasibility and economics of the proposed development.

3. Baseline environmental conditions at the project site indicated that the coral cover around the harbor basin area was very low. The coastal vegetation around the proposed harbor area was mainly *hirundhu* and *kaani,* and does not represent any specific preservation value.

4. Significant environmental impacts are predicted for the proposed development project. But these are short term impacts (e.g. sedimentation). These impacts can be mitigated through proposed environmental impact mitigation measures.

2 Introduction

2.1 Purpose of this EIA Note

This impact note presents the findings of an Environmental Impact Assessment (EIA) for the construction of H.A. Uligamu harbor. This project was granted a special permission by the Ministry of Environment, Energy and Water (MEEW) to prepare only an impact note rather than a full scale EIA report. The Ministry of Construction and Public Infrastructure (MCPI) is required to obtain approval from the MEEW prior to the implementation of the project.

2.2 Tasks carried out in this impact study

These tasks were conducted in this study:

1) Description of the Project – A short description of the overall project, project locations and areas selected for development was discussed.

2) Description of the existing environment – The physical and ecological setting of the project was assessed. A brief assessment of the existing conditions of the proposed site was provided. Baseline data was obtained on relevant environmental aspects including the physical, coastal oceanographic and biological parameters.

3) Descriptions of potential impacts – Major environmental issues were identified with short and long term impacts. The significance, the magnitude and the reversibility was assessed.

4) Mitigation of negative impacts – Cost-effective and feasible measures to reduce the negative impacts was provided.

5) Discussion of project alternatives – Project alternatives including alternative sites and the "no project" option was analyzed.

6) Monitoring and reporting – Project's environmental monitoring methods was discussed.

2.3 The legal setting of the project

The construction of harbors in the Maldives should follow the guidance provided by several environmental laws, regulations, by-laws, plans, and strategies. Some of these included.

- Environment Protection and Preservation Act of Maldives (Law No. 4/93)
- EIA Regulation 2007
- Second National Environmental Action Plan (1999)
- National Biodiversity Strategy and Action Plan

- Regulation on Sand and Coral Mining
- By-Law, Cutting down, uprooting, digging out and export of trees and palms from one island to another

In addition to these national laws and regulation there are several international conventions and treaties that are Maldives is a party. These should also be taken into consideration. Some of the most important ones include the Convention on Biological Diversity (CBD), UN Framework Convention on Climate Change (UNFCCC), and the UN Law of the Seas (UNCLOS).

3 Survey methods

The data collection, analysis and compilation of this impact study included;

- Assessment of existing environment to identify significant environmental components that would be impacted,
- Public consultations to exchange information on the project,
- Literature review.

Data on existing environment was collected during the field visit to Uligamu on 05 January 2008. General information on the existing environment was based on available secondary data, such as climatic data from other regions.

Both quantitative and qualitative methods were used to assess the coastal vegetation, marine benthic substrate and fish at the survey sites. Where possible and appropriate a 0.5 by 0.5 m quadrat were used to quantify benthic substrates. Belt transects were used to assess (count) the fish community structure. Fish count and the invertebrates count were conducted on the same area where the quadrat survey was done. Visual assessment was used in sites where physical or weather conditions hinder the use of quadrat methods. This was mainly carried out using the ‘timed swims’ techniques.

This study was complemented with photographs of the areas in question. Methodologies adopted for these surveys are internationally accepted (English et al. 1997) and are widely used to assess the status of coral reefs and other coastal areas in the Maldives as well.

3.1 Vegetation transects

Qualitative surveys of vegetation around the project site were carried out. These include estimates of percentage canopy cover and identifying the dominant species. These surveys in most cases documented bushes and trees that are just at the forefront facing the beach. The Line intercept transect (LIT) method was used here. The length of the each transect was 50m. Only those that intercept with the tape are recorded. The commonly encountered vegetation was documented in their local Dhivehi names. The vegetation transects are marked and depicted in Figure 2.

3.2 Quadrat method for benthic substrate assessment

Quadrat method was used to assess the benthic substrate at the survey sites. Data from 21 random quadrats (0.25m^2 each) were taken from the selected representative sites on and around the proposed harbor development area. Quadrats were thrown randomly over head in a demarcated area (see Figure 2). Percentage cover of each benthic substrate is recorded.

Quantitative percent cover data of morphological characteristics of the reef community is obtained using this method and it can be repeated over time to obtain temporal changes. Disadvantages of this method include difficulty in standardizing the life form categories and the limitation of the data collected, on percent cover and relative abundance (English et al. 1997). Quadrat method surveys produce valuable data even though they require considerable effort and skills to record notes underwater.

3.3 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. Swims on a straight path were done on the 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. 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.

3.4 Public consultation

Consultations were carried out with the Harbor Committee (HC). Their concerns were heard and mentioned in the impact statement. Apart from the HC, leading people from the community provided valuable inputs in terms of coastal processes and beach movements. The Island authorities agreed on keeping the harbor on the proposed location. However, they are not happy with the design and size of the harbor (Figure 1). Their wish list included:

- A larger harbor than 300 by 200ft; they wanted it to be 400 by 200ft
- Breakwaters on both sides of the entire length of entrance channel.

The western side according to the islanders is the only suitable site for a relatively safe entrance and anchorage in most part of the year due to the shelter from extensive reef-flat and the reef-crest. The committee further wanted to keep the harbor about 100 to 200ft away from the existing beach line.

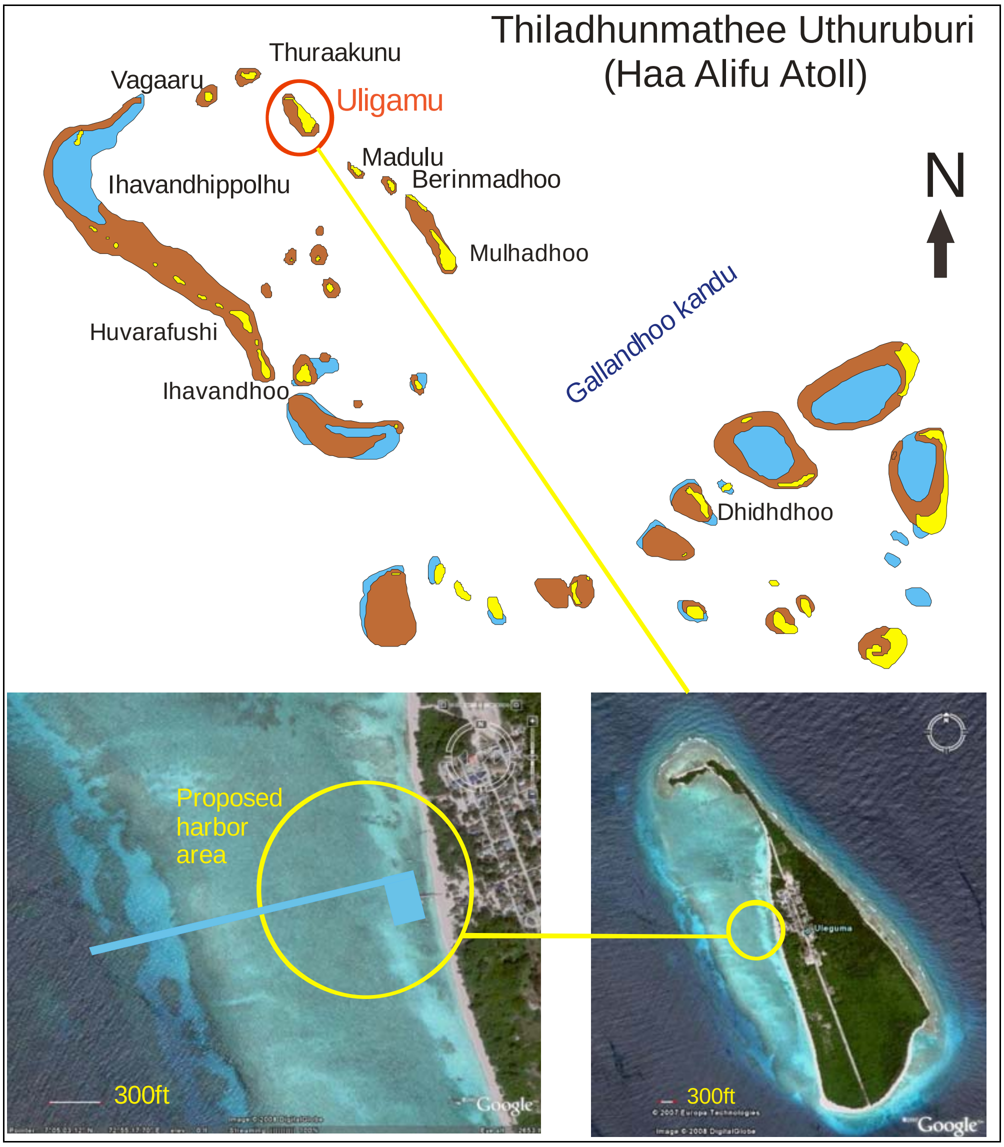

Figure 1: Location map of H.A. Uligamu and the project site. Proposed harbor position is near the existing Jetty on the west side of the Island.

4 Description of the project

4.1 The proponent

The project proponent of this project is MPCI. The project is funded by the Government of Maldives through the Access Improvement Program.

4.2 The project

This harbor construction project is executed under the Access Improvement Program of the Government of the Maldives. The project was awarded to the RKL Group, Maldives. The scope of the project included:

- Dredging the harbor basin of 300ft length and 200ft width to a depth of 8ft in mean low tide

- Building a quay-wall of 300ft along land-ward side
- Building of breakwaters along other sides of the harbor
- Dredging of a 50ft wide, entrance channel to the harbor

4.3 Project location

Uligamu is situated at the north-eastern atoll rim reef of the geographic Ihavandhippolhu atoll (administratively Haa Alifu Atoll). Uligamu was formed on a patch reef occupying over 55% of that reef. The harbor will be dredged on the western side of the island as marked in (see Figure 1). Inhabited islands that are close proximity to Uligamu included Thuraakunu, Mulhadhoo and Hoarafushi. The atoll capital Dhidhdhoo lies about 29km south-east of Uligamu. Uininhabited islands that are close to Uligamu are Madulu (an agricultural island), Berinmadhoo and Vangaaru. The tourist resort of Manafaru also lies about 10km south of Uligamu.

4.4 Project justification

Uligamu is an island with no safe harbor or anchorage. The existing concrete jetty is apparently not in very good condition. The lack of a proper anchorage and a harbor hindered both the agricultural productivity and fishing activities of the island which are directly linked to the economic development of the Island. The housing (construction of modern houses) was also greatly affected by this. The communication (transport to other islands) was very difficult due to the lack of a harbor. The island is being frequently visited by foreign yachts. Loading of fuel and water to theses vessels is extremely difficult due to the lack of proper harbor. In general the health and well being of the islanders are linked to having a proper access the Island. The current project is aimed to build a harbor that would improve the access to the Island.

4.5 Project boundaries

The construction work will be carried mainly on the reef-flat of the island. The project site is rather un-altered. The dredging of the harbor will have a significant direct impact on the seabed and its associated flora and fauna. This direct impact area will be limited to the 300ft by 200ft harbor basin and 50ft by 1800ft entrance channel. The indirect impact area in relation to sedimentation will be felt all around the harbor area since the vast length of the entrance channel (see Figure 3).

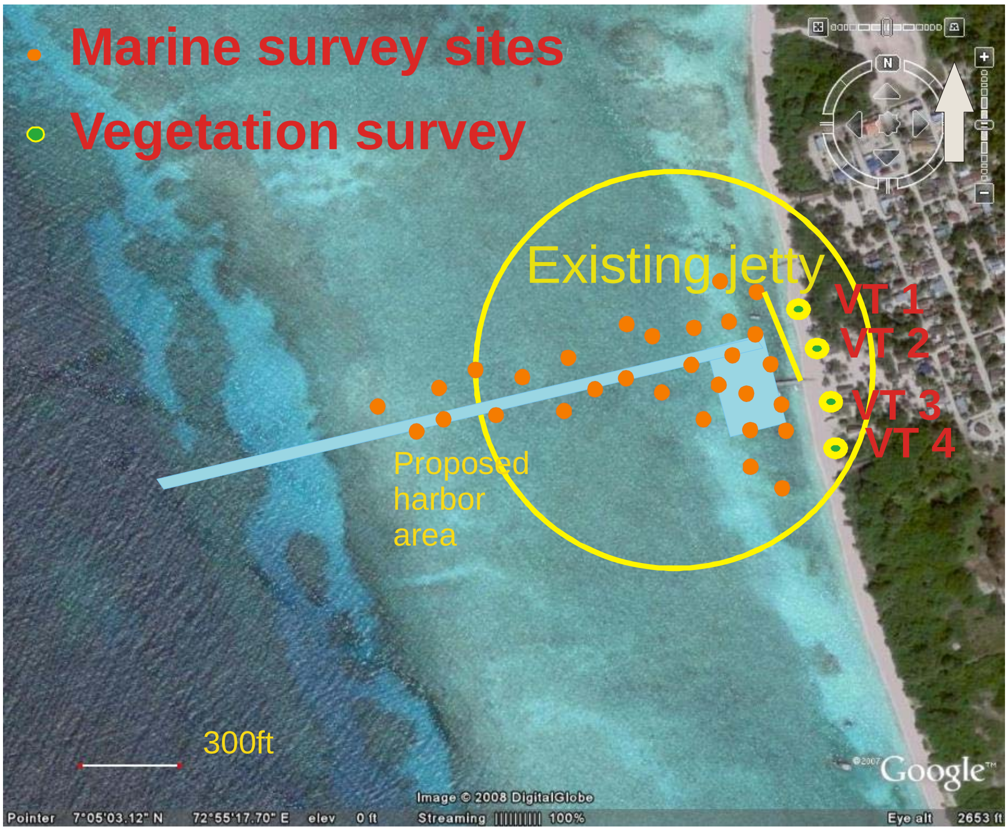

Figure 2: Proposed harbor area and survey sites. Green dots represent the vegetation survey area. The orange dots represent the quadrats (marine survey spots).

Figure 3: Project boundaries with possible direct and indirect impact areas. Dark red color represents direct impacts while the lighter color represents indirect impacts

There will be a loss of coastal vegetation near the harbor area to pave the way for harbor utilization. It is worth noting that a large portion of this land is thinly vegetated with some *kaani* and *hirundhu* trees facing the beach (Figure 2). These large trees will not be cut; instead they will be cropped to make the harbor utilization easy (see Figure 4). The back filling of the dredged spoil will be on the sides of the harbor and the eroding areas around the island.

Figure 4: Large trees are retained at the harbor area in many islands. Left R. Rasgetheemu; Right R. Hulhudhuffaaru.

4.6 Project inputs and outputs

Major inputs of the project included:

- construction materials – cement, rock boulders, rock aggregates, river sand, iron bars, timber, wood-flakes etc
- machinery and equipments – excavators, dump trucks, lorries, barges, concrete mixers
- workforce – locals and expatriates

Major outputs of the project will be:

- The harbor and the entrance channel
- quay walls
- breakwaters
- dredge spoil and
- solid waste

4.7 Project risks and impacts

Potential risks associated with the project are damage to the marine environment due to sedimentation by excavation and clearance works. Chronic impacts such as this could be cumulative and long term.

Coastal modification involved with this project may have considerable impacts on the littoral movement of the island. At present no net beach erosion is observed.

Death and damage to live coral is inevitable in this harbor construction project. Impacts involved are sedimentation and smothering of live coral that are near the dredging areas.

Disposal of dredge materials would have a positive impact by creating more land around the harbor area and stabilizing the beach if dumped into an eroding area. The impact of spoil disposal will be minimal since the dredged spoil disposal sites are almost dead reef-flat areas.

Positive socioeconomic impacts are envisaged by the proposed project. The construction of the harbor will enable the islanders to interact with other islands in terms of economic and social aspects.

5 Existing environment

5.1 Physical environment

Haa Alif Atoll consists of two geographic atolls – the Ihavandhippolhu and the northern most part of Bodu Thiladhunmathi. There are very large islands and reefs in this atoll. The island of Uligamu lies in the north-eastern tip of Ihavandhippolhu. The geographical coordinates of Uligamu are 72° 55' 40" E and 07° 05' 00" N. there are channels on both northern and southern side of the island. The reef-flat on the western side of the island is very wide.

This is an inhabited island with a population of 453 people (MOAD). The island has a length of approximately 2500m and a width of 800m. The total land area of the island, i.e. area within the vegetation line 112.68 hectares (MOAD online). The lagoon surrounding the island is 0.5 to 1.7m depth at mean sea level (MSL).

5.2 Climatology

The Indian Ocean Monsoons govern the climatology of the Maldives hence monsoonal reversal plays a significant role in weather patterns. Two very distinct monsoon are observed: the Northeast (*Iruvai*) and the Southwest (*Hulhangu*) monsoon. Monsoons can be best characterized by direction of wind and the amount of rainfall. The southwest (SW) monsoon is the rainy season which lasts from May to September and the northeast (NE) monsoon is the dry season that occurs from December to February. The transition period of SW monsoon occurs from March and April while that of NE monsoon occurs from October to November. The figure below represents mean daily wind speeds and direction for H.Dh. Hanimaadhoo. As can be seen from the diagram the prevailing wind is from north-west for the majority of the year (Figure 5).

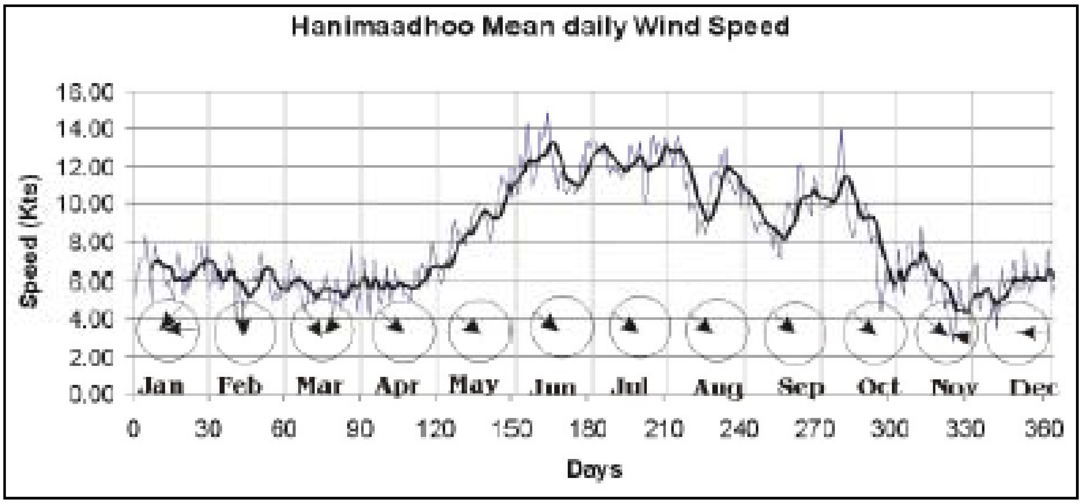

Figure 5: Mean daily wind speed and direction for Hanimaadhoo. Arrows indicate dominant wind direction (Naseer, 2003).

Generally the SW monsoon generates westerly winds and the seas are rougher than the NE monsoon. The NE monsoon in the Maldives is marked by east to northeast winds (Woodroffe 1992) which are generally lighter except during the *Iruvai halha* during which the winds is rather strong with high waves.

Localized climate data for the Island of Uligamu does not exist. Therefore, available data on HDh. Hanimaadhoo, and K. Male' is used here since the proximity of these regions will enable it to make good estimate for Uligamu (see Figure 6).

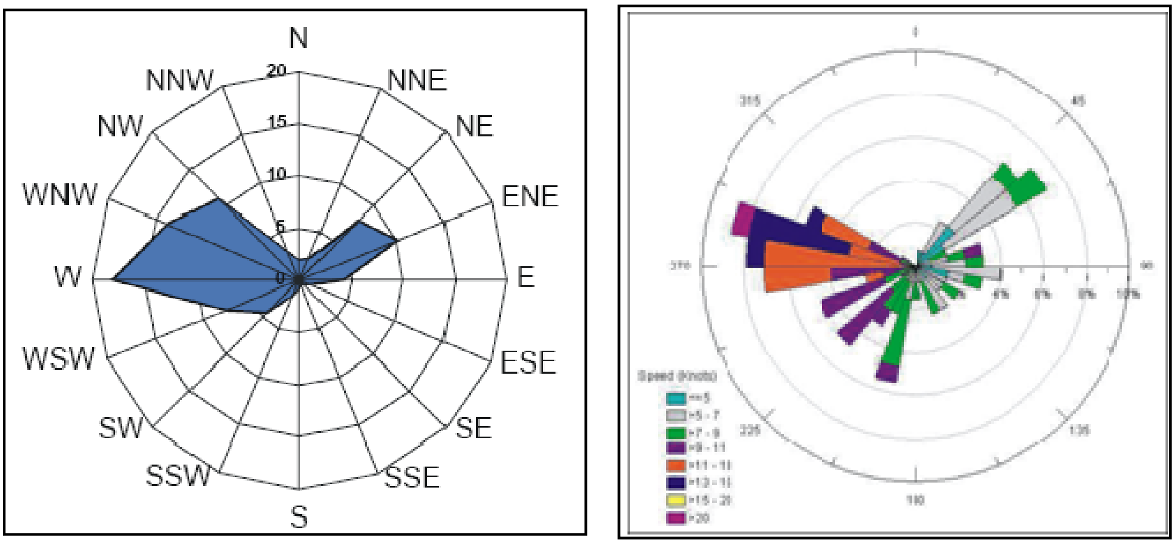

Figure 6: Right: general wind rose for the Maldives (Environment 2005) and left monthly average wind for HDh. Hanimaadhoo (DoM).

General wind characteristics for the Maldives and H.Dh. Hanimaadhoo shows that frequency of wind coming directly from the west is relatively high and the speed is high too. However, Uligamu gets shelter from SW monsoon's rough seas due to the presence of an extensive reef-flat on the western side. This suggests that the location of the Uligamu harbor is appropriate since the inner harbour will be calmer most part of the year. However, occasionally there will be strong winds coming from

SW during the SW monsoon. During such occasions the mouth of he entrance channel may get large wind waves.

5.3 Tides and currents

Maldives experiences mixed semi-diurnal and diurnal tides with a strong diurnal inequality. Tide records at K. Hulhule, and HDh. Hanimaadhoo which can be applied for estimating tide levels at Uligamu with reasonable accuracy, shows that, the maximum tidal range to be about 1.20m (see Figure 7). The highest astronomical tide level is +0.64m (Mean Sea Level) and the lowest astronomical tide level is -0.56m (MSL).

In the Maldives tides have significant influence on the formation, development, and sediment movement process (coastal processes) around the islands. Tides also play an important role in lagoon and reef-flat water circulation.

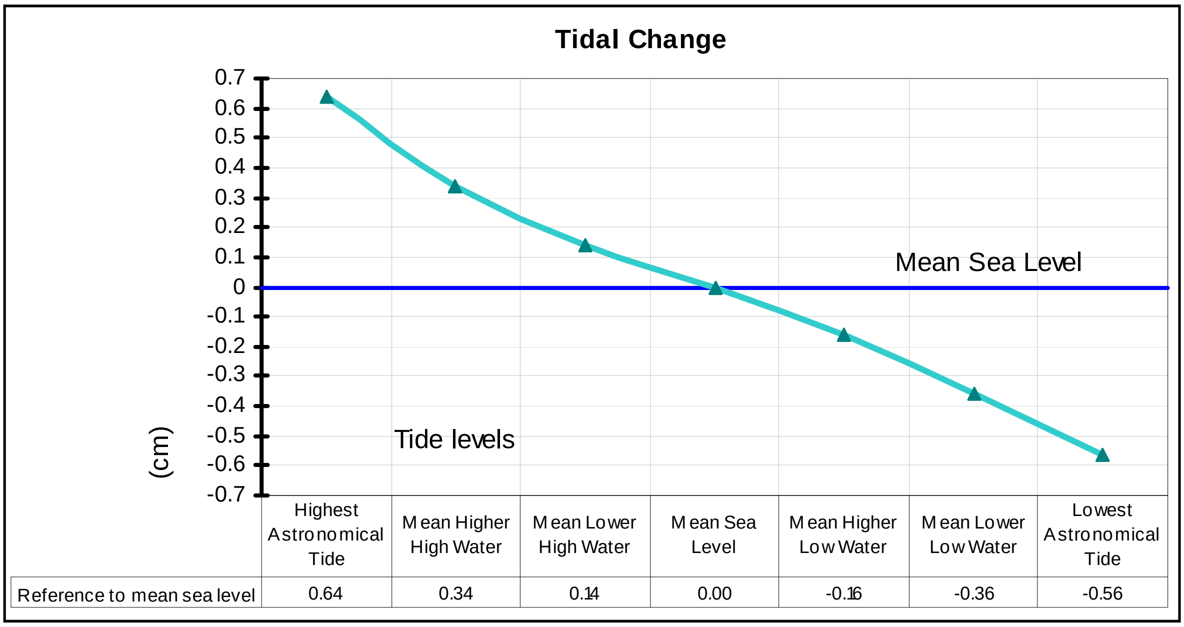

Figure 7: Astronomical tidal variation in Maldives, (Environment Maldives SoE Maldives 2002)

The currents on the reef-flat and near the reef edge changes direction daily with the ebb and flood tides. During the ebb tide the direction of current near at the harbor area is from west to east. When at flood tide the vise versa is seen. At flood tides the atoll basin is flushed with fresh oceanic waters.

During the low tide a large portion of the reef-flat is exposed to air in Uligamu. The water level during the mean tide at the proposed harbor area is between 0.5 to 1m at (MSL). In many cases dead coral heads are exposed to air at low tide

5.4 Waves

The coastal dynamics such as accretion and erosion of islands depends on wave energy. The type of beach and the beach materials also depends largely on the strength of wave energy. Uligamu is exposed to waves generated by swells on the north-eastern and eastern side of the Island. On the south-western side, short wind generated waves from the atoll lagoon are felt (Figure 8).

5.5 Sediment transportation

The beach and nearshore environments of Maldivian islands are composed of coralline and skeletal remnants derived from the reef. The sediments in this environment are mostly coral fragments, calcareous algae and foraminiferans. It has been determined that the major forces which produce sediment on the reefs, are storm waves and waves driven by monsoon winds Figure 8.

Tides and wave driven currents play a very important role in the transport of sediment around the islands. The sediment movement around Uligamu was crudely presented in the Figure 8.

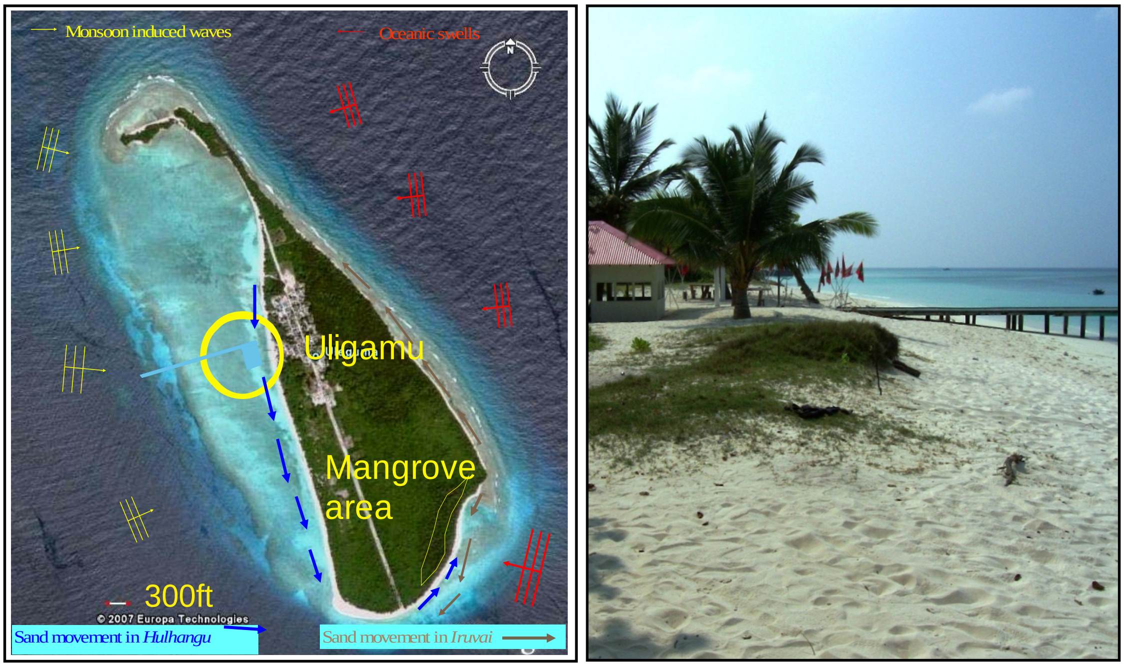

Figure 8: Wave and sand movement around Uligamu during the two monsoons (left). Fine grained sand at the proposed harbor area (right).

5.6 The beach environment

Beach is normally defined as the white sandy area between the vegetation line and the lowest astronomical tide. Width of the beach varies with the tidal fluctuations. The beach has a narrow width along much of the length of the north-east coast of Uligamu (see Figure 9). The west coast beach is relatively wider. A very large sand pit (*thundi*) was on the southern tip of the island.

Figure 9: Beach widths of Uligamu (left). Wider beach was found at the southern side of harbor (right)

The island's shoreline is mainly made up of a sandy beach. Existing beach at the proposed harbor also consisted of fine grained sand derived from biogenic substances. Observations of the beach during the survey showed that the western and southern side beach was much wider than the beach facing the other sides of the island. A rather narrow strip of beach was seen at the north-eastern and eastern side. One large sand spit (*thundi*) was there on the southern tip of the Island. This sand spit would be experiencing higher waves generated during the stormy SW monsoon, hence is likely to under go seasonal variations. No sign of net erosion at the proposed harbour area's beach was seen during the field visit.

In Uligamu, beach sediment movement is mostly from western to southern side in SW monsoon and from north-eastern to western side (through the southern side) during NE monsoon. Most of the sediment movement is seen on the southern and western part of the Island. In general beach around the island is quite stable.

5.7 Coastal vegetation

The coastal vegetation of the harbour area is characterised by typical island coastal vegetation consisting of *kaani, hirundhu, boashi, ruvaa, mirihi* and *magoo*. Dominant species at the harbor area were *hirundhu and boashi*. There was no so called *heylhi* in the proposed development area.

The results of the 2 transects (VT 1 and VT 2) carried out at the northern side of the harbour reveals that 18% of the beach vegetation cover was *hirundhu*. Other species encountered included *kaani* and *boashi*. About 60% of the surveyed area was observed to be bare since the *heylhi* have been cleared off (see Figure 10).

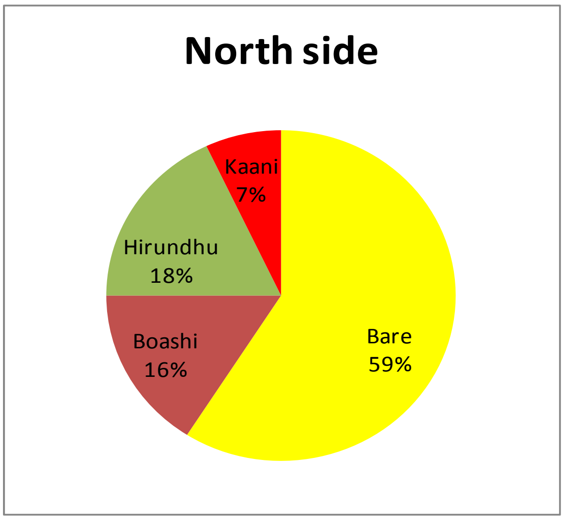

Figure 10: Coastal vegetation at northern side of the proposed harbor area (left), dominant vegetation was *hirundhu* at the site (right).

The vegetation cover at the southern side of the harbour (VT 3 and VT 4) shows that that 11% of the beach vegetation cover was *kaani* - the dominant. Other species encountered were *ruvaa*, *mirihi* and *magoo* (see Figure 11). About 80% was observed to be bare with no vegetation. This bare area corresponds existing jetty area and boat hauling area where the vegetation has been cleared.

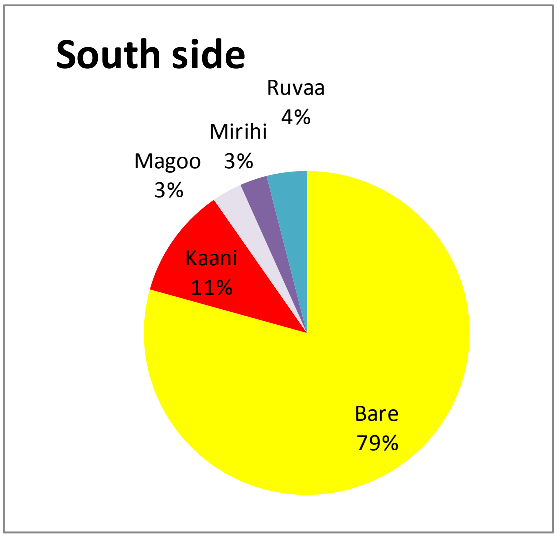

Figure 11: Coastal vegetation at southern side of the proposed harbor area (left), the area close to the jetty and boat hauling area has been cleared (right).

No inland vegetation transects were conducted since most of the under-growth and other short shrubs have been cleared here.

It is worth mentioning that the there was a strip of mangrove on the eastern side of the island. Species such as *kandoo* and *randoo* were present there. The proposed project will have no impact on the mangrove communities of the island.

5.8 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, and the fish communities. The findings of the surveys were used for impact evaluation and mitigation during the proposed development. The surveys used here are easily replicable and involves in-expansive techniques. Theses surveys could 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.

The marine environment around Uligamu is being somewhat modified since the blasting and clearance of entrance channels around the Island. These modifications may have changed the hydrodynamic flow patterns. The environmental impacts of these coastal modifications are not known since there was no systematic monitoring of the effects of these coastal modifications in the Maldives (Kench et al. 2006).

5.8.1 Coral reef system

The reef-flat around the proposed harbor area is not very poorly developed with about 1% live coral cover (see Figure 12). The bottom of the reef-flat was dominated by sand. Thinly grown seagrass were present at the area. The reef slope at this side forms a steep slope to the atoll basin. The reef condition here was better than the reef-flat in terms of coral cove, fish and other marine life.

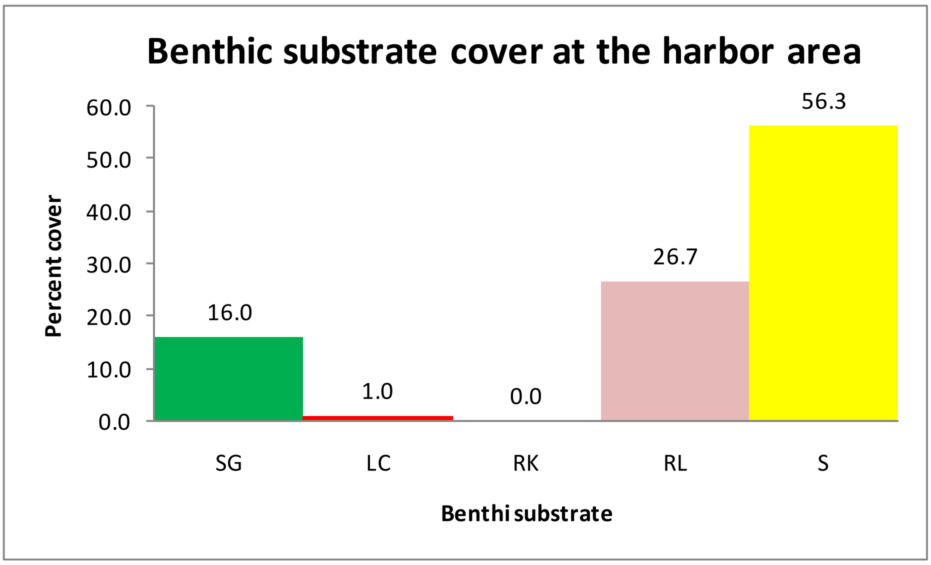

Figure 12: Percentage cover of benthic substrate present at the proposed harbor site's reef-flat. The dominant form of benthic cover is coral rubble. Massive forms of *Porites* spp. predominates the live benthic cover. Branching type corals namely *Acropora* spp. (staghorn), other massive types *Favites* spp., *Favia* sp. and encrusting types were also present. The benthic covers are given in percentages of the bottom area surveyed. SG = Seagrass, LC = live coral, RK = rock, RL = rubble, and S = sand.

The coral reef system of Uligamu is apparently not recovering (after 1998 bleaching event) in terms of diversity and percentage live coral cover. Quite a few colonies of live corals were seen at the reef slope as well as on the reef-flat around the harbor area. Species richness and diversity of corals and fish were low at the reef-flat. The diversity and abundance of life forms were higher at the reef edge.

Based on the survey data of the harbor area, coral rubble and sand was found to be over 83%. The photographs below (Figure 13) provide an idea of benthic cover present at the harbor basin area.

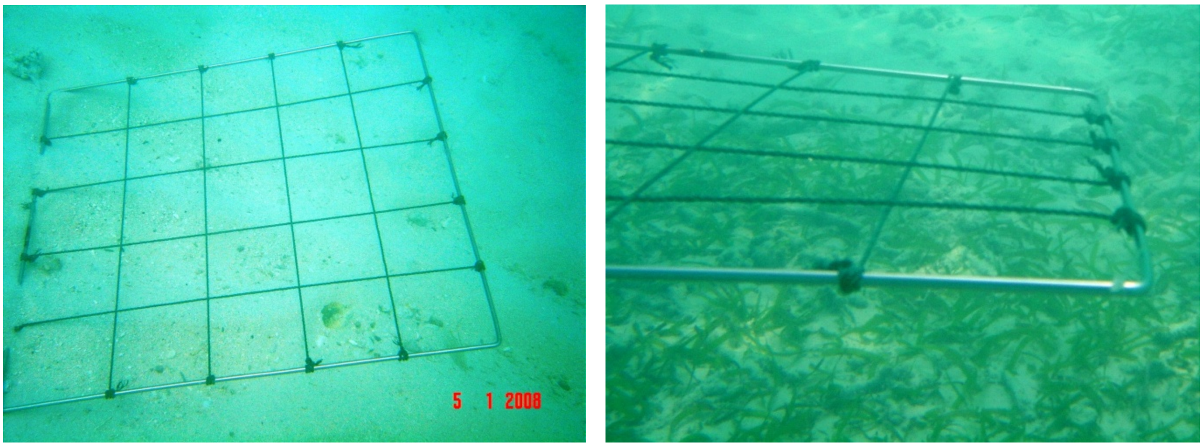

Figure 13: Benthic substrates observed at the harbor basin. Sand (left); Seagrass and rubble mixed with sand (right).

The live coral cover was higher at the reef edge and near the mid of the entrance channel. Seagrass cover was lower here. Fine sand dominated here too (Figure 14).

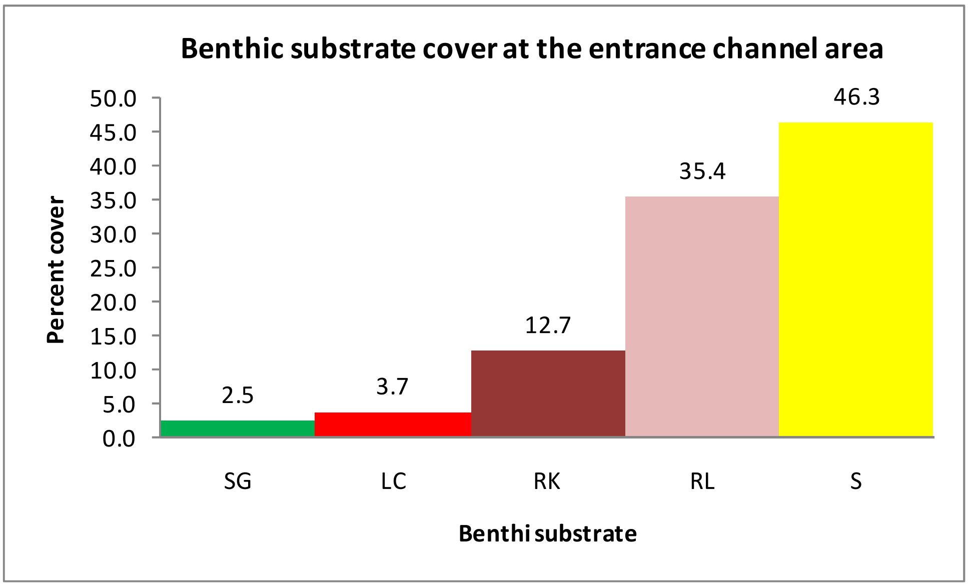

Figure 14: **Percentage cover of benthic substrate at the proposed channel area. Codes have been explained in Figure 12.**

More hard substrate is seen here. The fish life is also richer here. The depth remained rather similar with 1 to 1.5m at MSL. The benthic substrate at the entrance channel area is presented below (Figure 15).

Figure 15: Benthic cover at entrance channel area. Branching Porites (left); Rock and rubble (right).

5.8.2 Assessment of fish communities in the surveyed area

The result of 15 minutes swim for fish count along the harbor area revealed that the abundance and diversity of fish as very low. This may be due to the lower level of live coral cover. Since most of the area was covered with coral rubble, sand and seagrass, fishes associated with this type of environment were encountered. The dominant fish taxa observed in the surveyed area included grazers like surgeon fishes, wrasses and parrotfishes (see Table 1).

Table 1: Results of the fish encounter survey at the harbor area

Family	Species	Count
Acanthuridae	*Acanthurus leucosternon*	4
Acanthuridae	*Acanthurus lineatus*	5
Acanthuridae	*Acanthurus triostegus*	6
Acanthuridae	*Ctenochaetus* sp.	3
Balistidae	*Rhinecanthus aculeatus*	1
Chaetodontidae	*Chaetodon auriga*	2
Mullidae	*Parupaneus* sp.	4
Labridae	*Labroides dimidiatus*	5
Labridae	*Helichoeres hortulanus*	2
Labridae	*Helichoeres scapularis*	4
Labridae	*Thalassoma hardwicke*	3
Lethrinidae	*Lethrinus harak*	2
Pomacentridae	*Dascyllus aruanus*	3
Pomacentridae	*Chromis viridis*	5
Scaridae	*Scarus* sp.	4

5.8.3 Reef invertebrates

Three species of echinoderms were encountered. Due to the nocturnal nature of mollusks, they were not encountered during the survey. What is observed during the timed swims are:

- Common star fish
- Diadema urchin and
- Sea cucumber.

5.8.4 Reef aesthetics

This was determined by timed-swim (15 minutes) surveys conducted at the reef areas around the proposed development area. Reef aesthetic is a very subjective attribute. The out come of this depends on how the observer considers the health of the reef. Experience is very important when conducting reef aesthetic surveys. The parameters looked for included live coral cover, diversity of coral life forms, fish population distribution, reef rugosity, habitat diversity and general appeal. The following table shows the results of the reef aesthetic surveys.

Table 2: Summary of reef aesthetics

Reef attributes	Comments
General aesthetics	Low
Live hard coral cover	Low
Rugosity	V. Low
Recruitment of corals	Low
Coral bleaching	None
Coral diseases	None
Herbivory	Low
Fish life	Simple
Physical damage	Low

6 Predicting the environmental impacts and mitigation measures

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

The four components of the environment that will be impacted are identified as the beach, coastal vegetation, coral reef benthos and reef-flat waters, and associated nektons. Quantitative assessment of potential direct and indirect impacts due to the proposed project was based on area calculation of the affected area.

6.1 Impacts on the environment from the proposed harbor project

Harbor dredging projects have both construction and operational impacts on the coastal environment. These impacts may be either short term reversible or long term irreversible damage or alterations. 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 damage to the environment which may be reversible on the long run.
- Moderate: Impacts are significant, may cause long term environmental concerns but are likely to be short termed, acceptable and justifiable
- Major: long term impact, large scale environmental alterations

Potential environmental impacts predicted for this project will be the damage during construction and irreversible modification of environment as a result of excavation and vegetation clearance. These impacts are presented together with mitigation measures in the Table 4.

Dredging and excavation work 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 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 shore-line and near the entrance channel. There is also a moderate impact on the benthic and nektonic communities that inhabit in the possible impact zone.

Indirect impacts will be felt to the adjacent coastal vegetation, pelagic organisms inhabiting the reef-flat, lagoon and coral reef areas close to the development locality.

6.2 Impacts on disposal sites due to dredged materials

The dredged material disposal sites of Uligamu will be on both sides of the harbor (see Figure 3). Additional materials, if present will be dumped in to the eroding areas of the island. The observations conducted revealed that the disposal sites are almost devoid from life; hence there will be no major impact on the biotic environment. The long term changes in the coastal hydrodynamics are unclear. However it is evident that the filling of these areas will have some impacts on the coastal processes of the Island.

6.3 Mobilization impacts

The transport and supply of construction material, the excavators and other heavy 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.

6.4 Impacts from construction materials and other waste

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

During the construction of the quay-walls, leaching of cement will have short term minor impact on the immediate area. Once the cement is hardened, re-colonization of marine fauna and flora will take place.

6.5 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 currents will aid in the dispersal and removal of fine suspended materials. Growth and recruitment of live corals may have moderate short term negative 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. This work includes a lot of manual transport of materials, trampling and breakage of live coral is possible at the seaward side of the harbor basin and the sides of the entrance channel.

Vegetation clearance and site-hardening is un-avoidable in harbor construction projects due to the use of large and heavy vehicles.

6.6 Impacts of built coastal structures

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

- Change in near-shore hydrodynamics (see Figure 16).
- 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.

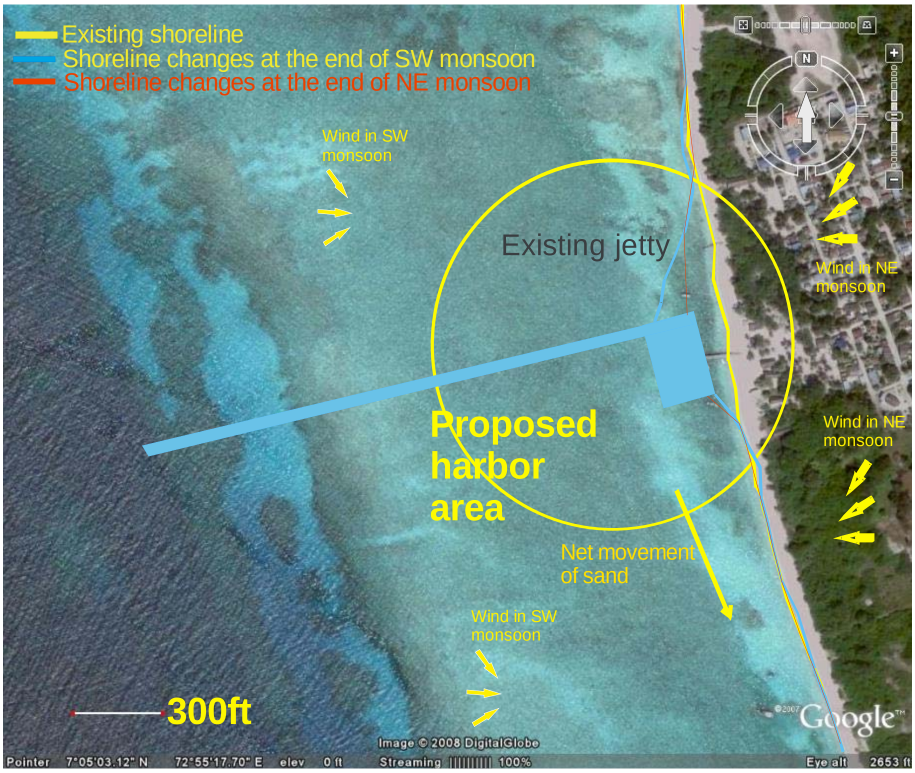

Figure 16: Possible alteration of shoreline as a result of harbor construction

6.7 Impacts due to harbor operation

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

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

6.8 Significance of the impacts

Impacts that may arise from activities of the proposed harbor project were categorized into the characteristics mentioned in the Table 3.

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 Table 2 shows the main impacts that would arise from the proposed project activities and their significance based on impact characteristics.

Magnitude of impact is calculated in relation to the total area. Direct geographic range of impact felt will be the immediate proposed development area and indirect impacts on the environment will be felt on a larger area due spreading of fine sediment and vegetation clearance of adjacent areas. Duration of the impact is predicted in terms of severity of impacts. The impacts are likely to be felt on an estimated 20% of the reef-flat and less than 10% of the coastal vegetation.

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

Table 3: Significant impacts of the proposed harbor project

Impact characteristics	Dredging	Dredged spoil discharge	Vegetation clearance
Nature of impacts	Cumulative	Cumulative	Cumulative
Magnitude of impacts	Moderate - negative	Moderate - negative on coastal ecosystems. Major +ve on socioeconomic aspects – sand for various purposes	Moderate - negative
Geographical range and environmental attributes	Direct impact on 14000m^2 of reef-flat and lagoon Direct impact on coral reef on 4000m^2 Indirect impact on 20000m^2 of reef-flat	5000m^2 - Direct impact on reef-flat Negligible impact on coral reef 8000m^{2-} indirect impact	Direct impact on 6000m^2 of coastal vegetation In direct impact on 4,000m^2 of coastal vegetation
Duration of impacts	Short term on coral reef and long term on reef-flat and beach	Long term	Long term
Reversibility of impacts	Permanent alteration of physical and biological system of the harbor basin, Short term reversible impacts on coral reefs, and reef-flat adjacent to the harbor basin	irreversible	Permanent alteration of coastal vegetation around the harbor area, Impacts can be reversible.
Significance of the impacts	Major impacts on the harbor basin, shore-line and beach. Minor impacts on the adjacent areas of reef-flat and other environmental attributes	Moderate impact on the reef-flat benthos,	Moderate impact on the coastal vegetation

6.9 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 Uligamu can be mitigated by joint cooperation and careful environmental planning. All parties, the Island authorities, the implementing agency 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 government staff with experience in same or similar work in the local environment will be consulted and allowed to inspect and monitor the work activities of the project life-cycle. 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 dredging 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 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 environmental degradation.

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

The Table 4 below provides more information on potential impacts during construction and operation of the harbor project and mitigation measures (LaMer 2006).

Table 4: Potential impacts during construction and operation of the harbor project and mitigation measures to minimize the impacts

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Littering on environment	Avoided by proper planning in transportation and waste disposal. Use 3R (reduce, re-use, recycle). Proper garbage disposal	Reef-flat, and land	During construction	Minor to moderate, short term -ve impact. Reversible	Contractor, Island authorities	N/A
Alteration to localized hydrodynamic regime	Maintaining water exchange through the protection walls	Reef slope, reef-flat, beach	During construction	Moderate, long term, likely irreversible	Contractor, MCPI	N/A
Damage to reef by Loading/unloading works	Raising awareness and utilizing environmental best practice, careful planning	Reef-flat and reef slope	During construction	Minor, short term –ve impact. Reversible over long run	Contractor, MCPI	N/A
Sedimentation and siltation on the reef and lagoon due to excavation works	Creation of a sandy bed to reduce the sedimentation impact, this bed would reduce sediment from spreading; work to be carried out in low tides.	Reef-flat and reef slope	During construction	Moderate, short term –ve impact. Reversible over long run	Contractor, Island authorities	N/A
Loss of habitat, damage or death of Coral at harbor basin and protection wall area	Clearly marking the areas to be excavated.	Reef-flat,	During construction	Minor, long term –ve impact. Most likely irreversible	Contractor	N/A
Habitat modification at the spoil disposal site and loss of **coastal vegetation** around the harbor area	The material will be disposed at the sites where there was virtually no life. Trees will be cut only in unavoidable circumstances. Once the harbor is complete, new trees will be planted.	Land, coastal area	During construction and Operational phase	Minor –ve impact Positive impacts due to availability of sand for multiple purposes. +ve impacts once the new trees grow. Reversible	Contractor, Island authorities	N/A

Potential impacts	Mitigation measures	Impact locality	Development phase	Intensity and reversibility	Responsible authority	Projected cost (MRf)
Impacts of storm-water drainage and coastal flooding.	The dredge spoil will be disposed at both sides of the harbor. The reclaimed area will not be higher in elevation than the existing level of the Island.	Coastal area	During construction and Operational phase	Minor, impacts not fully clear. Most likely no change.	Contractor, Island authorities	N/A
Impact of dredging works on the existing operations of the lagoon	Dredging will be carried in a low tide; hence the activity will be less.	Reef-flat, lagoon	During construction	Minor, –ve impacts on the use of the lagoon, Reversible	Contractor, Island authorities	N/A
Air pollution	Completing the excavation works as soon as possible.	Air	During construction	Negligible, 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, long term and unpredictable –ve impact. Most likely irreversible	Contractor, Island authorities	Cost is difficult to estimate since the timing of impact unpredictable
Solid waste	Employee a staff for monitoring and cleaning the harbor	Harbor area	Operational phase	Minor, long term –ve impact Reversible	Contractor	monthly salary equivalent to 2000.00
Accidental spillage	Put up sign boards	Harbor area	Operational phase	Minor, short term –ve impact Reversible	Island authorities	1000.00 - 1500.00

6.10 Uncertainties in impacts identification

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

7 Project alternatives

7.1 Locations

The current project location (MCPI Design 1) was agreed by the Island Harbor Committee with the consultation of the island community and the Island Office. No other alternative location was proposed by either MCPI or Island authorities. There seemed to be no other best location to place the harbor at this island.

7.2 Construction method

The method used for deepening the proposed harbor using excavator, will have significant impacts on the environment. One alternative to employ a cutter-suction dredger which reduces the amount of silt suspended in the water column. It will also eliminate the need for blasting hard substrate if encountered. However, the use of cutter-suction dredger for the small scale dredging project is not economical due to the high costs of mobilization and operation. Given the financial constraints this technology could not be used for this project.

A single sandy bed will be used to reduce environmental impacts of suspended sediments. An alternative to this is the use of geo-textile curtains. Given the strong tidal flushing of Maldivian waters the use of such barriers becomes un-necessary with respect to the expenses it incurs. Therefore, the construction methods for this project seemed to be cost effective with minimal environmental impacts.

7.3 Constructing jetties

Instead of dredging a harbor jetties could also be built to facilitate access to islands. This could have less environmental impacts if properly built. Jetties if built on pillars will do very little to alter hydrodynamic flow, thus reducing erosion/accretion problems. For the case of Uligamu, building a jetty will not suffice considering the level of exposure of the island to the monsoonal rough weather. Building a jetty will not solve grave difficulty that the boat owners face due to the lack of a safe anchorage. Maintaining jetties has also proven to be rather costly. Therefore building a harbor – however small - will be more beneficial since it can serve both as a safe access and a safe anchorage.

7.4 The no project scenario

If "no project scenario" was considered, environmental impacts associated with the project could be avoided completely. Consider this option is not worthwhile since the reef system and the coastal areas (beach and vegetation) have no significant features that could be labeled as significant environmental assets.

The "no project scenario" can also be ruled out since the current policy of the government is to provide a safe and sound access to all communities. A safe access is vital for the well being and socioeconomic development of an island.

8 Environmental monitoring

Proper environmental monitoring is essential to ensure that potential impacts are minimized and unanticipated impacts are mitigated. The parameters that are most relevant for monitoring the impacts that may arise from the proposed harbor project include turbidity and nutrient, sedimentation, beach profile, coastal vegetation cover and live coral cover and nektonic fauna. However, given the scope of this project and budgetary deficiencies, monitoring work will be limited. Nevertheless it is important to note that all necessary measures and precautionary action will be taken to mitigate and minimize negative environmental impacts. The Table 5 below summarizes the aspects of monitoring program. The monitoring team will consist experienced staff from the MCPI and MEEW.

A 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 (see Table 5).

Table 5: Aspects of the monitoring program

Monitoring Attribute	Indicator	Methodology	Monitoring Frequency	Estimated Cost (if out sourced
Coral and other benthic cover	Percent cover	Quadrat	Once during the project and one year after the completion of the project	US$ 350 per survey
Diversity and abundance of fish communities	Number of fish present. Population structure	Visual fish census	Once during the project and one year after the completion of the project	US$ 350 per survey
Coastal vegetation	Percent cover	Line Intercept Transect	A year after the completion of the project	US$ 100 per survey
Seawater quality	DO and turbidity	Lab analysis	Once during the project and one year after the completion of the project	US$ 80 per test performed
Freshwater quality	Salinity and other important parameters	Lab analysis	Once during the project and one year after the completion of the project	US$ 80 per test performed
Beach profile	Beach dynamics	GPS tracks along the beach	Once during the project and one year after the completion of the project	US$ 100 per survey
Hydrodynamic s	Changes in the current movements	Drouge tracks	Once during the project and one year after the completion of the project	US$ 350 per survey

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10 Annex 1: Proposed harbor concept drawing