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Environmental Impact Assessment

Three Islands - K. Thulhusdhoo

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1 Introduction

1.1 Background

The aim of the Three Islands Project is to turn three islands in three different atolls into larger, safer community centres for the entire atoll in which they are located. This is achieved by building land reclamations at each of these islands, and protecting these reclamations (and the existing islands) with new revetments. This approach to increasing safety and enabling social and economic development is based on the Safer Island/Focus Island policy that was developed by the Government of the Maldives at the beginning of the 21st century, well before the tsunami of December 2004 struck.

The Government of the Maldives has selected the following islands to be developed in the Three Islands Project:

- Hinnavaru in Lhaviyani atoll
- Thulhaadhoo in Baa Atoll
- Thulhusdhoo in Kaafu Atoll

The execution of the Three Islands Project will be under the responsibility of the Ministry of Housing, Transport and Environment (MHTE), which will therefore act as the Project Proponent.

The Three Islands Project as a whole will involve the placement of approximately 3 million cubic meters of sand, which will more or less be evenly distributed over the reclamation areas of the three islands. Approximately 5500m of revetments will be constructed, and at Thulhaadhoo and Thulhusdhoo a new quay wall will be constructed in the existing harbour.
The total cost for the Three Island Project is approximately 34 million euros.

A separate EIA is done for each of the three selected islands in order to better emphasise the environmental and socio-economic impacts at each island and atoll. The islands are located at more than 150 km distance from each other, so no cumulative environmental effects are expected that need to be addressed in an EIA for the project as a whole.

1.2 Aim and scope of EIA

The present scope of the EIA is based on the EIA Regulations from the Ministry of Housing, Transport and Environment (EIA Regulations 2007, ref. 1), the IFC Performance Standards (ref. 2) and EHS Guidelines (ref. 3) and the guidelines prepared by the Dutch Commission for the EIA for two other, similar, projects in the Maldives (Vilufushi Island Reconstruction and Viligili Island Reconstruction, ref. 4, ref. 5), The EIA report covers both the natural and the social environment and includes the following main aspects(see also Appendix 1 for cross reference of IFC Performance Standards):

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

The focus of this EIA is on the construction phase of the project. The Three Islands Project is part of the National Environmental Action Plan III (ref. 6), which calls for the construction of coastal

protection around six Safe Islands, and fits well within goals set in the National Strategy for Sustainable Development (ref. 7)
The Safe Islands/Focus Islands program was conceived by the Government of the Maldives well before the tsunami struck the Maldives in 2004. The plan called for the development of larger islands, which would contain areas with higher elevation above sea level and would be protected from storm and tidal surges by modern coastal defences. This coastal defence would include a high bund along the ocean side of the island, paved with stone revetments on the outside, and an Ecological Protection Zone consisting of trees and shrubs just behind the bund on the island itself. The Safer Islands/Focus Islands program started out as a separate development plan, but has since been incorporated into the National Environmental Action Plan III, and the National Strategy for Sustainable Development.
The decision to develop the islands of Hinnavaru, Thulhaadhoo and Thulhusdhoo for the Three Islands Project was made within the framework of these programs.

1.3 Terms of Reference

The Terms of Reference (TOR) for this EIA were submitted to the Ministry of Housing, Transport and Environment on 8 December 2009. Formal approval was received on the same date during a scoping meeting with the Ministry of Housing, Transport and Environment, the Ministry of Fisheries, Ministry of Planning, and the Environment Portection Agency (EPA). In addition a separate meeting was held with the Ministry of Tourism.
The TOR follow the Environmental Impact Assessment Regulations 2007, as prepared by the Ministry of Environment, Energy and Water.The TOR also address requirements arising from the IFC Performance Standards on Social and Environmental Sustainability and the IFC Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals.
The complete Terms of Reference can be found in Appendix 2).

1.4 Experience of proponents with similar projects

In 2005-2006 and 2007-2008 the Government of the Maldives contracted Royal Boskalis Westminster to do the land reclamation works for Safer Islands Vilufushi (Thaa atoll) and Viligili (Gaafu Alifu atoll) respectively. Both projects had the same premise as the Three Islands Project: to create new and safer land adjacent to an existing island to create more space for population growth and economic and social development. The reclamations have a higher elevation above sea level than the existing island, and are protected on the ocean side with a revetment that can withstand severe storm and tidal surges. This so-called “Safer Island” concept is described in further detail in Chapter 3.

2 Problem Analysis and Justification of Project

2.1 General

In the Maldives, there are significant problems regarding the natural environment. The most important problems are caused by:

- sea level rise;
- extreme weather conditions;
- tsunamis;
- population pressure;
- lack of space for future development.

These problems with the natural environment lead to problems in economic development, living standards and well-being of the inhabitants.
In order to address these problems and ensure sustainable social and economic development, the Government of the Maldives has defined long and short term goals. The National Environmental Action Plan III contains the short term goals and plans to reach these goals. The National Strategy for Sustainable Development contains the long term goals to ensure a safe and healthy future for all Maldivians.

The tsunami of 26 December 2004 and the damages caused have created a further threat to the environment, but also an opportunity for appropriate action. In this chapter the relevant problems will be analysed and the need for the project and its general outline and dimensions will be discussed.

2.2 Problem analysis

2.2.1 Lack of space for future development

On most of the inhabited islands of the Maldives, every last square meter of space has been used for housing or public facilities. Most islands have some green areas, mostly strips of shrubbery along the shore of the island, and a few slightly larger areas of higher bushes and palm trees in the far corners of the island.
On most islands, there is no space left to build more houses to accommodate population growth, there is no space for small industrial development, improved fish market, fish drying and fish smoking facilities, or to build a waste management and sewage water treatment facilities or even expand power generation facilities to meet current, let alone future power demands.
On top of this, most islands are subject to erosion, which has reduced useable space even more.

2.2.2 Population pressure

Only part of the surface area of the Maldives is inhabited. Usually the population is concentrated on a limited number of rather densely populated islands, thereby providing a reasonable basis for social subsistence. Twenty atolls are populated ranging from 1,600 to 18,000 people (not including Malé). The entire population of the Maldives is scattered over 200 inhabited islands. By mid 2009, the population was calculated at 298,000, with about a quarter of the population concentrated in the capital. The population growth in the Maldives has recently been as high as 2 to 3%; in the outer atolls the majority of the population is below 20 years of age. These outer atolls experience a large outward migration predominantly to Malé.

Due to the significant population growth, on many of the islands there are no more empty lots available for development. This means that there is no place for additional people, for further communal and/or commercial activities, and for natural migration from smaller islands to the larger regional centres.

2.2.3 High costs of communal infrastructure and provisions

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

In a country with high GDP growth, and a society that is rapidly modernising, demand for better infrastructure and services will often grow at a much faster pace than GDP growth. This may result in migration to a larger island, often to Malé, which is already filled to capacity and can not provide livelihoods for newcomers.

2.2.4 Sea level rise

The Maldives are vulnerable to climate change and predicted sea level rise, due to the low elevation of the islands and therefore large impacts of even small rises in the sea level. During the past century the global temperature increased by about 0.6 degree. Climate modelling calculations predict that global mean surface temperature of the earth could rise by about 1 to 4.5 degrees by 2100 (see

Figure 2-1).

Due to the higher temperature many glaciers and ice caps are melting and the melting mass of water will cause a rise in sea levels. During the past century the average sea level increased by about 15 to 20 cm. The estimated predicted sea level rise in the period 1990 to 2100 is 0.1m to almost 1.0m (see Figure 2-2). This sea-level rise combined with more frequent extreme weather occurrences makes the Maldives one of the most vulnerable countries to climate change and sea level rise in the world. Due to the effects of future climate change and related sea level rise, it may be expected that the Maldives will face a number of impacts, being:

- increased coastal erosion;
- higher storm surge flooding;
- more extensive coastal inundation;
- changes in groundwater characteristics;
- increased flood risk and potential loss of life;
- loss of tourism and recreation.

Figure 2-1 - Global climate change

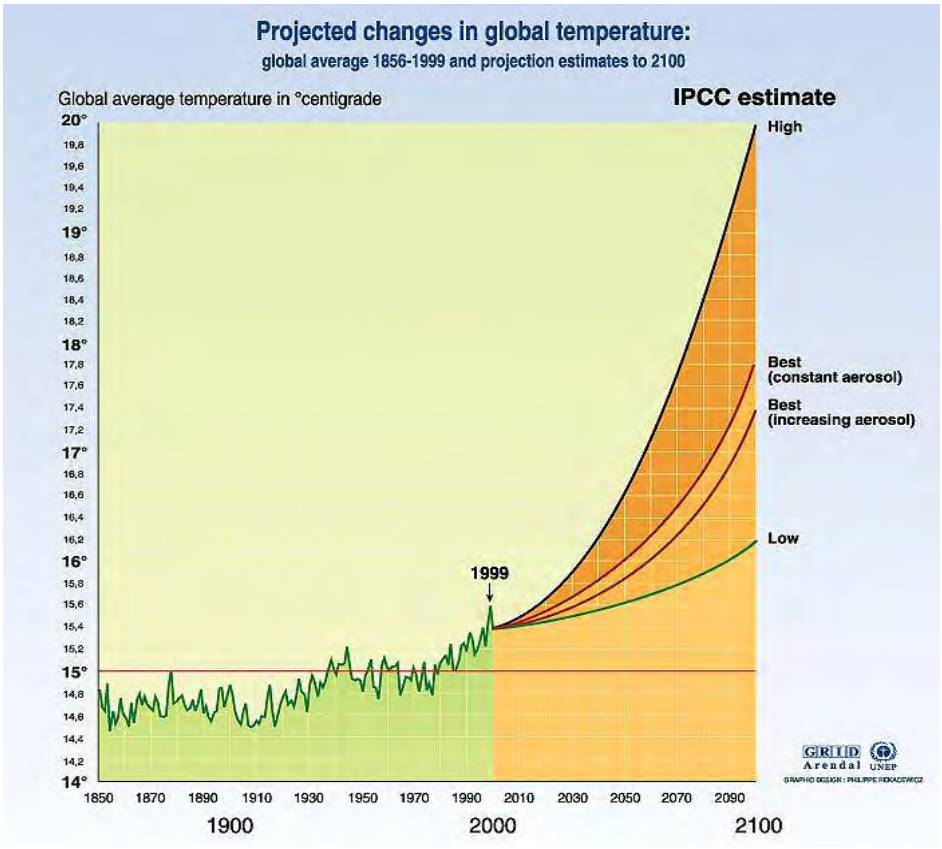
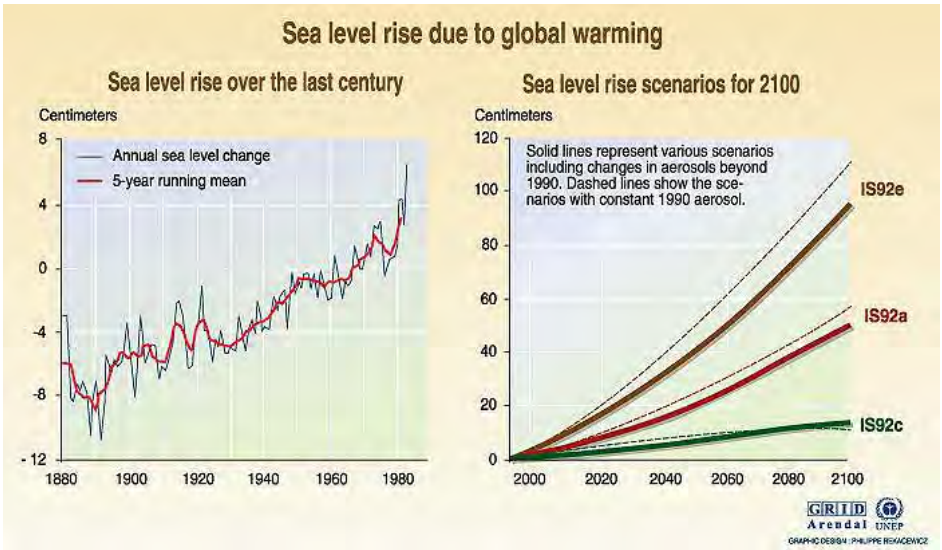


Figure 2-2 - Sea level rise



2.2.5 Extreme weather conditions

At the Maldives virtually no cyclones occur, but sometimes there are significant storm surges with up to one meter sea level rise. In April 1987 there was a storm surge at Malé, which resulted in unusually high waves. One third of Malé was inundated by about 60 cm of water, and Male' International Airport sustained damages worth US$ 4.5 million. Again in 1991 a storm surge occurred near Malé. Although the damage was minimal, the experience was a forceful reminder of how vulnerable the Maldives can be to even a small rise in water level. The initial response to

this threat was to start construction of a series of breakwaters on the outer coast of Malé, which protect the capital from damaging storm waves.

In the Maldives high waves and storm surges are considered natural hazards. Most of the atoll islands are very low and significant damages, including changes in groundwater characteristics, can occur.

A recent report by RMSI of India for the UNDP ("Developing a disaster risk profile for Maldives', November 2005) gives more information with respect to the extreme weather conditions and their consequences, including the tsunami hazard.
There is a low earthquake hazard for most of the Maldives; the three most southern atolls, have a medium earthquake hazard.

2.2.6 Tsunamis

The Maldives are highly dependent on the fragile ecosystem of the coral reefs, because energy of the high waves is dissipated and reduced by the reef crest (breaker zone). This protects the islands and their inhabitants from direct impact by the waves. The coral reefs also play a very important role the tourist industry, luring scuba-divers from all over the world for a unique diving experience.
The December 2004 tsunami has proven once again the extreme vulnerability of such small and low lying islands. It was reported that 35% of the country's 200 islands had been subject to high or very high impact by the December 2004 tsunami, with major physical damage to buildings, infrastructure, crops and natural vegetation. The tsunami-related environmental damage can be summarised in five main groups:

- Disaster waste: uprooted vegetation, re-distributed domestic and hazardous waste, drums, large amounts of demolition waste were spread over the impacted islands.
- Groundwater contamination: shallow freshwater aquifers were impacted by infiltrated flood water, oil spillages from generator stores and leaks from septic tanks.
- Coral reef damage: damage was caused by direct wave impact and secondary damage occurred from sedimentation and excessive amounts of debris.
- Coastal damage: extensive beach erosion and damage to coastal protection measures occurred.
- Beach, soil, vegetation and crop damage: extensive washing-off of soils, stress and dieback in certain species from direct impacts as well as possible salt contamination occurred.

The tsunami hazard in the Maldives comes mainly from the eastern direction; of the total of 85 tsunamis that hit the Maldives since 1816, 67 originated from the Sumatra Ocean. Especially islands along the eastern fringe of the eastern atolls are exposed to this hazard. The probable maximum tsunami wave height is estimated at between 4 and 5 meters. The return period of the 26 December 2004 tsunami is in the order of 200 years (ref 4, 5).

2.3 Justification of the project

2.3.1 Justification

There are two main objectives of the project,:

- increase the usable space on the island, allowing space for social and economic development,
- providing more safety against the sea for at least the next 50 years (storm events, sea-level rise),

The first justification of the present project is the increase in space for urban use to allow for population growth, migration from other smaller islands to the larger island, and new developments on the island, including those creating new employment. At present, all available space on the islands is used for housing, commercial and community facilities. In addition, the extension of the islands allows for space for extra social infrastructure such as schools, sport facilities and medical facilities and for a solid waste management area.

The second justification is that the tsunami disaster has again underlined the critical importance of providing environmental safe zones for isolated communities living on distant islands. For this and other reasons, the Government of the Maldives had already, prior to December 2004, developed the so-called 'Safe Islands Programme'. The main objective of the government's Safe Islands Programme includes:

- protection against storm events and the effects of sea-level rise;
- rebuilding and improving existing infrastructure and economic facilities;
- providing better services and more employment opportunities on 'larger' islands;
- ability to plan and implement effective measures to mitigate environmental hazards and for surviving disasters.

This will be achieved by providing ecologically safe zones including bunds, principally to mitigate the impact of storm surges and tidal swells.

Numerous studies, in particular related to various social and economic aspects and consequences of the Safer Islands policy, have been executed in the last 5 to 10 years, especially after the tsunami of 2004 (see ref. 4 and 5). It is therefore not surprising that the World Bank / ADB / UN program for post tsunami reconstruction and the EU tsunami indicative program, accept the linkage of island reconstruction with a certain number of safer and larger islands to be constructed.

There are a number of reasons/ criteria for the selection of the three islands as being the future focus island of their respective atoll:

- the present population is larger than average, which makes it economically sustainable to develop community services;
- there is already a wide range of services and amenities present on the islands;
- the islands already have a harbour;
- increasing the islands' sizes is possible without creating (large) erosion elsewhere;
- the reef area is large enough to allow winning of enough coral sand resulting in fairly low costs for enlargement of the island;

3 Project Setting

3.1 General

The Maldives are a democratic republic with a written constitution. The protection of the environment is a national priority in the Maldives and efforts have been made to incorporate environmental protection and preservation across all sectors. As such, environment is granted ministerial status (Ministry of Housing, Transport and Environment); in addition an Environment Protection Agency (EPA) and a high level National Commission for the Protection of the Environment (NCEP) have been set up.

3.2 Environmental legislation

The enforcement of EIA regulations in the country began with the formulation of the Environmental Protection and Preservation Act (Law 4/93) in April 1993 in order to protect, preserve and safeguard the fragile environment of the country. The Environmental Act or Law 4/93 is the single most important legal instrument with regards to environmental management. The main aim of the legislation 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.
It is currently being implemented by the Ministry of Housing, Transport and Environment. Under this act, regulations and guidelines have been developed concerning the environmental protection, especially regarding development activities, through implementation of EIA procedures.

Important national environmental legislations relevant to this study are, including the above-mentioned act no. 4/93:

- National Environmental Action Plan III (2008/2009);
- Environmental Protection and Preservation Act of the Maldives (law No 4/93);
- the law of Tourism (law No15/79);
- Environmental Impact Assessment Regulations (2007);
- regulations for coral mining (1992);
- Fishery Law of the Maldives (law No 5/87);
- National Biodiversity Strategy; project initiated late 1998;
- National Strategy for Sustainable Development (2009).

The Environmental Act also provides the basic framework for the Environmental Impact Assessment (EIA) process in the Maldives. Under article 5a of the act, an impact assessment study shall be submitted to the Ministry of Housing, Transport and Environment before implementing any project related to economic development that has potential environment implications. According to the EIA regulations, for example, all new resort developments require an EIA before approval for development can be issued. In an early stage of project-development a so-called IEE (Initial Environmental Examination) may be prepared. After the evaluation of this IEE, the Ministry of Housing, Transport and Environment, together with the project proponent will decide whether a full EIA study is still required.

3.3 National policies

In addition to the relevant environmental legislation, various National Policy Plans address the environment as well. The most important ones are:

- the Third National Environment Action Plan (NEAP III);
- the National Strategy for Sustainable Development, and;
- the Seventh National Development Plan.

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

The aim of NEAP III is to protect and preserve the country's environment and to properly manage natural resources for the sustainable development of the country. It also encompasses a framework for action for the future. The NEAP III identifies the environmental priorities and policy directions for the next five years and also addresses key issues and respective measures towards the betterment of the environment, which will benefit present and future generations. The NEAP III aims to achieve six results:

- Resilient Islands
- Rich Ecosystems
- Healthy Communities
- Safe Water
- Environmental Stewardship
- Carbon Neutral Nation

To achieve these six results, thirty 'Goals' have been formulated, addressing issues such as protection of human settlements, increasing resilience of the coral reef to climate change, improving waste and sewage management, providing safe drinking water, improved environmental education and awareness, environmental legislation and research. The development of Safe Islands is one of the goals listed under "Resilient Islands".

The seventh National Development Plan was developed in 2007 and also identifies important measures and the role the government will play in terms of developing and implementing sound environmental management strategies. The goals formulated for economic, spatial and social development are also incorporated in the NEAP III and the National Strategy for Sustainable Development, both of which were developed after the NDP7 was released.

3.4 Safe islands Program, Focus Islands

Already before the tsunami struck, the Ministry of Planning and National Development had disclosed its decision to develop safe islands in each of the 20 atolls under the "Safe Islands Program" (ref 4, 5). According to the minister, these safe islands, or focus islands, will have seawalls, a vegetation enclosure surrounding the island, high ground areas and drains to clear away floods should there be high waves. The present plan for construction of safe islands for the Three Islands Project is in line with this Safe Islands Program. The design includes a land level of 1.4 meter above sea level and a protecting bund wall of 2.4 meter above sea level at the islands vulnerable east side. At the inner part of the EPZ (Environment Protection Zone), which is on the outside of the island, palm trees will be planted.

3.5 International Context

The major global issue facing the Maldives is climate change, global warming and subsequent sea-level rise. The small size of the islands and their low elevation above MSL makes the islands susceptible to sea level rise. Consequently, the country plays a prominent role in fore fronting environmental issues faced by many other small-island developing states, mainly located in the Pacific regions of Polynesia and Micronesia. The Maldives is therefore, a party and signatory to various international conventions and declarations. These include:

- UN Framework Convention on Climate Change;
- Kyoto Protocol;
- UN Convention on Biological Diversity;
- Montreal Protocol on Substances that Deplete Ozone Layer;
- Basel Convention on Transboundary Movement of Hazardous Waste;
- UN Convention on Law of the Sea;
- Washington Declaration of Protection of the Marine Environment from Land-based Activities;
- UN Convention to Combat Desertification;
- Regional Agreement to Conserve Marine Turtles under the Convention on Migratory Species.

3.6 Responsible Ministries and Institutions in the Maldives

The main governmental institutions, involved in the construction of the Three Islands and the EIAs for this project, are described below.

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

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

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

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

In the case of tsunami-reconstruction projects also the two following ministries play an important role:

- the Ministry of Economic Development, which coordinates data gathering and specifies/proposes long term responses, and
- the Ministry of Finance and Treasury, which coordinates donor assistance and other financial resources for tsunami reconstruction.

In the wake of the tsunami-disaster, the then Ministry of Planning and Development set up the National Disaster Management Center (NMDC) which focuses on the reconstruction process, ensures that pre-tsunami risks are not automatically build in again and establishes guiding principles for reconstruction.

In the case of the Three Islands Project the Ministry of Housing, Transport and Environment will act as client (employer) for the construction contract execution, as project proponent, as Responsible Agency, and as Licensing Agency.

3.7 IEE or EIA

In case a proposed project may cause significant adverse impacts, an EIA study is required. Whether this is necessary is generally considered in an early project stage by developing a so-called IEE (Initial Environmental Examination).

For this project, Hydronamic bv of Papendrecht, the Netherlands has prepared the Initial Environmental Examinations (IEE's). The reports have been submitted to the competent authorities in the Maldives. One of the recommendations of this IEE is to execute a full scale EIA for the project. The IEE contains terms of reference (TOR) for such EIA which are fully in accordance with the demands of the relevant authorities in the Maldives in this respect; they are also very similar to the ToR prepared for a similar projects 'Reconstruction of Viligili island' and 'Post-tsunami reconstruction of Vilufushi island', as proposed in 2007 and 2005 respectively for those projects by the Netherlands Commission on Environmental Impact Assessment.

The full ToR (Terms of Reference) for the EIAs for the Three Islands Project were accepted and approved by the MTHE during the scoping meeting on 8 December 2009, which was organised by the EPA. The EIA scoping phase of the Three Islands Project can be considered as completed.

3.8 Owner's consent to the project

The reef surrounding the islands is owned by the Government of the Maldives and is not classified as private property. The Ministry of Housing, Transport and Environment is the project proponent on behalf of the Government of the Maldives. Since the areas that will be affected by the project are the property of the project proponent, no separate procedure to obtain formal consent for the project is followed.

4 General project description

The global construction design of the Three Islands and the main construction activities are described in this chapter. First, some general information about the project is given.
This section describes the general design outline of the Three Islands and the main construction activities. The following items are addressed:

- Design outline of Safer Islands
- Previously constructed Safer Islands
- Planning of the works
- Environmental constraints
- Dredging & reclamation method alternatives
- Revetment construction
- Quay wall construction
- Applied Environmental Management System
- Availability of utilities, resources etc.
- Promotion of sustainable development
- Employment opportunities
- Enhancement works

4.1 Safer Islands

4.1.1 Design outline

The Three Islands will be designed according to Safe Island principles. Important elements of the Safe Island Concept are

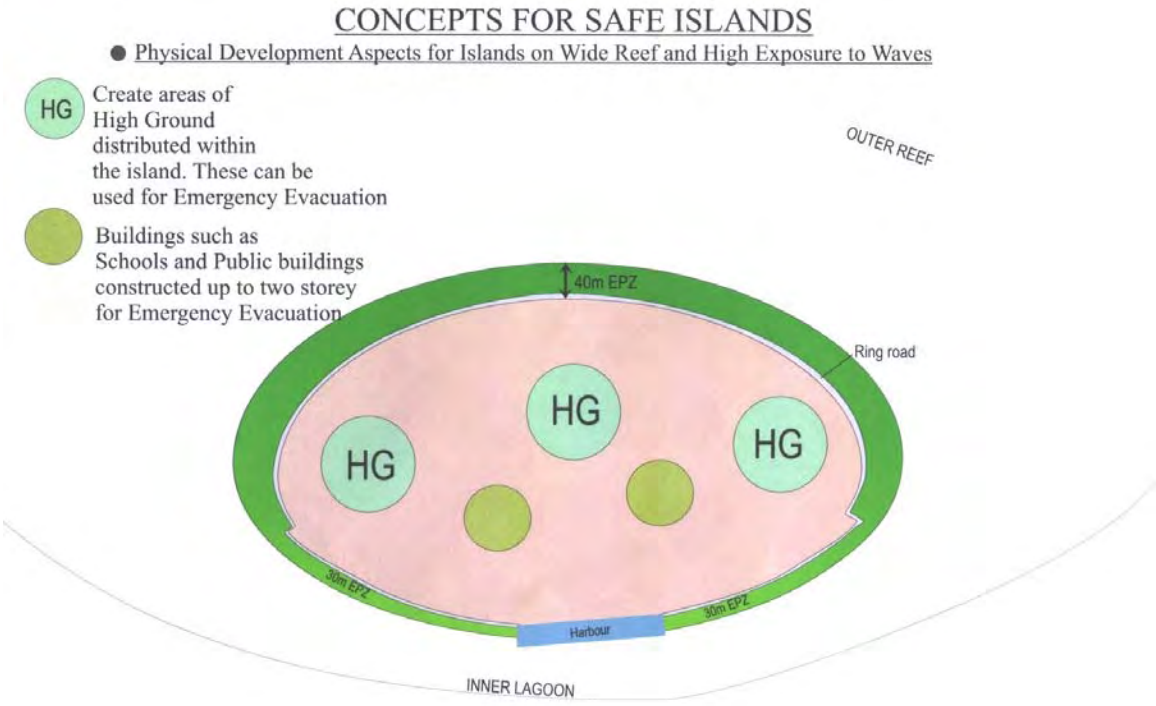
- the Environmental Protection Zone (EPZ),
- the High Grounds (HG) and
- some buildings prepared for emergency evacuation.

The EPZ is in fact a broad crested dike along the part of the coast that is facing the outer reef and consequently the open seas. The EPZ needs an appropriate slope protection (revetment) against erosion due to currents and waves. The high grounds and the buildings for emergency evacuation need to be distributed evenly over the island in such a way that they can always be reached within a few hundred meters. The coast of the island with the harbour, facing the inner reef, needs less protection as the lagoon side is relatively sheltered against waves.

The High Grounds will have a higher elevation above sea level than the rest of the island. These High Grounds will provide refuge in case the waves do run over the top of the EPZ revetments. The buildings on these High Grounds will be suitable for emergency evacuation of the inhabitants of the island.

The principles of the safe islands concept as used for the design of the Three Islands are given in Figure 4-1.

Figure 4-1 - Principles of the "Safe Island" concept



4.1.2 Previously developed Safer Islands

In 2006, in the wake of the December 26, 2004 tsunami, the island of Vilufushi in the Thaa atoll was the first island to be reconstructed according to the Safer Island concept. The island had been completely evacuated after the tsunami, and the inhabitants had found a temporary, and very crowded, home at the nearby island of Buruni.
Vilufushi is located on a wide reef, which provided ample space for both the reclamation of new land and the borrow area that was needed to provide sand for the reclamation works.
Due to the devastation brought by the tsunami, all the existing houses on the island were demolished, and the entire 'old' island was brought from an average of 1.1m above sea level to 1.4m above sea level with several areas raised even higher above sea level.
The total area of Vilufushi was doubled and along the eastern shore, facing the open ocean, revetments were constructed to give extra protection against storm and tidal surges.

In 2008, at the island of Viligili in Gaafu Alif atoll new land was reclaimed on the eastern (ocean facing) side of the island. In the past, there had been land here, but this had disappeared due to the eroding forces of the ocean. The new land was protected by a dyke and revetments on the ocean side, and the surface area of the island of Viligili was doubled.
Reclamation works were carried out while the inhabitants of Viligili continued their normal day-to-day lives on the island.

Both these projects were developed and executed by Royal Boskalis Westminster dredging company, and were financed by loans from the Dutch Government.

4.2 Planning of the works

For the construction works of the Three Islands Project, roughly 3 million cubic meters of sand will need to be dredged and placed in the reclamations of each of the three islands. Each reclamation will require roughly 1 million cubic meters of sand.
After the sand is placed, revetments will be constructed to protect the parts of the reclamation that are exposed to the ocean.

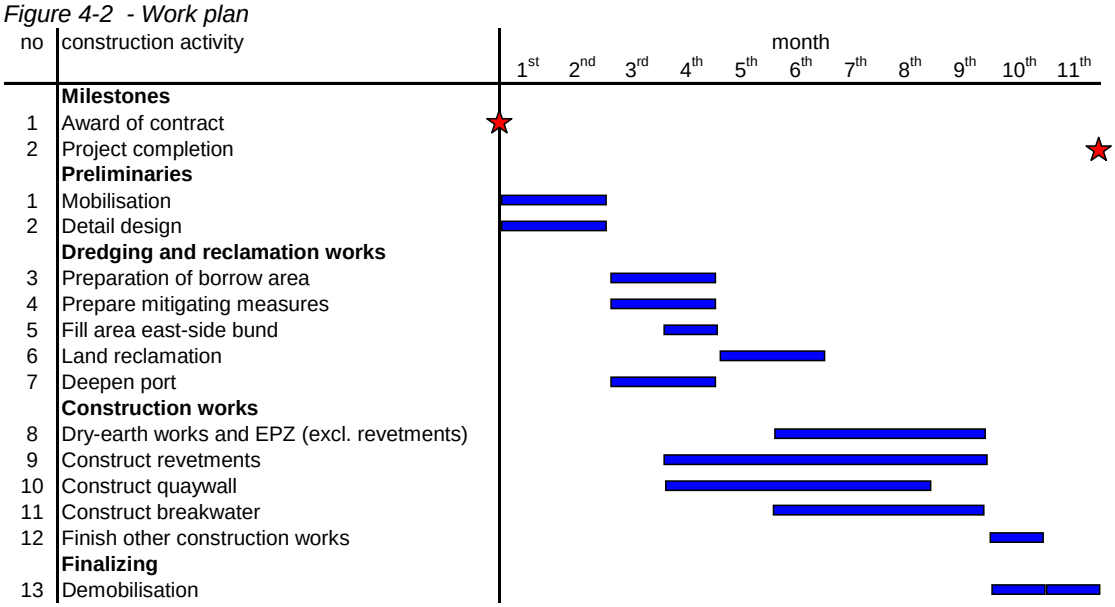
Detailed design of the exact shape and size of the reclamations at each island, and of the revetments and quay walls will be done after this EIA has been submitted, but before the start of construction works.

The main activities to implement the construction of the Three Islands are listed below.

- surveys;
- detailed design
- site preparation;
- mobilization of dredging and survey equipment, office and housing,;
- dredging the borrow area, land reclamation and stockpiles;
- profiling the reclaimed land and existing island to the required levels;
- construction of revetments on the slope of the EPZ, facing the outer reef;
- construction of quay-wall, breakwaters;
- demobilization of dredging equipment, office and housing
- environmental monitoring during construction,;
- measures to protect environmental values during construction and thereafter;

In general terms the work plan, see Figure 4-2, shows that preparatory activities like site preparation and mobilization take about 2 months per island. The duration of dredging is mainly related to the capacity of the deployed dredge and the location of the borrow area. The dredging will take about 2 months when using a mid size dredge, shorter when a large size CSD is employed. The construction works of revetments, breakwater and quay-wall will take about 6 months. The total duration of the project will take about 10 to 12 months.

Figure 4-2 - Work plan



Coordination with activities outside the project is required, especially regarding use of the harbour.

In principle the dredge/survey fleet, dry-fill- and auxiliary equipment will be transported to the Maldives aboard a dock-ship. The equipment will reach the project site with several transport loads as equipment is coming from different locations abroad.

Dredging fleet
The fleet consists of:

- one dredge;
- one transport barge with pipeline and containers (spares, workshop, etc.);
- one multicat (self-propelled barge with a hydraulic crane);
- one derrick barge or A-frame (for handling of pipeline);
- one general purpose launch for survey work, crew shifts, etc.;

Dry-fill equipment
So-called dry-fill equipment will comprise:

- two excavators;
- 2 dumpers;
- two bulldozers and one wheel loader

Survey and logistics
The following equipment needs to be on site in order to execute hydrographical surveys and an efficient project

- a fast launch for long distance transport of personnel;
- from the local market a tug and a barge or a self-propelled cargo vessel and a speedboat will be rented to maintain logistic services between Malé and the Three Islands (for food, fuel, etc.);
- the general purpose launch (mentioned above under fleet) will be equipped with the - Motorola DGPS positioning system;
- atlas Deso dual frequency echo-sounder;
- niskin water samplers;
- laboratory equipment for sediment analysis

4.3 Global environmental constraints

This paragraph summarises the most important weather and sea conditions affecting the project activities (for more details see Chapter 6).

4.3.1 Climate

The Maldives experience two seasons per year. The rainy southwest monsoon lasts from May to September and the dry northeast monsoon from December to January, with transition periods in between. Winds get stronger in the southwest monsoon especially during June and July (Beaufort force 8 is possible). Wind forces of 5Bft are common in both monsoons. Mean annual temperature is 30.8^{o}C with day-/night-time variations of a few degrees only. Monthly rainfall amounts to 50-75 mm in the dry season and 125-250 mm in the wet season.

4.3.2 Bathymetry

The islands of the Maldives are generally located on a submerged reef. The size of the submerged reef varies from several tens of meters diameter to several thousands of meters long or wide. Islands that are located on the atoll edge seem to have one of two types of reef on the ocean side:

- The reef flat is very shallow and almost equally shallow all the way to the edge of the reef. The edge of the reef is slightly above MSL just before it drops off steeply into the deep ocean.
- The reef flat has one or more terraces, each of which is deeper than the previous one when moving from the island to the deep ocean. The deepest terrace is between 10 and 20m below MSL and drops off steeply into the deep ocean.

4.3.3 Sediments

The islands and reef consist of coral reef formations consisting of coral sands, gravel and coral rock. The sediments have a very high permeability.

4.3.4 Sea conditions

Typical tidal ranges during spring and neap are 1.0m and 0.3m respectively. The tides are mixed, diurnal/semi-diurnal. The seasonal changes are +0.1m in February to April and -0.1m in September to November. Oceanic currents, driven by the monsoon winds, are flowing westerly from January to March and easterly from May to November. Tidal currents, flowing westwards during flood and eastwards during ebb are rather weak. Local currents on the reef plane often include an important wave-induced component. Recent flow measurements on the reef indicated maximum current velocities in the order of 0.5m/s. Considerable swell at the ocean side may occur with heights of 2 to 3m and periods of 18 to 20s. Local wind waves have periods of 2 to 4s

and heights up to 1.5m. The shallow depths on the reef plane cause significant wave breaking, reducing the wave height to about 1m (maximum).

4.4 Dredging & reclamation methods alternatives

This paragraph describes the different options for dredging methods and borrow areas. Options include the use of a Cutter Suction Dredge (CSD) to dredge material from a borrow area in the reef surrounding the island, or the use of a Trailing Suction Hopper Dredge (TSHD) to dredge material from a borrow area in the atoll lagoon area.

4.4.1 Method and equipment, alternatives

Sources of fill material and type of dredger

The potential available sources of fill material, which can be used in this project, are given below:

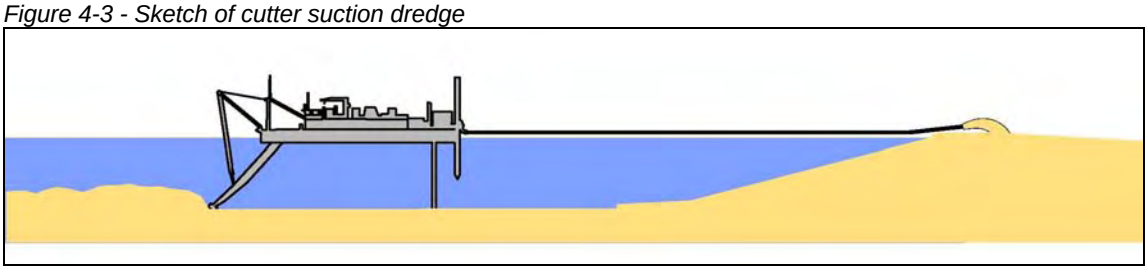
1. sand and coral material from the shallow reef flat area next to the island, to be dredged by a cutter suction dredge (CSD);
2. sand from the bed of the lagoon of the atoll (away from islands), to be dredged by a trailing suction hopper dredge (THSD);
3. sand and coral material from the reef elsewhere in the atoll, to be dredged by a CSD;
4. sand imported from overseas using a large scale TSHD.

Option 1 has simple logistics, the impacts on the environment are localised (limited to an area around the island where dredging and reclamation activities take place) and manageable.
Option 2 also has relatively simple logistics, although deep water access to the islands is required. The impacts on the environment are localised (limited to the borrow area and the island where reclamation activities take place) and manageable.
Option 3 involves more complicated logistics for transportation of the dredged material from the borrow area to the reclamation area. The impacts on the environment are also more severe, due to the fact that coral reefs will be exposed to dredging and reclamation activities at two different locations. Environmental impacts are therefore more difficult to manage. This makes this option environmentally prohibitive.
Option 4 involves very long sailing distances for the TSHD and a very long execution time of the project. This makes this option economically prohibitive.

Option 1: Dredging with a CSD in the reef near the island

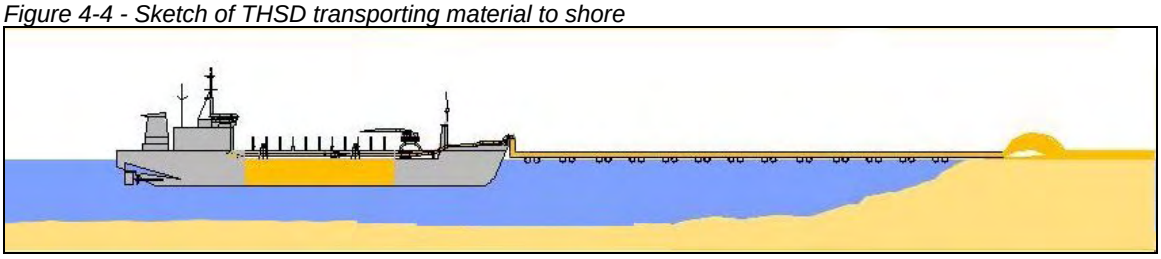
A CSD is a stationary dredger, which dislodges the material with a rotating cutterhead mounted on a ladder (see also Figure 4-3). The cutterhead is equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of a centrifugal pump, which is installed on the dredge pontoon or on the ladder of the dredger. The amount of material not entering the suction mouth may be as much as 30% of the total dislodged material. Much of this material will fall immediately to the seabed and will be dredged on the next cut. Only the finer particles will stay in suspension and will be distributed throughout the water column by the local currents. With a CSD, the creation of turbidity is a more or less a continuous process. Due to the fact that a rather deep basin will be created by the CSD of about 6 – 7 meters depth, the majority of the suspended sediments will stay within this created basin. As the cut material will be disposed by a discharge pipeline to the land reclamation site no additional turbidity will be created at the dredging site. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local hydrodynamic conditions.

Figure 4-3 - Sketch of cutter suction dredge



Option 2: Dredging with a TSHD in the lagoon area
A TSHD is a normal sea-going ship equipped with one or two suction pipes. At the end of each suction pipe is a draghead, which can be lowered onto the seabed while the TSHD navigates at a reduced speed. The material loosened by the draghead, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump, and subsequently placed in the hopper of the dredger. The TSHD will transport the sediments to the shore connection, where the TSHD will be connected to a pipeline system (see Figure 4-4).
Most of the turbidity generated by a trailer suction hopper dredge is caused by the overflow of turbid water during the hopper filling operations. Overflow is the flowing overboard of excessive process water, together with a part of the finer material. Overflow is used to maximise the load of sand inside the hopper. When dredging pure sandy sediments the amount of overflow of particles is mainly determined by the grain size distribution of the dredged sediment. It is to be noted that the overflow process will not be a continuous activity, since its duration will be limited to operational dredging time, which is usually less than half the total cycle time.
The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas. As no dredging site has been identified within the lagoon no relevant impact can be assessed.

Figure 4-4 - Sketch of THSD transporting material to shore



Preferred option
With both types of dredgers a sediment-water mixture will be pumped to the reclamation site from where the excess of water will flow back (return flow) to the sea and most of the sediments stay behind. The potential issue of turbidity is basically the same for both dredging methods. The main difference between the methods is that impact of the re-suspension from the CSD at the borrow area can be better controlled than from the THSD at the lagoon. For this reason option 1 would be preferred above option 2.
Other issues may have to be included in the evaluation, such as

- sailing distance,
- affected surface in the borrow area etc.;
- keeping the reef intact
- etc.

Size of CSD
Three alternatives can be considered, viz. a small, a medium and a large CSD. For the selection a number of aspects have been taken into account:

- dimensions in relation to mob/demob;
- dimensions in relation to the access to the borrow area;
- dimensions in relation to the size of the borrow area (including depth = thickness of layer of relatively loose sediments);
- capacity in relation to pumping distance (max length of pipeline is an important factor);
- capacity in relation to construction time;
- economical and environmental consequences;
- operational consequences.

The small size cutter dredge is advantageous in relation to the dimensions but not in relation to the capacity. The use of a medium size CSD seems to be positive, also in relation to the economical, environmental and operational aspects.

Size of TSHD
Three alternatives can be considered, viz. a small, a medium and a large CSD. For the selection a number of aspects have been taken into account:

- dimensions in relation to mob/demob;
- dimensions in relation to the distance to the borrow area;
- dimensions in relation to the depth of the seabed at the borrow area (including thickness of layer of relatively loose sediments);
- capacity in relation to pumping distance (max length of pipeline is an important factor);
- capacity in relation to construction time;
- economical and environmental consequences;
- operational consequences.

A small sized TSHD will not be able to dredge sand from the seabed at the required depths (40-80m), and even a medium sized TSHD will not be able to do this. The is therefore a technical need to use a large size TSHD.

4.5 Revetment construction

The slope of the outer bund and the final level of the reclamation area will be profiled during the hydraulic fill of the reclamation area by using dry fill equipment. The profiling activity will start as soon as sufficient reclaimed material is available. The reclamation area will be protected with an environmental protection zone, EPZ. The construction of revetment will start right away after a section of the EPZ has been put in required profile. Figure 4-5 shows an example of how the EPZ may be designed. Detailed design for each of the Three Islands will be done at a later stage, before construction starts.

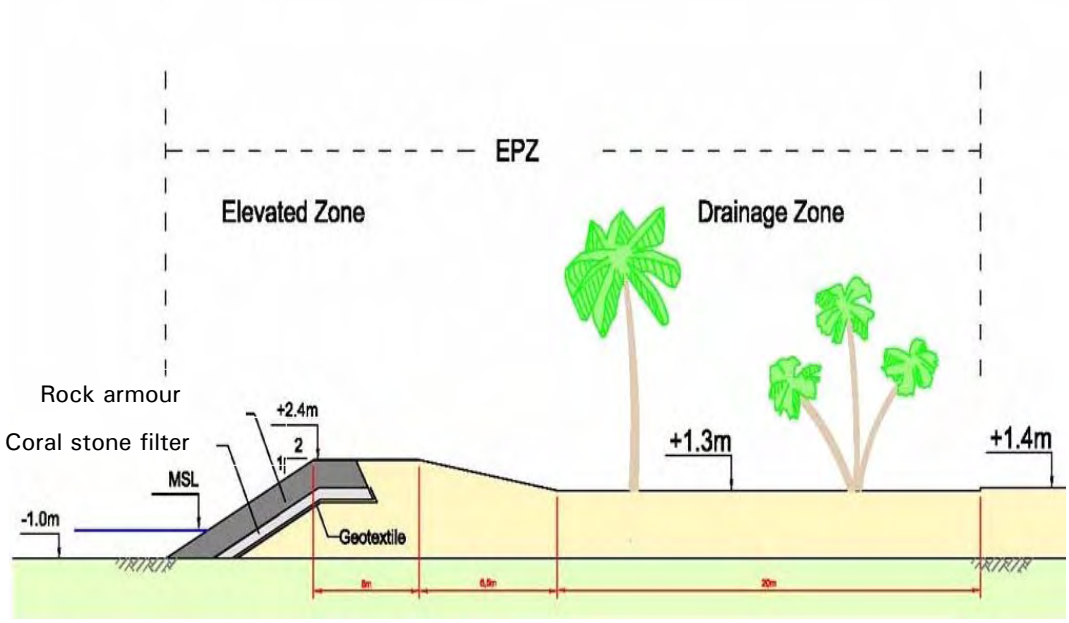


Figure 4-5 - EPZ example design

The revetment consists of geotextile, which is positioned on top of the profiled slope. The geotextile is subsequently covered with a filter layer of rubble coral rock which is dredged in the borrow area. Suitable material will be gathered and transported with dump trucks. The filter layer is subsequently covered with an armour layer of rubble granite rock material. The material will be positioned with a hydraulic excavator (see

Figure 4-6).

Figure 4-6 - Construction of revetment with armour layer of rock

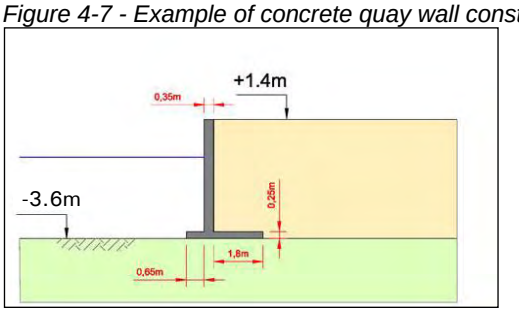
Protection, durability and maintenance
The selected revetment alternative needs to comply with the required level of protection against hydraulic conditions. The lifetime of the revetment structure with rock rubble is longer than with sandbags. On the other hand, maintenance works are easier when sandbags are used in stead of rock rubble.

Testing the materials
Inspection and testing of materials will be carried out as an integral part of the contractor's quality control programme with the objective to ensure the quality of the works. All materials proposed by the contractor will be subject to the engineer's acceptance before transported to the site.

4.6 Quay wall construction

As in the previous Safer Island projects, pre-fabricated reinforced concrete elements will be used, which will be placed on a trimmed harbour bed. The elements will be coupled by a capping beam.

Figure 4-7 - Example of concrete quay wall construction



4.7 Applied Environmental Management System

Royal Boskalis Westminster nv has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.
Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OSHA and environmental requirements, and are adjusted if a client has even more stringent requirements.
All vessels are IMS certified and have to meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Appendix 3 contains the framework that is used to make a specific Environmental Management Plan for each individual project that Royal Boskalis Westminster undertakes. Similar frameworks are applied for project specific Safety and Health Management Plans.

4.8 Availability of utilities, resources, space for work shop etc

On shore activities will be organised in such a way as to minimise the interference to the day-to-day life of the inhabitants of the island.

Stores and workshop
Stores and workshop areas will be created as close to the reclamation area as possible, at the edge of the existing island in an area where no human activities take place.
Facilities needed will consist of:

- container based stores for spares and food;
- container based workshops for maintenance and repair of equipment.

Mobilisation of office and housing
Most of the required accommodation will be land based. Existing houses will be used, if available, for lodging of staff and reclamation workers, and for office space. Alternatively houseboats or barges with house- and office containers need to be considered.

4.9 Employment opportunities

Specialised equipment is usually operated by expatriate personnel. However, local employees will be employed as much as the work will allow. Employment opportunities are for instance available on the fleet, the workshops and/or on the reclamation site.

Indicative numbers are shown in Table 4-1 about employment opportunities of local employees during project construction phase.

Table 4-1 - Employment opportunities

Group	Unit	Specialists	Spec no's	Labour
Dredge fleet	Dredge (CSD or TSHD)	master, eng	4	6
	transport barge	operator	1	1
	Multicat	operator	2	2
	general purpose launch	driver, surveyor	2	1
Dry-fill	Reclamation area	recl. supervisor	1	4
	Dumpers	drivers	2	
	excav. bulldozer, loader	operator	4	
Special equipment	excavator, sheet piling crane	operator	2	4
	concrete plant	operator	2	4
Workshops	for fleet and dry-fill	engineers	2	4
Logistics	fast launch	driver	1	1
	cargo vessel	master, eng	2	2
	kitchens CSD+landbase	cooks	2	2
	Housekeeping, laundry			4
		totals	**27**	**35**

It needs to be noted that the dredge will be working 24 hours per day and the crew working in 2 shifts, so at least there will be a double dredge crew. Furthermore, the reclamation supervisor is responsible for the reclamation works such as the timely construction of temporary bunds, the handling of the landline and spreading of the dredged material. The actual number of employment of local people will depend strongly on the available skills in relation to required skills for the construction works.

4.10 Enhancement work

No additional enhancement works are planned, although some roads may have to be improved to be able to carry the heavy equipment necessary for the reclamation and construction activities.
Any such improvements necessary to execute the dredging, reclamation and revetment construction works will be left after project execution is completed.

5 Specific project description per island

5.1 General

The present plan for reconstruction of the island Thulusdhoo is in line with the Safe Island Program. The designs include:

- a (higher) land level of 1.4 meters above sea level for the newly created areas
- a protecting bund wall on the exposed sides of the island of 2 meters above sea level.

an EPZ (Environmental Protection Zone), directly behind the bund wall on the island side.

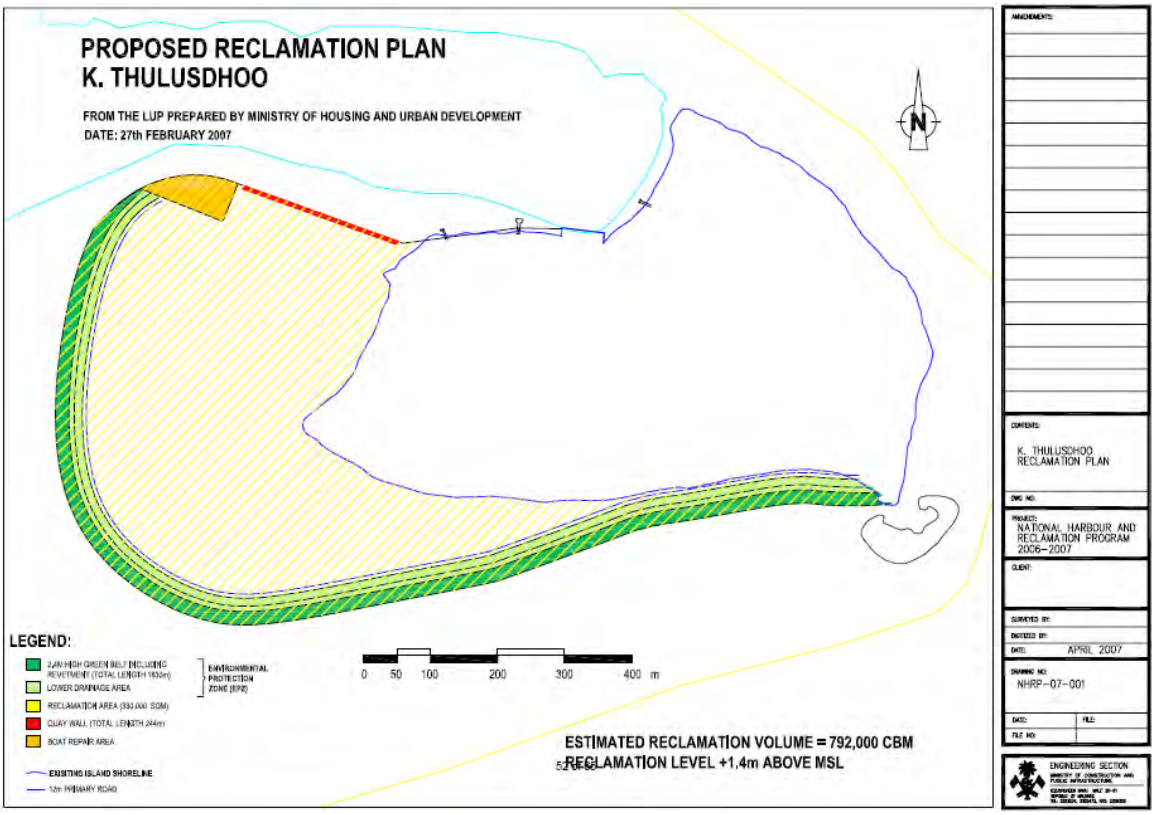


Figure 5-1 - Preliminary design of reclamation areas, revetments, breakwaters and quay wall at Thulhusdhoo

The island would be enlarged from 33 hectares at present to about 65 hectares. Also a new and larger port area will be created, as general transport will increase following the increase of the island population.

The main land-use categories are the following;

Existing island-housing-social infrastructure	25 ha
Existing island-green zone	8 ha
Reclamation-housing-social infrastructure-industrial	25 ha
Environmental Protection Zone (EPZ), green zone	7 ha
Total	65 ha

Figure 5-1 (above) shows the project layout including of the reclamation area, bund walls, revetments, and the new quay wall inside the existing harbour basin.
Appendix 4 contains the preliminary land use plan for the newly reclaimed land. The island will provide in future space for housing and for communal and economic activities for up to 3000 to 3500 inhabitants. It is noted that the Pre-Tsunami number of inhabitants was approximately 800.

5.2 Planning

The project would include the following construction activities (see also Figure 5-1).

- Dredging and reclamation of about 0.8 million m^3 of coral sand;
- Construction of approximately 1600 meter EPZ, including revetment;
- Dredging of new harbour area;
- Construction of quay wall, approximately 250 meter;
- Mitigating measures for the environment.

Duration of the construction is estimated to be between 6 and 8 months. Dredging and reclamation works will take 4 to 8 weeks.

5.3 Island specific environmental constraints

Inside the island lagoon, bottom reefs and pinnacles of coral are present. These reefs and pinnacles can reach quite close to the water surface, preventing large vessels with deep draughts free entrance. When deciding on the location of the borrow area, the location of the entrance to the borrow area should be carefully chosen to minimise damage to bottom reefs and pinnacles.

5.4 Detailed design

5.4.1 Dredging and reclamation

The amount of sand required for the reclamation is estimated at about 0.8 million m^3. Most of this will be dredged from a special borrow area west of the island and some material will be dredged from the new port area. The borrow area will be some 12 to 20 hectares in size and depends on the exact location chosen. The equipment required for the dredging and reclamation works comprise:

- A medium to large size cutter suction dredger;
- A pipeline system;
- Various bulldozers and wheelloaders.

The total time required for the reclamation works is estimated at 1 to 2 months.

Alternative sources of fill material
The possible sources of fill material and dredging equipment are the following:

- Option 1: Sand from the shallow reef flat area west of to the island by a CSD (cutter suction dredger) with a pipeline system.
- Option 2: Sand from the bottom of the Thulusdhoo lagoon area north and west of the (extended) island.
- Option 3: Sand from the bed of the atoll lagoon by a TSHD (trailing suction hopper dredger) with a pipeline system
- Option 4: Sand and coral material from a coral reef (faro) elsewhere within the lagoon.
- Option 5: Sand imported from overseas by a Jumbo trailer.

5.4.2 Revetments

Total length of the south and west-side shore protection (part of the EPZ) is approximately 1600 m; the protection will be executed as a 1:2 slope protected by rock placed on geotextile. The rock protection on the west-side will be lighter than the protection on the south-side. The rock will be imported from India.

5.4.3 Quay wall and breakwaters

The present Thulusdhoo island has a well- sheltered anchorage in it's inner lagoon on the north-west side; there are some jetties for loading and unloading (see figure below). The larger island will have a new harbour-area and quay-wall of 250 meter in length, with a water dept next to the quay-wall down to -3.5 below MSL. Pinnacles in the inner lagoon will be removed to -5.0 meter below MSL to allow safe passage to the quay-wall. In view of the existing hydraulic conditions in the inner lagoon and anchorage, no breakwater is foreseen.

6 Description of Natural Environment

6.1 General

Kaafu atoll is located approximately 400 km north of the equator. Its diameter is approximately 40-50km. The water depth in the semi-enclosed lagoon ranges from some 40m to 80m.
The island Thulusdhoo is located in the north-east of Kaafu Atoll (Figure 6-1), some 30 km north of Male. The island has a length of 1000 m and a width of 650 m. The total surface area of the island is 33 hectares. The island lies on a broad shallow reef flat with a width of some 1000 meter which extends some kilometres to the west. The typical reef flat depth around Thulusdhoo is about 1 meter below MSL or less. The existing island surface is some 1 to 1.5 meter above mean sea-level.
The Thulusdhoo reef has on its north side an inner lagoon which is separated from the atoll lagoon by a coral strip of about 150 meter wide, the inner lagoon has a dept of about -8.0 meter MSL. There are numerous rocks and pinnacles in the lagoon with a top level of about -1.0 or -2.0 meter MSL.

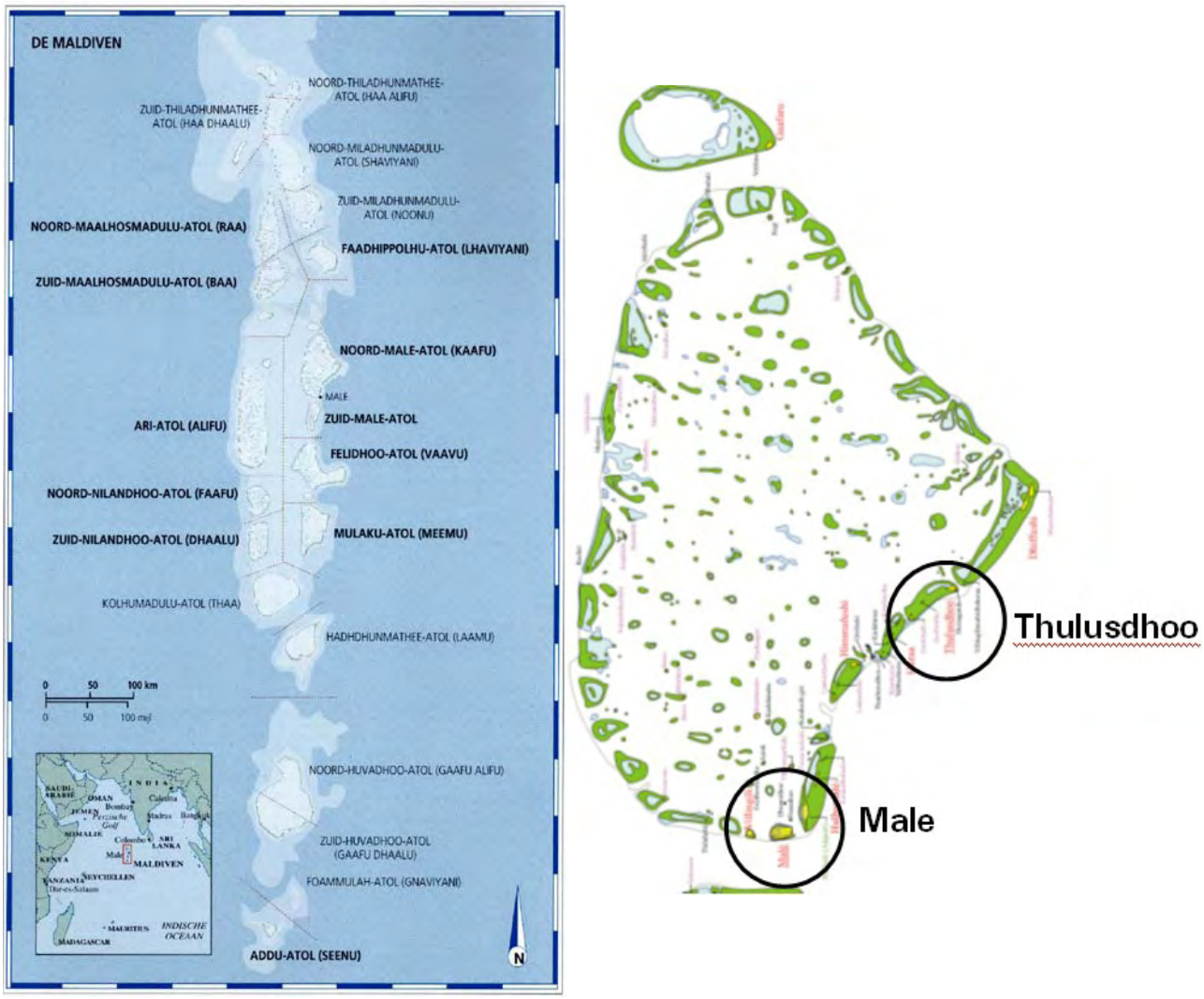


Figure 6-1 - Location of Thulhusdhoo in Kaafu Atoll

6.2 Physical environment

6.2.1 Geology

Figure 6-2 shows the typical geological structure of an atoll in the Maldives. The island itself owes its origin to the deposition of shingle or coral debris during storms. The island is made up of coralline sand, partly covered with a thin layer of soil consisting of a mixture of sand and organic matter.

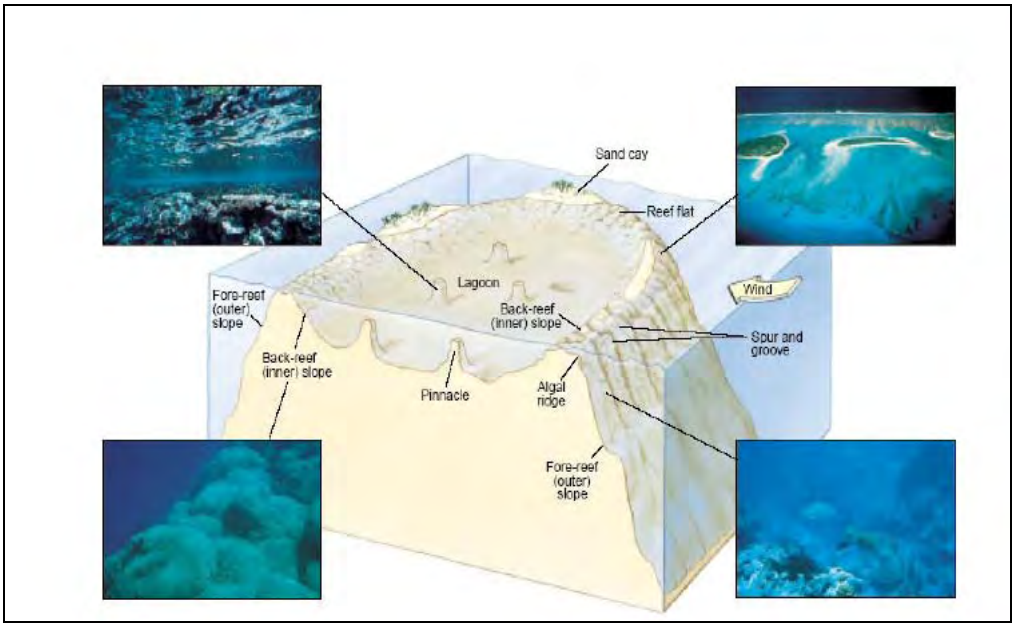


Figure 6-2 - Typical structure of an atoll

A coral reef formation underlies the sea bed of all the atolls of the Republic of Maldives. The coral reef can be classified as Coral Float Stone. It is likely that this original coral reef has been exposed to weathering, which is a destructive or disintegrating process by which rocky material on exposure to atmospheric agents, changes in colour, texture, structure, composition and form. Thus, through this weathering process, this formation can be further classified into two weathered zones:

- Coral sand I – this material is loose, completely decomposed coral sand. Samples are friable and can be easily crushed using finger pressure. Sand grains are angular to sub-angular in shape, with some medium plasticity silty matrix. Sand grains are poorly graded. (D50 varying from 0.2-0.5mm);
- Coral sand II – this material is generally found underlying Coral Sand I. The material is generally constituted of highly decomposed coral from the original coral reef. It is very dense to dense coral sand with gravel. Gravel size varies from 20-30mm in diameter, and grains are angular to sub-angular. Samples are friable and can be crushed using considerable finger pressure.

Awaiting further drilling and laboratory testing, the material of the Thulusdhoo borrow area can in general terms be described as “loosely packet, silty, coral sand, with pieces of coral and shells”. The grainsize envelope is expected to be as in Figure 6-3.

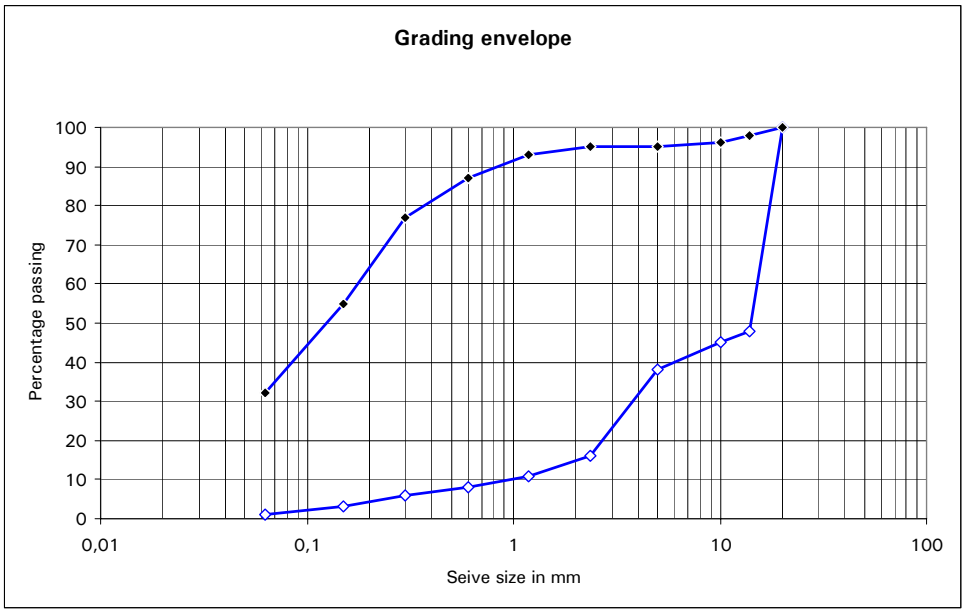


Figure 6-3 - Thulusdhoo, assumed grading envelope

On top of the coral reef formation, most of the islands have shallow, humus topsoil layers only where there is vegetation. Residential areas are almost free of topsoil layers. In agriculture zones, thin topsoil layers are concentrated only around plants, i.e., in the fertilizing zone. Overall the tsunami had only a slight impact on topsoil.

The soils have a very high permeability for water. Much of the rainfall occurs as intense storms but no signs of erosion are observed, confirming the high infiltration capacity. The hydraulic conductivity (K-value) of medium sized sand should be at least several meters per day. Also the underlying coral bedrock has a high permeability (K-values of at least 5-10m/day). Groundwater aquifers in the Maldives islands normally lie between 1 and 1.5 meters below the soil surface. The proximity of the aquifers to the island surfaces makes them vulnerable to pollution and contamination from human activities as well as saltwater intrusion. In addition, population and development pressures have led to increased groundwater extraction, resulting in depletion of the country's freshwater lenses.

6.2.2 Climate

The Maldives lie in the monsoon area of the northern Indian Ocean and consequently the Maldives have a rather complex climate. There are two seasons in the Maldives, being a dry northeast monsoon (iruvai) and a wet southwest monsoon (hulhagu). The wind comes from the south west from May up to November and brings an average rainfall of 200 mm, and 200 sun-hours per month. In the middle of December the wind turns to the northeast and the climate becomes a lot dryer, the quantity of rain decreases to 75 mm per month and the number of sun hours is 250 per month.

During the entire year the days are hot and humid, with temperatures of 25 up to 30 °C and a humidity of 60 to 80%. If it is raining in the Maldives it rains very hard, but generally the showers do not last long. In April/May and in October/November frequently hurricanes pass through the Gulf of Bengal. These storms rarely hit the Maldives and the impacts are generally of short duration. The area around the equator is known as the Doldrums, an area with often little to no wind.

6.2.3 Tides

The tidal cycle at Thulhusdhoo is an irregular diurnal cycle with a small and large peak. Tidal currents are strong and flow in and out through the channels north and south of the islands reef flats. On the south side of the island, there is a reef crest located at approximately 300 meters from the shore. On the south east and east side, the reef has several plateaus before it slopes down steeply to the deep ocean. Waves from the ocean side break on the crest and the

shallowest plateau. The currents originating from wave activity are therefore strongly reduced but still fierce.

Currents which affect the areas around the islands and on the shallow reef flats can be caused by tidal currents, wind-induced currents, wave induced currents and oceanic currents. The tidal currents can be quite strong in the deep channels between shallow reefs, despite the limited tidal range. The wind (especially during the monsoons) can be a major factor affecting current velocities on the shallow reefs. Over the reef flats, wave over wash is also a major factor in generating currents.

The oceanic currents are influenced by the monsoon climate. In the Maldives, the oceanic currents flow eastwards during the southwest monsoon period (May – Oct) and westward during the northeast monsoon period (Dec – Mar). An estimation of the currents on the reef flats is likely to be between 20 and 50 cm/s.

Typical spring and neap tidal ranges are approximately 1.0m and 0.3m respectively and tides are (semi) diurnal. The present estimates for the sea level rise at the Maldives due to the climatic changes are in order of about 0.5 cm per year. This is based on the fact that the sea level has risen 20cm over the past century.

6.2.4 Wind, water, waves

The swell and wind waves in the Maldives are conditioned by the two monsoon seasons, being the north east monsoon from December to March, and the south west monsoon from May to November.
Thulhusdhoo is relatively sheltered from both the south west and the north east monsoons, but the reef on the south side of the island plays a crucial role in breaking the waves before they reach the island.

It is estimated that the maximum wave height outside the flat reefs can reach more than 3m (ocean side, south and east sides of Thulhusdhoo), whereas on the flat reef areas the wave height can reach from 0.6 to 1.2 meters (maximum).

6.3 Terrestrial Environment

6.3.1 Flora

A relative high level of soil salinity is found on the island due to the limited size. As a result, the local vegetation does contain a high amount of salt tolerant species, shrubs as well as trees. Most of the trees and shrubs on the island are respectively of the types coconut tree or sea lettuce. Several types of fruit plants grow in the gardens around the houses, such as for instance banana trees, which are very popular with the population.

Figure 6-4 - Coconut palm trees – Cocos Nucifera

Several types of fruit trees grow in the gardens, including banana and coconut trees.

Figure 6-5 - Trees in gardens, including banana tree and coconut trees

6.3.2 Fauna

A small number of animal species live on the island, such as rats, mice, ants, lizards, and several species of crabs. Once in a while fruit bats can be spotted, which live in the atoll. Furthermore, a large population of mosquitoes and insects is found. Cats and chickens are found in the residential areas of the island, but no dogs.

Figure 6-6 - A lizard, cat, crab and three crows

Over 190 different bird species have been recorded in the Maldives including seabirds, shorebirds and terrestrial birds. Most of the birds are seasonal visitors, migrants or vagrants. Most of them are seabirds due to the small islands ecosystem. The bird species spotted on Viligili are: crows, gulls, terns, grey heron and several wading shore birds like plovers, snipes and sandpipers.

6.3.3 Waste and sewage system

There is a well organized refuse collection and sorting centre in the south. It has been set-up and paid for by Australian and Canadian Red Cross. All (tsunami) waste has been brought here (by Red Cross), sorted out and most non-reusables have been brought to Thilafushi. There is no incinerator.

The sewerage system is connected to the sea; there is no surface drainage system.

6.4 Marine environment

A very rich marine biodiversity is found along the reefs of the Maldives, including more than 250 coral species, 1,200 reef fish species, 5,000 species of shells, 100 – 200 species of sponges, over 1,000 species of marine crustaceans and more than 100 species of echinoderms.

The most important ecosystems in the Maldives are the coral reefs. In the period 1995 to 1998 (and also before this period) extensive coral reefs in good condition could found throughout the Maldives. The increase in sea surface temperatures in 1998 caused extensive bleaching and destroyed large areas of shallow-water coral reefs and, as a result, in several areas about nearly 90% of the corals died. At present, although new recruitment has been noticed at all sites, the cover of live coral is almost 20 times lower on the shallow reef flats than recorded before the bleaching event. On the other hand, the deeper reefs appear to be in better condition than before.

The dominant species on the reefs are corals and fishes. The top ten families of fishes in the Maldives are: gobies, wrasses, groupers, damsel fishes, snappers, cardinal fishes, moray eels, blennies, butterfly fishes and surgeon fishes. 37 species of sharks can be spotted in the Maldives. The only protected shark specie, by law, is the whale shark. Some species can be found close to the edge of the reef, but most can only be found in deep waters. Stingrays, manta rays and the eagle rays are some of the most delightful of all creatures on the Maldives reefs. The most popular fishes for divers are sharks (especially the whale shark) and rays. The whale shark is the largest fish in the world; the manta ray is very popular and can have a width of about 3m; both fishes are plankton feeders. Stingrays are bottom feeders, they dig out clams and other animals which are covered in the seabed.

Five species of sea turtles can be spotted in the waters of the Maldives, being: the hawksbill turtle, the loggerhead turtle, the green turtle, the olive ridley turtle and the Leatherback turtle. The green turtle (Chelonia mydas) and the hawksbill (Eretmochelys imbricata) are the most common two species that breed in the Maldives.

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

Several components of the marine environment of the atoll islands can be distinguished. A cross section of a typical atoll reef in the Maldives is given in Figure 6-7.

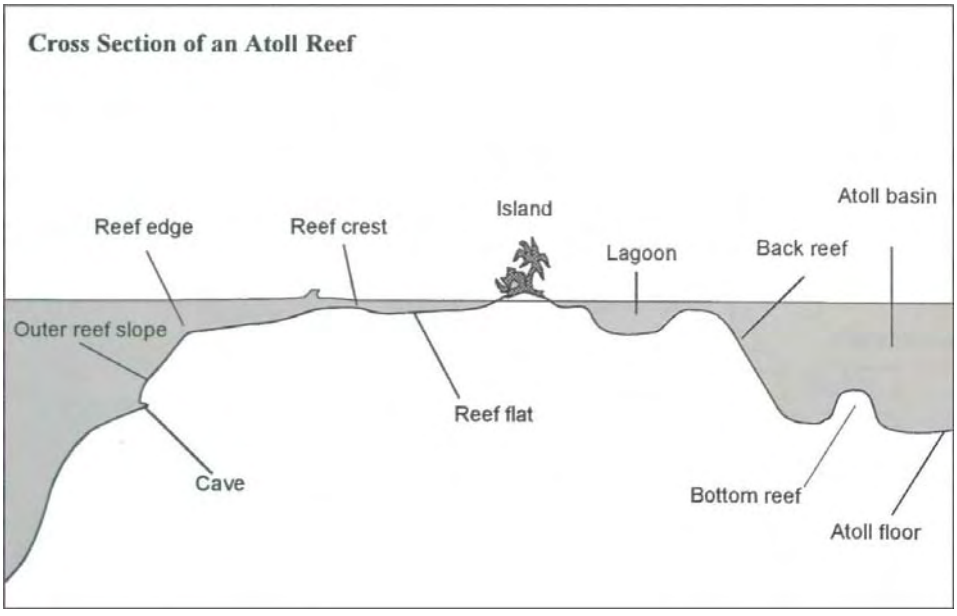


Figure 6-7 - Typical cross section of an atoll reef

6.4.1 Beach areas

There are only some small sandy beach areas around the island. No nesting area for turtles can be found. The islands Thulhusdhoo, Huraagandu, Gasfinolhu and Lhohifushi are located on the same shallow reef and the area between the islands is very shallow.

6.4.2 Reef flat and lagoon area

A channel, with a width of about 400m is located at the north side of the island and its shallow reef. The shallow reef flat in the south is about 275m wide, the reef to the west is about 950m wide (southeast to northwest), and 4.5km long (northeast to southwest). The lagoon inside the reef that runs southwest from Thulhusdhoo is 400m by 2400m. At the eastern side of the island, the typical reef flat varies from 100m to 200m. The depth of the flat reef around Thulhusdhoo depends on the tide and varies from 0 to -2m MSL.

Despite the outflow of untreated sewage into the ocean, very little seagrass is found in the vicinity of Thulhusdhoo.

The reef crest at the ocean side comes above the water level at the low tide (see Figure 6-8). No live coral was found at the reef crest. Only a few live hard corals are present at the seagrass area and the sand and rubble area.

Figure 6-8 - Reef crest above water level

6.4.3 Reef ocean side

At the ocean side there is a reef edge and an outer reef slope with caves at about 30 meter depth. At the reef edge there are only a few hard corals and practically no soft corals.
At the reef edge sometimes there are very large groups of fishes (see figure 6.14), but sometimes there are only a few fishes.
The reef slope drops down very fast to more than 2000 meter or more. Along the slope there are hard corals, soft corals and some sponges. The quantity of corals is rather limited (see figure 6.12 and 6.13).

Samples of fishes, moray, stingray and a sea turtle are presented in Figure 6-12. Hard and soft corals at the reef edge and reef slope are presented in Figure 6-13.

Figure 6-9 - Reef edge with very limited corals

Figure 6-10 - Reef slope at a depth of 15 meter

Figure 6-11 - Reef slope at a depth of 30 meters


Yellowback Fusilier – Caesio xanthonota


Neon Fusilier – Pterocaesio tile


Kashmir snapper – Lutjanus kasmira


Cooper's Anthias – Pseudanthias cooperi


Humpback Red Snapper – Lutjanus gibbus


Grey Morey – Uropterygius marmoratus


Hawksbill turtle – Eretmochelys imbricate

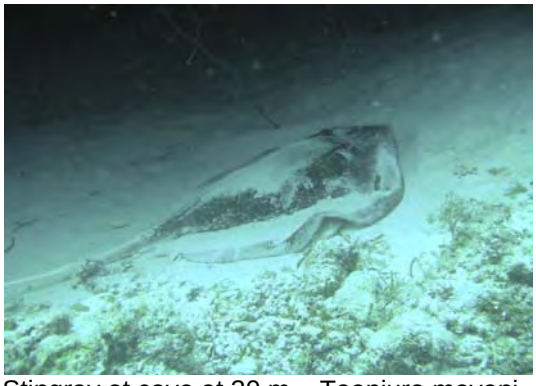

Stingray at cave at 30 m – Taeniura meyeni

Figure 6-12 - Samples of fishes, moray, sea turtle and stingray at the ocean side

Hard coral – Family Pocilloporidae

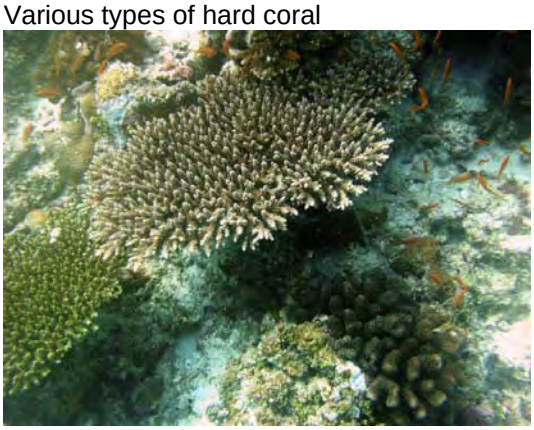
Hard coral – Family Agariciidae

Hard coral – Family Poritidae

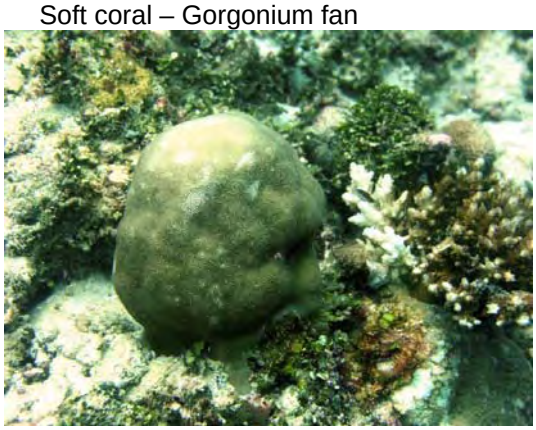
Soft coral – Family Alcyoniidae

Various types of hard coral

Soft coral – Gorgonium fan



Hard coral – Family Acroporidae



Hard coral – Family Faviidae

Figure 6-13 - Samples of soft and hard corals at the ocean side

In the island lagoon, there are bottom reefs with corals. Most the bottom reefs are small and only 5-20m in diameter (see Figure 6-14) The distances between the bottom reefs differ from 10 meters to more than 50 meters. At the reef bottoms there are limited groups of fishes (see Figure 6-15).

Figure 6-14 - Inside the lagoon with several dark bottom reefs at the sandy floor

Figure 6-15 - Sample of bottom reef with corals and fishes inside the island lagoon

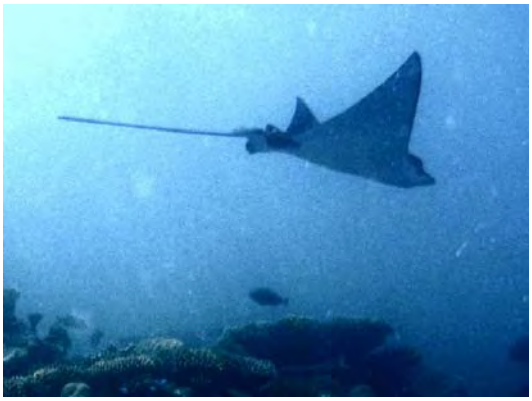
6.4.4 Reef atoll side

At the atoll side a slope is found from 2m to 10 to 20m deep. On the bottom mainly sand is found, with a few corals; the slope of sandy material does have a gentle steepness. A lot of corals can be seen on this slope, mainly of the family Acroporidae (see Figure 6-16), but also the family Poritidae, family Faviidae, family Fungiidae, family Pocilloporidae and the family Alcyoniidae. Some parts of the slope are covered with sandy material only.

Figure 6-16 - Sample of corals inside the atoll and some fishes

Several sea turtles, stingrays, spotted eagle rays were spotted at the atoll side, but no dolphins nor manta rays. A limited number of fish groups were spotted near the reef slopes. Samples of fishes including the moray, sea star, sea squirts, spotted eagle ray and three giant clams are presented in Figure 6-18. Samples of soft and hard corals in the atoll are presented in Figure 6-19.

Figure 6-17 - Sample of bottom reef with corals and fishes inside the atoll


Spotted Eagle Ray – Maetobatus narinari

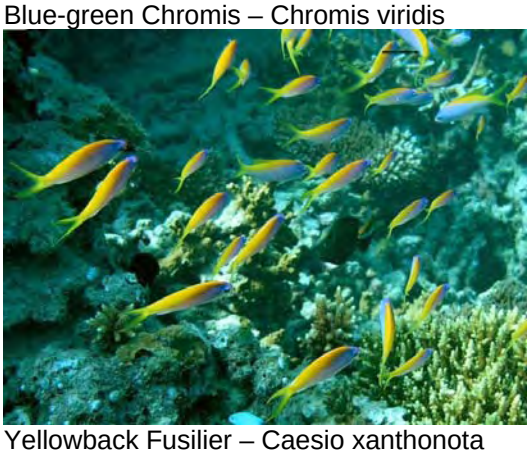

Trumpetfish – Aulostomus chinensis


Undulated moray – Gymnothorax undulatus


Giant clam – Tridacna crocea


Blue-green Chromis – Chromis viridis


Sea star – Family Oreasteridae


Yellowback Fusilier – Caesio xanthonota


Indian steephead parrotfish – Scarus S.

Figure 6-18 - Samples of fishes, sea star, spotted eagle ray and three clams at the atoll side

Hard coral – Family Acroporidae

Hard coral – Family Acroporidae

Hard coral - Family Poritidae

Hard coral – Family Faviidae

Hard coral - Family Fungiidae

Hard coral – Family Pocilloporidae

Soft coral - Family Alcyoniidae

Hard coral – Family Faviidae

Figure 6-19 - Samples of soft and hard corals at the atoll side

6.5 Fisheries

Fishing is an important activity in the Maldives in general but on Thulusdhoo it is less so, with about 100 fishermen
Hook and line tuna fishing, the methods used, involves catching baitfish from the inner atoll, using lights and nets. The baitfish is then held in tanks on the fishing dhonis (boats) until tuna are found.
It should be noted that fishing is not necessarily a fulltime occupation.
Fish processing – cooking and drying or wood smoking - is carried in the compounds and on a site near the landing area. Fresh fish is taken to canning factories in Male.
Catches are fluctuating; the best periods mentioned were June-July and November-December. Demand was seen as stable, but as a consequence prices are fluctuating with the catch.

Trends in fishing.
The last twenty years have seen a downward trend in catches, because of overfishing.

7 Description of Economic and Social Environment

7.1 Thulhusdhoo

Thulusdhoo's main feature is its proximity to the Capital Malé and the Hulumalé airport. It has a shallow well-protected anchorage on its west-side and there is a large seawater intake belonging to the Coca Cola factory in the new harbour area.
There is presently a Coca Cola dock and a dock owned by the government. There is a huge shed directly behind the quay wall. Safe anchorages are located north of entrance channel. The Police are excavating a new entrance north of the present one.

The State Trading Organization (STO) has one of its main warehouses for dried fish on the island. It is a transhipment point for dried fish and smoked and salted fish for export. Vessels from the northern atolls loaded with dried fish stop by at Thulusdhoo to sell their fish. In addition to these there are garment factories and a boat building facility that uses fibre-glass to build the traditional 'dhonis'.

Multilinx is another factory on Thulhusdhoo, specialised in packaging, bottles, cardboard etc.

Thulusdhoo is a centre of commercial activity. The eastern side of Thulusdhoo is famous for its surfs, aptly named 'Cokes', because of the Coca Cola plant on the Island.
The Thulusdhoo Island Lagoon has two other – small - islands, Huduranfushi and Gasfinolhu (or Mahureva) both developed as resort, called Lohifushi and "The Village" respectively. The Colosseum and the Aquarium are two popular diving sites on the eastern (= ocean) side of the Atoll.
Thulusdhoo has an area of 36.4 hectares as measured by the vegetation line and 36.6 by the beach line.

7.1.1 Drinking water supply

The abundant rainfall – some 2.000 mm a year - is the source of fresh water on the island. About 75 % of the houses have tanks collecting the water from the roof, which the source of drinking water.. The fresh water lens on top of the salty seawater underneath is source of cleaning, washing and gardening water.
The International Red Cross and Red Crescent society has installed a Reverse Osmosis Unit and Water distribution system on Thulusdhoo with a producing capacity for 5.000 people. Under the project of clean water system this is the first unit installed among the 20 units to be installed in different islands of Maldives. The Irish Red Cross is the main donor for the programme.

Facilities:

Public Water Tanks	6
Rain Water Tanks (Public)	1
Rain Water Tanks (Private)	225
Number of Houses with Water Pumps	103
Water wells	175, the quality is good
Number of Houses with Toilets	103
Houses without Proper toilet	153

7.1.2 Landmarks, cultural and heritage sites

Thulusdhoo is a typical Maldive island and as such quite characteristic, but there are no sites or buildings with an otherwise special status.

7.1.3 Island administrative offices

The Thulusdhoo Island office is central located and has the facilities - and internet access – necessary for its functioning.

7.1.4 Postal and other utilities

Thulusdhoo has an almost complete range of services and amenities, albeit not necessarily up to standard in all areas.

Communications
The communication with the outside world is fairly comprehensive. Mail is delivered, and there is a Post Office. Satellite TV is 'everywhere', cell phones have an excellent transmission, two masts on the island, no cyber café is present. Transportation in this island country is an important item. With the high oil price, people are complaining about the rise in costs, especially with medical care to be sought elsewhere. Small dhonis and speedboats maintain the connection between the islands.
Print media are not important, the size of population is too small and transportation is a major obstacle.

7.2 Socio-economic characteristics

7.2.1 Population

The population as per the 2006 census is

Gender	
Male	594
Female	555
Age structure	
0 - 18	466
19 - 25r	128
26 - 64	459
65 +	68
Rimbudhoo settlers	340
Foreign: India, Sri Lanka, Bangla Desh	400
Total	**1861**

The Rimbudhoo residents live in newly build temporary houses on factory land, on the east side of the Island, foreign workers are housed at the factories.

Housing

Number of boundary marked house plots	154
Number of houses boundary NOT marked	76
Fully built households	135
Fully not built households	11
Mosques (Ladies)	3
Mosques (Gents)	2

A few houses have two stories, most have one storey only. The land is government-owned, houses, 'compounds' are private.

7.2.2 Economy, present and future

No statistics on employment were available.
Fishing – men – **curing of fish** – women - and the tourist resorts are the main earners.
Women are employed in shops, restaurants, the Health Centre, school, and administration.
Building dhonis has come to a standstill because of problems with loans.
Tourism is mentioned, but the surfers and divers do not visit the island itself.
Handicraft, basket weaving, carpentry.
Home gardening is common practice. Fruits – banana, bread fruit, coconut, guava - are present in all compounds, and vegetables - cabbage, salad, herbs and the like – are grown along the streets and in the plots allocated to seasonal farmers.
Unemployment is not an issue.

Mobility
The island has a dredged harbour with good facilities, the Island harbour entrances have been deepened in 1992. The community started their own ferry to Malé (1,5 hour) which goes on a daily round trip. Fares are 25 Rfs for a single, and roundtrip 40 Rfs for a round trip.

Vehicles

Type	Number	Owner
Bicycle	4	Govt
Bicycle	163	Pvt
Cycle	11	Pvt
Taxi	1	Pvt
Van	1	Govt
Lorry	10	Pvt
Dumper	1	Pvt
Tractor	3	Pvt
Others	3	Pvt

Sea Transport

Vessel Type	Total	Used For
Mechanised Dhoni	3	Fishing
Yacht Dhoni	1	Travels between Malé and Atolls
Sathari Dhoni	1	Travels between Malé and Atolls
Boats	2	Travels between Malé and Atolls
Operational fishing vessels	3	

7.2.3 Unique cultural characteristics

Social structures
Differentiation within the Thulhaadhoo population is along tree lines:

- the local population, rather homogenous in background and culture (Traditional Islamic), including those from neighbouring islands; and the temporary foreigners (Bangla Desh, India, Sri Lanka);
- gender, with the women in a rather traditional position of household and typical female employment, women hold jobs in the school, the youth centre, hospital health centre, government offices and shops;
- Income, and hence education, this also within families. Some difference is found in the size of houses, but the minimum is simple, not poor.

Conflicts are not an issue, it was not mentioned. Drug use, with drugs brought from other islands was mentioned once.

Culture
The culture of the island population can be characterised as 'modernising, non-fundamentalist Islamic':

- Islamic: no alcohol to be found outside tourist resorts, Friday and Saturday 'weekend', prominent mosque and prayers in the 4 mosques, two for ladies, two for gents.
- Modernising: satellite TV and cell phones, 'everywhere', most women are wearing a head scarf, with young women in modern dress, the dress code is liberal.

7.2.4 Services

Health
Thulusdhoo health issues are 'normal', and although mosquitoes are abundant, there is no dengue fever reported.

The Health infrastructure has:

	Numbers
Personnel	
Medical Officers	1
Staff Nurses	9
Mid wives	2
Community Health Workers	1
Family Health Workers	2
Pharmacists	1
Laboratory Technicians	1
Total in Public Sector	14
Total in Private Sector	1
Total health Personnel	31
Facilities	
Public Health Centres	1
Public Pharmacy	1
Laboratory Facilities	1

Education
All children have to option to go to school, though it is not compulsory. Education is given in the local Divehi language and in English, and the school kids were all immaculately turned out in white uniforms.

The Thulusdhoo educational facilities are:

Atoll Education Centre	1, highest grade taught 10
Total Number of Students	308, the pre-tsunami number was 240
Pre-Schools (Day Care Centres)	1
Primary Schools (Grade 1 - 7)	1
Secondary Schools (Grade 1 - 8)	1
Vocational Centres	1
College Campus	1, Highest Grade: Certificate 3
Quran Classes	1
Teachers in Public Sector	28
Tutors in Private Sector	1
Administrative Staff	6

Electricity (STELCO State Electric Company)

Hours of power distribution	24 on 24
Power houses	1
No. of generators (Diesel)	3

Customers

Domestic	119
Govt	24
Business	34

Shops
Shops on Thulusdhoo are:

Public Shops	1
Private Shops	13
Fast Foods/Tea Shops	2
Carpentries	2
Pharmacy (Public)	1
Tourist Souvenir Shops	4

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

7.2.5 Tourism

Surfing at Coke point is the one specific tourism related activity in Thulusdhoo. However, the tourists stay on board their vessel at night, it is not allowed to stay overnight on the island without a permit. There is capacity (guest-rooms) at the community centre.

7.2.6 Land Allocated for Seasonal Farmers

Seasonal farmers in Thulusdhoo were allocated land as per availability for their farming needs. 47 applicants responded to a general announcement made by the island office, and the plots were allocated by lots. All plots allocated were 720 square feet in size, and were fertile enough to facilitate the seasonal varieties. The main purpose of this allocation was to improvise and support the local farmers and to encourage the. The land which was allocated, used to be a landfill and also the empty plots which were planned as future house plots.

7.3 Description of power structure, government

Thulhusdhoo is situated in North Male' (Kaafu) Atoll of the Middle Province of the Maldives. The Atoll capital is Maafushi.
Thulhusdhoo has an island counsellor, who reports to the atoll chief in Maafushi, who in turn reports to the government in Male'.

8 Public Consultation

8.1 Description of public consultation process

The socio-economic assessment, which was done in 2006, was organised along the following lines:

1. Meetings with government authorities, first in Malé with officials from the Ministry of Environment, Energy and Water, and then on Thulhusdhoo with the Island Chief (now Island Councillor) and his staff.
2. Introductory meeting organised by the Island Chief, attended by about 130 persons from the island as well as representatives from the Ministry and contractor Boskalis.
3. Introductory meetings with government offices, services and NGOs.
4. Follow-up meetings for more specific subjects pertaining to the people or institutions in question.
5. Visits to institutions such as the Health Centre, the Educational Centre, power plant, etc.
6. A series of interviews with fishermen and factory labourers
7. 'Random walk' interviews, covering the whole of the island, with interviews with both women and men, covering the age classes.
8. The interviews were conducted by a social impacts consultant and a professional interpreter. All people approached responded positively, the discussion was open and easy, and bystanders ventured opinions. No names were asked, or given.

The people of Thulhusdhoo can lodge their grievances over any government actions with the Island Chief. He will bring the issues to the attention of the Atoll Chief, who in turn will address the issues with the government in Male'.
Both the Island Chief and the Atoll Chief have the power to address certain issues without having to involve the government in Male'.

8.2 Summary of outcome of consultation

The attitude of all categories encountered towards the project was positive, people were thinking in terms of potential for development. No negative impacts of the project as such were identified.
The main problems mentioned by the people were, first and foremost the space issues and issues related to the availability of health care. The project was seen as an opportunity to tackle issues which would have to be taken on anyway.
It is strongly advised if not imperative to continue with an open (everybody is welcome) and structured (with an agenda – where are we now, and what is next -and proceedings) stakeholders' consultation, in order to mobilise and stimulate the present potential.

Main recommendation
The process of information and consultation is all-important, even a condition - for succeeding, in particular regarding the land use plan, and has to be continued in order to mobilise the potential and ideas present: the Thulhusdhoo people think about the project in terms of opportunities.
In particular the female part of the population will have to be stimulated to actively participate.

9 Assessment of Environmental and Social Impacts

9.1 General

This chapter discusses the environmental and socio-economic impacts, both during construction of the Safe Island and after construction has finished. It also discusses the different dredging and reclamation options and the option of No Construction and the environmental effects related to these options.

9.2 Environmental impacts during construction

The major environmental impacts during construction at Thulhusdhoo are related to:

- The selection of the dredging location and impact of dredging processes on benthic communities;
- Suspension of sediments caused by the dredging and reclamation works with effects on the marine ecology, and
- Waste handling and pollution control by the contractor

Smaller short term environmental aspects of the dredging and reclamation works at Thulhusdhoo are related to:

- Noise, light and air
- Socio-economic impacts (see paragraphs 9.5 and 9.6)

9.2.1 The dredging locations

There are four alternative locations for the mining of 800,000 m^3 of sand for Thulhusdhoo.

1. Mining sand by trailer dredger (TSHD) from the seabed in the atoll lagoon. In this case it is most likely that the dredging dept will be 1 meter or less; in that case the affected area will be some 800,000 m^2 for Thulhusdhoo.
2. Dredging sand (by cutter dredger/ CSD) within the island's own shallow reef area, provided there is enough space. The area affected, will be between 100,000 and 125,000 m^2.
3. Dredging sand (by cutter dredger/ CSD) within a lagoon present in the reef of the island.
4. Dredging sand (by cutter dredger/ CSD) within a shallow reef area nearby.

Since benthic organisms live in the top 30 – 40 cm of the seabed and on the seabed, the damage to the benthic communities at the reef flat area will be much smaller compared to dredging the atoll lagoon area. It is expected that on the sandy reef flat area, limited benthic communities are present, due to the limited water depth and the high water temperatures. On the sandy seabed areas in the atoll lagoon, it is likely that more benthic communities will be present.

Concluding: from an ecological point of view regarding the benthic communities dredging at the reef flat area or in the island lagoon is preferred over dredging in the atoll lagoon area. Whether to dredge in the island lagoon or on the islands shallow reef flat depends a.o. on the suitability of the material dredged for reclamation purposes; this will be decided after more detailed field investigations into local soil characteristics.

9.2.2 Suspension of sediments

The distribution of suspended sediments is related to three aspects:

- Dredging with a Cutter suction dredger at the flat reef area;
- Dredging with a Trailing suction hopper dredger at the atoll lagoon area;
- Outflow of the pumped water at the reclamation area.

Each of the dredging methods and the outflow of water from the land reclamation areas will re-suspend sediment to a greater or lesser extent in the open sea. This may cause significant effects on the coral reef areas.

CSD
A CSD is a stationary dredger, which dislodges the material with a rotating cutterhead mounted on a ladder. The cutterhead is equipped with cutting teeth. The loosened material is sucked into the suction mouth located in the cutter head by means of a centrifugal pump, which is installed on the dredge pontoon or on the ladder of the dredger. The amount of material not entering the suction mouth may be as much as 30% of the total dislodged material. Much of this material will fall immediately to the seabed and will be dredged on the next cut. Only the finer particles will stay in suspension and will be distributed throughout the water column by the local currents. With a CSD, the creation of turbidity is a more or less a continuous process. Due to the fact that a rather deep basin will be created by the CSD of about 6 – 7 meters depth, the majority of the suspended sediments will stay within this created basin. As the cut material will be disposed by a discharge pipeline to the land reclamation site no additional turbidity will be created at the dredging site. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local hydrodynamic conditions.

TSHD
A TSHD is a normal sea-going ship equipped with one or two suction pipes. At the end of each suction pipe is a draghead, which can be lowered onto the seabed while the TSHD navigates at a reduced speed. The material loosened by the draghead, together with some transport water, is sucked into the suction pipe by means of a centrifugal pump, and subsequently placed in the hopper of the dredger. The TSHD will transport the sediments to the shore connection, where the TSHD will be connected to a pipeline system.
Most of the turbidity generated by a trailer suction hopper dredge is caused by the overflow of turbid water during the hopper filling operations. Overflow is the flowing overboard of excessive process water, together with a part of the finer material. Overflow is caused by continued loading after the hopper has been filled to its maximum. When dredging pure sandy sediments the amount of overflow of particles is mainly determined by the grain size distribution of the dredged sediment. It is to be noted that the overflow process will not be a continuous activity, since its duration will be limited to operational dredging time, which is usually less than half the total cycle time.
The suspension of sediments and the effects on the coral reefs will mainly depend on the grain size distribution, the local currents and the distances to the coral reef areas. As no dredging site has been identified within the lagoon no relevant impact can be assessed.

Outflow of the pumped water
The reclamation works can result in considerable volumes of sediment escaping into the water column and this will affect the local marine habitats and may cause significant turbidity and sedimentation at the coral reef locations. To prevent this, it is necessary to construct permanent or temporary bundwalls around the reclamation areas in the shallow water, using suitable materials. This is needed before the land reclamation will be carried out. In addition correct adjustable weirs have to be installed at the outflow area.
Working with a reclamation area that was fully enclosed by bunds and included settling (or siltation) basin(s) proved very effective in minimising the release of suspended sediments to the ocean during the reclamation works at Viligili and Vilufushi.

9.2.3 Waste handling and pollution control

At the working sites on land, as well as on board the construction vessels, waste water, oily wastewater and solid waste will be produced. To prevent pollution of the coastal waters the following restrictions are set:

- AII the construction vessels need to be equipped with wastewater and solid waste handling facilities, to collect and handle the wastewater and the solid waste generated by each vessel. Disposal of wastewater and solid waste directly into the sea is not allowed.
- Oily wastewater and oily contaminated material generated from the construction machinery during the construction activities is also not allowed to be discharged directly

into the sea. These wastes need to be collected and transferred back on shore for treatment/disposal, to avoid causing any adverse impact on the marine environment.

- Solid construction wastes generated during offshore construction works are also not allowed to be discharged directly into the sea. They shall be collected and transferred for onshore disposal, to avoid causing of any adverse impact on the marine environment.

9.2.4 Noise, light and air quality

Dredging and reclamation works will continue 24 hours per day.

Noise
Experience from the projects at Viligili and Vilufushi has shown that the dredge (in those cases a CSD) cannot be heard on the island while it is working. Distance from the island to the dredge varied from 100m to 500m. A TSHD generates a similar amount of noise while pumping material ashore as a CSD, so no noise impacts are expected from the dredges.
At the reclamation area, bulldozers, excavators etc will be working non-stop. This will generate some noise at the houses located closest to the reclamation area, but this noise will be less than that experienced at the houses located next to the power generators for the island.

Light
When using a CSD to dredge sand from the reef around the island, the CSD will be visible day and night. Lighting on deck is necessary to maintain safe working conditions during the night. The lights can be directed away from the surrounding water as much as possible, as long as this does not jeopardise safe working conditions.
When using a TSHD, the dredge will be near the island at intervals. Same as on board a CSD, lighting on deck is necessary to maintain safe working conditions. These lights can be directed away from the surrounding water as much as possible, as long as this does not jeopardise safe working conditions.
The reclamation area will be lit during night times to maintain safe working conditions. These lights can be directed away from the surrounding areas as much as possible, as long as this does not jeopardise safe working conditions.

Air quality
The dredge and other floating equipment owned by Boskalis are subject to the Dutch shipping inspectorate and thus comply with Dutch norms for air emissions. Due to the open nature of the working areas (enough ventilation) the impact is assumed to be light. Nevertheless, the following actions should be undertaken in order to ensure that pollution of the atmosphere is minimised:

- The engines will be maintained in good working conditions, so that exhaust emissions of pollutants will be kept to a minimum.
- With complete combustion, emissions of soot particles, hydro carbons and carbon monoxide are minimised.
- The vessels will be subjected to regular inspection and maintenance programs as regular practise.

Equipment used on land will also be subject to regular maintenance in order to minimise emission of pollutants to the air.

Since the dredging activities take place entirely in a wet environment dust problems will not be encountered.

9.3 Boskalis SHE-Q

Royal Boskalis Westminster nv has ISO 9001, ISO 14001 and OHSAS certifications. The requirements of these certifications are met through company-wide Safety, Health, Environment and Quality system (SHE-Q), which provides clear procedures for safety, health and environmental management both at offices and project sites around the world.
Boskalis applies the same SHE-Q standards at all its projects around the world and to all its employees and subcontractors. These standards meet Dutch and international OSHA and environmental requirements, and are adjusted if a client has even more stringent requirements.

All vessels are IMS certified and have to meet international standards for waste, hazardous materials and sewage management, and fire, oil spill and other emergency response and prevention. Appendix 3 contains the framework that is used to make a specific Environmental Management Plan for each individual project that Royal Boskalis Westminster undertakes. Similar frameworks are applied for project specific Safety and Health Management Plans.

9.4 Environmental impacts after construction

The major long term aspects for the dredging and reclamation works at Thulhusdhoo are related to:

- Loss of marine habitats due to the land reclamation;
- The safety of the local population and the land ecology;
- A large basin within the shallow reef flat;
- Alien species transported to the island
- Increased population.

9.4.1 Loss of marine habitats

The land reclamations to enlarge both islands will result in a permanent loss of marine habitats and resources. However, the land reclamation is limited to a part of the shallow reef area and will not destroy the coral reef areas at the lagoon side and the ocean side.

9.4.2 Safety of the population and the land ecology

The existing islands are partly less than 1.2 meter above MSL. Due to the changing climate conditions, the sea level rise is estimated at about 0.5 cm per year. This means that serious threats to the population and the land ecology of Thulhusdhoo island exists during storm periods and the additional risks of tsunamis. Due to the higher land reclamation and the bundwalls around the island up to +2 meters above MSL, the risks for both the population and the land ecology is strongly reduced.

9.4.3 A large basin at the shallow reef flat

The borrow area for the land reclamation works may be located inside the shallow reef flat. A basin will be created with a depth of 7 – 9 meters. Due to the wave activities and the local currents it is likely that sand will be transported from the surrounding areas into the basin area. In time this may result in changes in bathymetry and morphology around the borrow area.

9.4.4 Alien species

Ships and vessels selected for the construction works are likely to come from areas outside the Indian Ocean. These vessels may contain foreign ballast water. Ballast water is fresh or saltwater held in the ballast tanks and cargo holds of ships. It is used to provide stability and manoeuvrability during a voyage, or when more stability is required due to rough seas. Organisms living in coastal waters may be pumped into ballast tanks along with the water. If a ship takes on ballast water in a shallow area, sediments and any associated organisms may be pumped into the ballast tanks. When ballast water is released, these organisms may also be released.
The release of ballast water may introduce non-native organisms into the Maldives coastal waters. These introduced species, or bio-invaders, are also referred to as exotic species, alien species and non-indigenous species. Typically, very few organisms are able to survive in new surroundings because temperature, food, and salinity are less than optimal. However, the few that do survive and establish a population have the potential to cause ecological and economic harm. Populations of bio-invaders may grow very quickly in the absence of natural predators. In turn bio-invaders may displace native organisms by preying on them or outcompeting native species for food and habitat space. Economic damage may occur when a bio-invader displaces species that are harvested for food or other goods, or when bio-invaders damage structures. Worldwide, the introduction of foreign species is a leading environmental issue.
The introduction of alien invasive organisms is now considered to be one of the most serious threats to the biological diversity of the Maldives.

To prevent exotic species from being introduced in the Maldives, all dredging and auxiliary vessels that are brought into the Maldives will follow international conventions and regulations regarding ballast water.

9.4.5 Increased population

An increase in population will lead to more waste and sewage being generated. This creates an increased need for sustainable waste and sewage management to ensure safe and healthy living conditions on the island.

9.5 Social impacts during construction

The effects and impacts of the dredging and filling on the present island and its population are rather limited. A dredger, including the crew will be out on the sea. Relocation and the like is not an issue, neither people nor the built-up area will be affected.
On the Island a small number of people will be active and 10 – 20 people, local or from elsewhere, will be employed for something like 6 -8 weeks. All this is well within the range of what is going on the Island at any given time and there are no specific categories of people which could be vulnerable anyway. Taking on the access to the jetty as early as possible will already solve a major problem
With Boskalis´ wide experience in such matters there are no special issues to be addressed. Continual contacts and access to information and issues arising will be an integrated part of the operation.

Rocks needed for the revetments will be sourced from India. The subcontractor responsible for the construction of the revetments and the supply of the needed materials, MT Hojgaard, has issued a statement regarding the absence of child and forced labour at the quarries they contract (see Appendix 5).

9.6 Socio-economic impacts after construction

- increased safety against storms, flooding, sea level rise,
- ensuring more sustainable economic growth.

The social-economic impacts of the project are really big in relation to the number of people and the size of the economy. These impacts are expected to be positive. No potentially adverse effects have been identified, the risks do not appear to be evident.
The outcome means land for:

- housing
- schools: classrooms
- a hospital
- recreation and a youth centre
- industrial developments, a fish market

This, together with the new harbour and better access to the jetty in the meantime, which will improve current conditions and give an impetus to (economic) development.

In addition, the revetments and EPZ will provide more safety for the people and the economic activities against flooding.

9.7 Comparison of No Development and different dredging & reclamation options

For this EIA there are two main options, which are (1) no-construction at all and (2) the accepted construction of the Safe Island. Regarding the overall design of the safe island there are no alternatives, but there are several alternatives with respect to construction methods. This paragraph discusses the impacts on the natural environment related to no-construction and the alternative construction methods.

9.7.1 No construction

In case the construction of Safe Island Thulhusdhoo would not take place at relatively short notice, the direct impacts on the land and the marine environment would seem to be neutral. In the somewhat longer term some environmental impacts will take place, mainly due to the fact that the pressure on the marine environment will increase. The more people living on the same island-surface, the more waste and wastewater will end up at the eastside in the sea. For the same reason groundwater quality will no doubt deteriorate.

9.7.2 Dredging alternatives

The project requires up to 0.5 million m^3 of suitable fill sand. The possible sources of fill material are the following:

- Option 1: Sand from the shallow reef flat area next to the island to be dredged by a CSD (cutter suction dredger) with a pipeline system, as planned;
- Option 2: Sand from the bed of the lagoon in the atoll to be dredged by a TSHD (trailing suction hopper dredger) with a pipeline system;
- Option 3: Sand and coral material from a coral reef (faro) elsewhere in the lagoon to be dredged by a CSD;
- Option 4: Sand imported from overseas by a jumbo trailer (very large trailer).

Option 1 is the most attractive location both from an economic and an environmental point of view (see also chapters 4 and 5).
Option 2 is a realistic alternative depending on the water depth of the seabed in the lagoon, and the available quantity of sand within the lagoon. Sand mining in the lagoon can be done by a Trailing suction hopper dredger. As the water depth is between 40 – 80m a large TSHD is required.
Option 3 will cause considerable damage to the environment.
Option 4 will result in very high costs.

Options 3 and 4 are not considered anymore in this report from here on.

9.7.3 The dredging location and its impact

Two alternatives locations for sand mining for the reclamation can be used. The selected area is located on the shallow flat reef area; an alternative is dredging sand from the seabed in the lagoon.

Dredging within the shallow reef flat by a CSD (option 1) will affect an area of about 70,000m^2. The created depth within the dredging area will be about 6 – 7 meter. In case dredging is carried out within the lagoon by a TSHD (option 2), it is most likely that the dredging depth will be less than 1m. In that case the affected area will be at least 500,000m^2, which is 6-7 times larger than in case of dredging within the reef flat.

Since the benthic organisms are living in the top 30–40cm of the sea bed and on the seabed, the damage to the benthic communities when dredging at the reef flat area will be limited to 20%, compared to dredging in the lagoon area. Also it is expected that on the sandy reef flat area, limited benthic communities are present, due to the limited water depth and the high water temperatures, the more so since the coral bleaching effects of 1998. On the sandy seabed areas in the lagoon it is likely that more benthic communities will be present.

Working with a TSHD in the atoll will generate a source of suspended sediments in a location further away from Thulhusdhoo. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected.

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

9.7.4 Resuspension of sediments

The distribution of resuspended sediments is different for the dredging processes:

- Dredging with a cutter suction dredger at the flat reef area;
- Dredging with a trailing suction hopper dredger at the lagoon area.

Each of these dredging methods will cause resuspension of sediments; this may in turn have significant effects on the coral reef areas.

CSD (option1)

A CSD is a stationary dredger which dislodges the material with a rotating cutter-head. During the dredging process part of the finer particles will stay in suspension and may be distributed by the local currents. To assess how the suspended sediments are spread over the coral reef areas, it is necessary to consider the local current regime (see chapter 6). Given the limited water depths over the reef (0.5 to 1.0m) this effect will be rather small at most times. Furthermore, due to the fact that a rather deep basin will be created by the CSD (depth 6-7 meters), the majority of the suspended sediments will remain within this basin.

TSHD (option 2)

A TSHD has one or two suction pipes and dragheads; the material is loosened by the draghead from the sea bottom, sucked into the suction pipe and placed in the hopper of the dredger. The material is then transported to an offshore disposal site where the dredger is connected to a pipeline system for discharging. Most of the turbidity generated by a TSHD is caused by the overflow of water and part of the finer materials during the hopper filling operations. The resuspension of these sediments and the effects on the coral reefs will mainly depend on grain size distribution, local currents and distance to the reef. The relevant impact has not been assessed (no specific borrow area has been selected), but is probably manageable.

Table 9-1 comparison of dredging options

Dredging alternatives	No dredging	CSD/ reef	TSHD/ lagoon	CSD/reefs in atoll	TSHD/ overseas
Environmental impacts					
Disturbed bottom m^2	0	125,000	800,000	250,000	800,000
Turbidity	0	+	+ +	+ + +	+ + +
Loss of sea grasses	0	10%	0	0	0
Loss of corals	0	+	+	+ + +	0
Loss of macro benthic	0	+	+ + +	+ + +	+ + +
Loss of fishes	0	+	+ +	+ +	+ +
Loss of vegetation	0	+	+	+	+
Groundwater	+	0	0	0	0
Alien species	0	0	0	0	+ +
Economic impacts					
Costs dredging	0	+	+ +	+ + +	+ + + +
Total	**0**	**+**	**+ +***	**+ + +**	**+ + + +**

0 = no impact,
+ = small impact,
++ = medium impact,
+++ or ++++ = big impact.
* The increased overall impact is mainly caused by the fact that dredging with a TSHD leads to a second area being exposed to increased suspended sediments concentrations. However, this area would be less sensitive, as it would be chosen well away from coral reefs.

10 Selection of Preferred Alternative and Mitigating Measures

10.1 Preferred Alternatives

From an ecological point of view regarding the benthic communities, fisheries, corals and sea grasses, dredging with a CSD at the reef flat area is a better option than dredging in the lagoon area. The only damage at the reef flat is the destruction of some of the sea grass area, but as the water will be rather clear, sea grasses can recover at the bottom of the borrow pit.

Working with a TSHD in the atoll will generate a source of suspended sediments in a location further away from Thulhusdhoo. Although the TSHD will dredge away from coral reefs and patches, the benthic fauna living on and in the seabed at the borrow area will be affected.

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

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

Based on these results, dredging sand from a borrow area inside the reef near Thulhusdhoo by CSD is the preferred option. Dredging sand in the atoll by TSHD is a viable second option, if the borrow area is chosen properly (ie. Away from coral reefs and patches, resorts, dive sites, Marine Protected Areas and other sensitive receivers)

10.2 Mitigating Measures

10.2.1 Preventative measures

The following preventative measures will have to be taken at the reclamation area:

- Construction of bunds to fully enclose the reclamation area before the start of dredging and reclamation works to minimise the loss of suspended sediments from the reclamation area.
- Construction of one or more settling basins (depending on the final layout of the reclamation area), to further minimise the loss of suspended sediments from the reclamation area
- Ensuring that there will be settling basin space available at all times until the dredging works have completed by creating of a stockpile of material that will be used to fill the final phase of the reclamation area.
- Choice of location of the TSHD borrow area away from coral reefs, coral patches, Marine Protected Areas, resorts and dive sites.
- Dredge the entrance to the CSD borrow area at the minimum depth and width necessary for the CSD to move into the borrow area. The borrow area itself should be dredged deeper. The threshold that is created this way will help reduce the dispersion of suspended sediments from the borrow area

10.2.2 Mitigating measures

The following mitigating measures will have to be given consideration during the detailed engineering and preparation phases of the project:

- Construction of bunds around the borrow area in the reef flat to minimise effects of the currents running over the reef on the borrow area. This may help minimise the dispersion of suspended sediments from the borrow area
- Use of limited overflowing when dredging sand from the atoll seabed by TSHD. Limiting overflow has large consequences relating to the cost of the dredging operations.

11 Environmental Monitoring Plan

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

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

11.1 Information needs

Several parties are involved in this project, including several ministries, the contractor, the local residents and the fishery communities. Each of these parties has its own interests and concerns and consequently specific information is needed.

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

- water quality aspects, including suspended sediments and sedimentation;
- ecological aspects related to coral;
- soil salinity;
- the re-colonization of the borrow area at the flat reef;
- erosion around the borrow area.

11.1.1 Water quality aspects

Information need: what is the actual effect of the dredging and reclamation activities at the islands on the water quality?

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

Due to the re-suspension of the fine fraction of the coral sand, dispersion and resettling of the sediments during the dredging and the reclamation activities, a wide range of effects can be caused, including damage to coral and other organisms that cannot leave the area to escape the increased suspended solids. If the turbidity level is continuously high for a period of 3 months or more, significant damage can occur to coral. Significant sedimentation will also cause damage to coral and other sessile organisms. In the EIA a wide range of mitigating measures has been selected to minimize the re-suspension and dispersion and sedimentation of suspended sediments at the reef flat. Experience with a similar project on the island of Vilufushi in Thaa atoll has shown that there are two very important mitigating measures to reduce the release of suspended solids into the ocean.

The first one is closing off the reclamation area from the ocean by placing a bund before reclamation activities start. By doing this, the inevitable run-off from the reclamation can be concentrated in one location, minimising the area that is impacted.
The second important mitigating measure is using sufficient space to allow the finest particles to settle out of the reclamation run-off water before it is released to the ocean. The more fine particles can settle in the reclamation area and/or settling basin, the fewer fine particles get released into the ocean.
Due to the mitigating measures, the potential reduction of oxygen levels will also be minimised.

However, because the exact effects of the dredging and reclamation works at the islands can't be predicted in detail, it is necessary to monitor the actual effects of the works on water quality. In

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

- to evaluate the effectiveness of mitigating measures already in place, such as the bund closing off the reclamation area from the ocean and the settling basing
- to signal the need for additional mitigating measures, such as the placement of silt curtains and adjustments in the dredging and reclamation processes.

The effects of dredging and reclamation on water quality are directly related to the working activities and the local physical characteristics, like the currents and waves. It is recommended to periodically monitor the currents along the reef on the atoll side of the islands to get more information on where the suspended sediments released at the borrow and reclamation areas may be transported to by the local currents.
During the construction of the reclamations at Vilufushi and Viligili, the suspended sediment plume did not disperse further than 2.5km away from the source under poor conditions. Suspended sediments settled within 2-5 days.

11.1.2 Ecological aspects related to coral.

Information need: what can cause damage to coral?

At the shallow reef area around the island there is hardly any coral. After the surveys at the shallow reef areas it is estimated that the life coral is less than 1%. Even at the reef edges there is practically no coral coverage. This is mainly due to the coral bleaching in 1998 and the tsunami in December 2004. Consequently at the shallow reef no monitoring of coral is required. At the 8 line transects that were surveyed around the shallow reef area, the life coral coverage varies from 8% to 15% at the ocean side and from 29% to 57% at the atoll side.

Turbidity and sedimentation
If turbidity levels are significant during several months, the light available to the coral is reduced and consequently coral colonies may die. The critical value of turbidity for coral is 50mg/l. Sedimentation on coral is quite different. Soft corals and branching corals are less vulnerable than massive and table corals. The critical value for sedimentation on corals is 0.1kg/m^2/day. Most coral species have a mechanism to clean very fine sediments off of their surface, but they have difficulty cleaning off coarse sediments.

11.1.3 Soil salinity

Information need: can salt contained in the sediment used for the reclamation cause damage to the fresh water aquifer of the existing island?

By creating many low stockpiles instead of one big stockpile at the reclamation area, the rain will wash the salt from the sand on the reclamation area. The aquifer beneath the reclamation area will still be salt, so no effect is expected in the aquifer beneath the existing island. Any sand that needs to be put on the existing island will be transported by bulldozers (not using pipelines). Consequently there will be no impact on the aquifer. However, the sand can only be transported in case the rainfall has removed the salt.

11.1.4 The re-colonization of the borrow area at the flat reef

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

Re-colonisation of meiobenthos (< 1mm) is a much faster process than the recovery of the macrobenthos (>1mm). Complete restoration of the nematodes community can take place within some days. The restoration of the macrobenthos community after the sand extraction depends on the degree in which the new substrate is arranged for re-colonisation and establishment of larvae. Due to the presence of sea grass in the area, it is likely that the sea grass will cover the bottom of the borrow pit. The biological period of recovery can take place within some months to 2 or 3 years. It is expected that a lot of fish and benthic organisms will use this new area.

11.1.5 Erosion around the borrow area

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

The borrow area created by a TSHD will be located at relatively large depth (15-20m), will be shallow, but have a large area. At these depths, waves will not hit the seabed to stir up sediments.
It is expected that currents will barely influence these borrow areas, since the fastest currents run through the channels between islands and reefs where no dredging of sand will take place.

The borrow area created by a CSD will be located in the reef flat, and will have a basin-like shape. When sediments are stirred up by wave action, they will be trapped in the borrow pit. As a result the borrow area will silt up slowly. However, in time the sea grass may (re)grow around the borrow area, where it will trap the sand. Consequently only a limited quantity of sand will be transported to the borrow area by the currents.

11.2 The monitoring program

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

- water quality monitoring;
- sedimentation rate monitoring;
- erosion around the borrow area;
- recolonisation of the borrow area.

11.2.1 Water quality monitoring

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

General parameters to be recorded during sampling and measurements

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

Parameters to be measured in situ

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

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

Parameters to be measured in the laboratory

- suspended solids (mg/l)

Methodology
For water quality monitoring the following equipment is required:
a survey vessel with DGPS positioning equipment;

- dissolved Oxygen and temperature measuring equipment;
- turbidity measurement equipment;
- water depth gauge;
- water sampling equipment.

Locations and frequency
The sampling and monitoring locations for the water quality will be determined at a later stage, after detailed engineering has been finalised, but before the dredging and reclamation works start. Prior to the start of dredging activities a baseline survey will be done.
During detailed engineering, the monitoring programs for the Three Islands will be integrated in such a way that water quality data will be gathered before the start of dredging and reclamation works, during dredging and reclamation works, and after the completion of dredging and reclamation works.

Table 11-1 water quality sampling and monitoring

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

Maximum value
The maximum value of turbidity for coral is 50 mg/l.

11.2.2 Sedimentation rate monitoring

Sedimentation rate monitoring should be carried out by the environmental monitoring team to ensure that a proper assessment is made of the sedimentation levels on coral. The objective of the sedimentation rate monitoring program is to determine the effectiveness of the operational controls and mitigation measures employed, and the need for supplementary mitigation measures to protect the coral.

General parameters to be recorded during sampling and measurements:

- Location;
- time and date;
- weather conditions;
- sea conditions;
- tidal mode;
- monitoring depth.

Parameters to be measured in the laboratory:

- sedimentation rate (kg/m^2/day).

Parameters to be assessed by a scuba diver (visual inspections):

- percentage coral covered with sediment.

Methodology
For sedimentation rate monitoring the following equipment is required:

- survey vessel with DGPS positioning equipment;
- sediment trap tubes to be placed at the monitoring locations;
- scuba diver with photo/video camera.

Locations and frequency
The sampling and monitoring locations are indicated in Table 11-2. The frequency and the monitoring and sampling depths are indicated in Table 11-2.

Table 11-2 sedimentation rate monitoring

Type	Parameters	Locations	Frequency
Placing and collection of sediment trap tubes Approx 1m above seabed	Sedimentation rate (kg/m^2/day)	Half the locations on the reefs (depends on location of reclamation and the local currents).	1 time per fortnight during dredging and reclamation works + 1 time after completion of the dredging and reclamation works
Visual inspection At coral areas investigated during the baseline benthic surveys	Coral coverage with sediment	All locations	1 time before the start of the dredging and reclamation works + once per week during the dredging and reclamation works + 1 time after completion of the dredging and reclamation works

Maximum value
The maximum value for sedimentation on corals is 0.1 kg/m^2/day.

11.2.3 Erosion around the borrow area

It is expected that the erosion around the borrow area will be rather limited due to the presence of the sea grass. The local authorities will have to check this area. In case significant erosion takes place some rubble coral material can be placed around the borrow pit in order to stabilise the slope.

11.3 The monitoring reports

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

Based on the weekly monitoring results the effectiveness of the operational controls, the mitigation measures employed and the need for supplementary mitigation measures will be discussed between the Engineer and the contractor on a weekly basis. In case of extreme urgent matters a meeting between the engineer and the contractor will be arranged within 24 hours. The weekly reports shall be submitted to the engineer, the employer and the contractor.

11.4 Monitoring after construction

In the year(s) after construction of the reclamation and revetments has been completed, will be undertaken by the Ministry of Housing, Transport and Environment (see appendix 6 for letter of intent),

At the reclamation area, it is recommended that the following aspects are monitored:

- Signs of erosion and/or sedimentation
- Recolonisation by benthic flora and fauna at areas that were affected by the construction
- Condition of the revetments

At the borrow area, it is recommended that the following aspects are monitored:

- Sedimentation and/or erosion inside the borrow area and at the entrance (in case of dredging with CSD)
- Recolonisation of the borrow area by benthic flora and fauna
- Stability of the reef outside the borrow area (in case of dredging with CSD)

Additionally, the land use plan needs to be finalised, after full consultation with the Thulhusdhoo community, and progress of the implementation of the land use plan needs to be monitored by the Ministry of Housing, Transport and Environment.

12 Conclusions

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

- The development of Thulhusdhoo as a Safe Island is acceptable from an environmental point of view, and project risks are relatively small.
- The reclamation of Thulhusdhoo with the EPZ and the higher bundwalls with revetments on the exposed sides can be done with minimal impacts on the environment, provided that preventative measures (closed reclamation, use of siltation basins) are implemented during construction and further mitigating measures are implemented when necessary.
- During detailed engineering, choices will be made regarding the final location of the borrow area and the final shape and size of the reclamation area. Environmental impacts, as well as economic feasibility, will be important factors in making these choices.
- During the dredging and reclamation activities, good care should be taken to allow only a pre-determined minimum of suspended sediments (50 mg/l) to escape from the working areas. Preventative measures will be in place to ensure minimal loss of suspended sediments, and additional mitigating measures will be available for implementation should the need arise. Monitoring should concentrate upon these aspects.
- Some coral reef will be damaged at locations where dredging takes place. All feasible measures will be taken to minimise the amount of coral damage by dredging the absolute minimum required depth and width to create access to the sand borrow area.

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

- consultations took place in an open and positive atmosphere, from both the local authorities and the population at large;
- the creation of the new land is widely seen as proving opportunities for development;
- infrastructure issues are lack of space, for school and hospital capacity
- no negative effects – under the preposition of careful planning and execution - are identified
- In case the island would not be provided with some kind of protection against the sea and not be increased in size, in time the population will have to move to other (safer?) islands.

13 Appendices

1. IFC Performance Standards cross reference table
2. ToR approved by GoM
3. Boskalis SHE-Q
4. Thulhaadhoo preliminary land use plan
5. Letter from MTHojgaard regarding labour at quarries
6. Letter from Government of Maldives stating intent to continue environmental and social monitoring after completion of construction

14 References

1. *Environmental Impact Assessment Regulations*, Ministry of Environment, Energy and Water, Government of the Maldives, 2007

2. *International Finance Corporation's Performance Standards on Social & Environmental Sustainability*, International Finance Corporation, World Bank Group, 2006

3. *International Finance Corporation's Environmental Health and Safety Guidelines for Ports, Harbours and Terminals*, International Finance Corporation, World Bank Group, 2007

4. *EIA for the Post-tsunami Reconstruction of Safe Island Vilufushi, Thaa Atoll*, EDC, 2005

5. *EIA for the Construction of Safe Island Viligili*, EDC, 2006

6. *National Environmental Action Plan III*, Ministry of Housing, Transport and Environment, 2008

7. *National Strategy for Sustainable Development*, Ministry of Housing Transport and Environment, Government of the Maldives, UNEP, 2009

Appendix 1

Cross Reference Table IFC Performance Standards

IFC PS #	Title	Points of Attention	Found in EIA
1	Social and environmental impact assessment and management systems	• Conducting EIA and/or SIA • Involve local communities in EIA/SIA process • Management of environmental and social issues through a management system	Main report contains EIA and SIA See Chapter 7 & 8 See par 4.7 & 9.3
2	Labour and working conditions	• Labour-Management relations • Equal opportunities, no discrimination • Meet Legal requirements • Prevent child and forced labour • Safe and healthy working environment	See par 4.10 See par 4.10 See App 2 See par 7.2.1, 9.4 and App XX See 4.7, App 2
3	Pollution prevention and abatement	• Prevention/mitigation of the risk of effects to public health and the environment	See App 2
4	Community health, safety and security	• Prevention/mitigation of the risk of effects on health and safety of local community during project cycle, under normal and special circumstances • Protection of personnel and property	See par 4.7, ch 9, app 2 See 4.7, ch9, App 2
5	Land acquisition and Involuntary resettlement	• Preventing of minimising forced relocation where possible. • Mitigating social and economical effects of land acquisition or restriction of use of land that is in the possession of (private) stakeholders • Improvement or at least reinstatement of standard of living for relocated people	Not applicable. There will be no relocation of island inhabitants Not applicable. The project will create new land, rather than require land acquisition. Not applicable. No relocations of people will take place
6	Biodiversity conservation and sustainable natural resource management	• Protection and conservation of biodiversity in natural, impacted and critical habitats • Measures to minimise the net loss of biodiversity • Projects in critical and protected areas need to meet requirements of	See Ch 6, 9, 10, 11, 12 See Ch 9, 10, 11 See Ch 6, 9, 10, 11

		management plan for these areas • Use of renewable natural resources should be sustainable, especially use of natural or planted forests, fresh water and marine systems (fisheries)	
7	Indigenous peoples	• The definition of indigenous peoples can differ between countries. Effects on these groups should be avoided. • When this is impossible, effects should be minimised, mitigated or compensated (Indigenous Peoples Development Plan) • Consultation. Participation and providing information to the local community are part of the project • Development benefits have to be defined in line with the project. • Effects on cultural heritage sites should be avoided or minimised. • If required, relocation may be offered to an alternative location that has similar amenities to the original location. Need to meet PS 5 • The use of cultural resources for commercial purposes needs to be compensated after consultation	There are no indigenous minorities on the islands. All residents are affected equally. See Ch 7, 8, 9 See previous point See Ch 8 See Ch 1, 2, 3 Not applicable. The project creates land, rather than using existing land. Not applicable as there will be no relocations. Not applicable.
8	Cultural heritage	• The PS applies to all cultural heritage whether protected by law or not, whether disturbed or not. • Both National and International law are applicable. • When the status of the heritage is not clear, an expert will be hired to assess the situation • Cultural heritage may in principle not be removed. In case of relocation, an assessment needs to be made of alternatives and the benefits of the project and whether they justify the removal of the cultural	None of these items are applicable. Dredging and reclamation activities will be done well away from any cultural heritage sites.

		heritage. • Consultation with stakeholders whose heritage may be affected is part of the project. • The use of cultural resources for commercial purposes needs to be compensated after consultation	

Appendix 2

Terms of Reference – EIA Three Islands

Problem analysis and project objectives

In the EIA report the following aspects should be addressed:

- Relationship with New Safe Islands Project, which has been developed to address the problems of sea level rise and increased extreme weather conditions, while at the same time aiming at concentrating population to provide better services and infrastructure;
- Whether and how environmental considerations played a role in the selection of Thulhaadhoo;
- Description of the living conditions including public health situation and safety aspects;

The main objective of the project is to create a safer and larger island for the present residents as well as for residents of some other smaller nearby islands who may move to the enlarged islands. The planned activities for this phase of the project are restricted to dredging, land reclamation, shore protection and the improvement of the harbour. The EIA report should also indicate required follow-up activities to fully contribute to the solution of the problems as identified in the preceding section.

The EIA report should contain a clear definition of the objectives of the proposed activity to enable identification and formulation of alternatives and to furnish criteria for monitoring and evaluation. Objectives should be formulated in such a way that identification of alternatives – meeting the same objectives- remains possible. Finally, the objectives should be specific and if possible quantified.

Project Setting

The EIA report should describe national laws, rules, regulations and policies governing the proposed activity and if relevant, international conventions and regulations. The EIA report should assess the probability of compliance of the intended activity with these legislative and regulatory considerations and policies.

The EIA report should give a clear description of the legal and administrative framework in the Maldives, including competent (licensing) authorities directly involved in the execution of the project and in the control of the executed works. A description of the EIA procedures to be followed is provided in the Environment Act 4/93 and in the EIA guidelines (2007).The EIA report must also indicate which competent (licensing) authority is committed to the follow-up activities once project activities are finished and how maintenance of the works will be secured.

The EIA report should contain a description of the stakeholders in the project and how their opinions and interests influenced the contents of the EIA report. The views of the following stakeholders should be taken into account:

- Project beneficiaries, men as well as women (inhabitants of Thulhaadhoo);
- Local fishermen possibly affected by dredging works;
- National, regional (atoll and island) government agencies with formal responsibilities in environment and social welfare, and
- National and international organizations (including NGOs) involved in the implementation of the project and follow up activities.

The EIA report must indicate in which way the inhabitants are involved in the project design and the project execution.

Description of the project and alternatives

The main project activities of the reclamation and coastal works for Thulhaadhoo are the following;

- Dredging of approximately 0.5 million m^3 of coral sand from a nearby borrow area and pumping the material into the reclamation area;
- Finishing the reclamation area to the required levels, including the elevated zone surrounding the island, based on the 'safe island' concept;
- Construction of revetments over a length of about 1400 m;
- Detailed design and construction of quay wall (230 m);
- Detailed design and construction of breakwaters;
- Environmental monitoring during construction activities;
- Measures to protect environmental values during construction and once the new island has been established.

The project execution is expected to take about 6-8 months for each island.

Dredging

The EIA report must describe the following aspects of the dredging activities:

- Location and size of sand borrow area(s) on a map;
- Justification for the selection of this location;
- Quantity, quality and characteristics of fill material;
- Indication of guarantees for sufficient availability of fill material;
- Method and equipment used for dredging, including description of positioning system, depth control system and operational control procedures;
- The arguments which form the basis for choosing this technical alternative;
- Way of operation; from which side and how will the dredging equipment be positioned in the designated borrow area (including depth of access channel, anchoring);
- Duration of the dredging activity;
- Labour requirements and (local) labour availability;
- Housing of temporary labour, and
- Emergency plan in case of spills (diesel, grease, oil).

The EIA report should study promising alternatives such as:

- Operation and positioning options;
- Alternative borrow area locations: have these been considered and if so, give arguments why these alternative locations were not selected, and
- Lay out of borrow pits, large shallow pits versus small deep pits to allow quick recovery of the seabed.

Land reclamation by filling

The EIA report must describe:

- Design of the reclamation area, including a justification (both from a social as well as from an environmental point of view) for the choice of the shape;
- Planning and timing of sub-activities (order of the works, clearance, dredging and reclamation);
- Method and equipment for transport of fill material and hydraulic filling;
- Distance of transport;
- Need for and location of temporary stockpile(s);
- Location and design of the external bunds for the containment of the sand, together with a description of their stability against waves and current attacks;
- Location(s) and method of discharging water from the reclamation area;
- Description of safety measures during the construction phases and
- Labour requirements and (local) labour availability.

The EIA report should investigate possibilities for alternative:

- Location, routing and design of pipelines;
- Design of bunds, including materials used.

Shore protection works
The EIA should indicate:

- Design criteria;
- Planning for construction of EPZ (Environmental Protection Zone) and of the shore protection works and
- Methods and equipment used for the construction of these works.

The EIA report should investigate alternatives for materials used in shore protection works (rock, sand-cement bags).

Harbour related activities
The EIA report should indicate:

- Construction and design of quay wall
- Construction and design of break waters, and
- Methods and equipment used for construction.

Mitigating measures and alternatives
Mitigating measures to prevent or reduce negative environmental or social effects during the implementation of the project must be described. These may include alternative dredging methods, measures to diminish risks (eg. safety precautions), phasing, such as the preferred season in relation to fish migration and sediment dispersal and measures to prevent disturbance, pollution or smothering of valuable ecosystems.

The decision to reclaim additional land at Thulhaadhoo has already been taken; this implies that only implementation alternatives have to be described.
The EIA report must describe at least two alternatives:

- The preferred alternative developed by the proponent;
- An alternative which contributes maximally to sustainable development, which may be a combination of the environmentally most favourable implementation with least hindrance for stakeholders.

Description of the natural and socio-economic environment and its autonomous development

The EIA report must contain a description of the current situation of the natural and socio-economic environment and its development if no project will be established (the autonomous development or reference situation). This serves as a basis for comparison of the impacts of various alternatives.

Natural environment
The EIA report must address the following aspects:
Climate:

- Temperature, precipitation, evaporation and wind (including extreme situations), and
- Risks of hurricanes and storm surges;

Geology and geomorphology:

- Offshore/coastal geology and geomorphology;
- Bathymetry (bottom morphology);
- (Seasonal) patterns of coastal erosion and accretion, and
- Characteristics of the seabed sediments;

Hydrography/hydrodynamics:

- Tidal ranges and tidal currents;
- Wave climate and wave induced currents;
- Wind induced (seasonal) currents;
- Turbidity/sediment concentrations;

- Sediment transport patterns by currents and waves.

Ecology:

- Protected areas, protected or endangered species;
- Ecosystems and their characteristic flora and fauna (terrestrial, coastal zone and marine environment, including the benthic layer);
- Identification of vulnerable ecosystems and environmentally valuable areas (eg. coral reefs, spawning sites for fish, nursery areas for crustaceans or specific sites for marine mammals, sharks, and turtles) and Ecological conditions required for sustainable fisheries and;
- Landscape integrity.

Socio-economic environment

The EIA report must describe:

Demography:

- Total population at Thulhaadhoo;
- Population structure, sex ratio, density, growth, and
- Population pressure on land and marine resources;

Economic:

- Income situation and distribution;
- Economic activities of both men and women (e.g. fisheries, home gardening, fish processing, employment in industry, government);
- Fishing methods deployed;
- Seasonal changes in activities;
- Land use planning, natural resource use and zoning of activities at sea;
- Land tenure and land allocation, and
- Accessibility and (public) transport to other islands.

Social and living conditions:

- Services quality and accessibility (water supply, waste/water disposal, energy supply, social services like health and education);
- Living conditions (e.g. size of plots, houses and households);
- Sites with historical or cultural interest or sacred places (eg. graveyard, mosques).

Impacts

The potential impacts must be described per alternative considered. Negative as well as positive impacts have to be described. Also impacts of the project activities after finalization of the construction phase have to be described.

Impacts on the natural environment
The EIA-report must describe:

- Changes in flow velocities/directions, resulting in changes in erosion/sedimentation patterns, which may impact shore zone configuration/coastal morphology;
- Loss of marine bottom habitat, both in the borrow area as well as due to enlargement of the islands, resulting in (temporary) loss of bottom life, which may impact fish stocks and species diversity and density of crabs, shellfish etc.;
- Sediment dispersal in water column (turbidity at the dredging site, the reclamation areas (overflow) and related to harbour construction activities), possibly resulting in changes in visibility, smothering of coral reefs and benthic communities and affecting fish and shellfish etc.;
- Impacts of noise, vibration and disturbance;
- Impacts on ground water table and quality as a result of reclamation (leaching of salts in the deposited sediments and change in groundwater quantity);
- Estimated time required to reach water quality of acceptable levels and soil conditions suitable for home gardening;
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

Impacts on the socio-economic environment
The EIA-report must describe for the proposed activity:

- Impacts of the works on fishing activities (disturbance);
- Impacts of the dredging and reclamation works on tourism (nearby resorts and dive sites);
- Impacts on employment and income, potential for local people to have (temporary) job opportunities (and what kind) in the execution of the works;
- Impacts of reclamation works on (diminished) access to groundwater and risks of covering up hazardous materials, and
- Level of protection against natural hazards like sea level rise, storm surges etc.

The follow-up activities of the proposed activity will also have socio-economic impacts, which require due attention, such as:

- Size and allocation of plots, including possibilities for home gardening;
- Impacts on food and nutrition security (fisheries, agricultural activities, supply of other food);
- Social services like health and education;
- Employment and economic opportunities and diversification;
- Increased demands on natural resources and services: domestic water supply, waste water disposal and treatment systems, solid waste disposal systems, energy supply etc.;
- Impact equity (economic activities, employment, income);
- Social destabilization of the island community, and
- Monitoring of socio-economic and demographic development.

Construction related hazards and risks
The EIA report should describe:

- Pollution of the natural environment (eg. oil spills, discharge of untreated waste water and solid waste, including construction waste);
- Impacts of noise, risks (accidents) and pollution on workers and local population and
- Impacts social values, norms and belief due to presence of workers of dredging company on local population.

Comparison of implementation alternatives

Environmental and socio-economic impacts of implementation alternatives must be compared, leading to at least the preferred alternative of the proponent and the alternative contributing

maximally to sustainability. It is recommended to present the comparison in the form of tables and diagrams. All alternatives must be compared according to international and commonly accepted standards as much as possible. The comparison must yield the preferred alternative for implementation. For comparison, selection and valuing of alternatives discriminating economic, technical, ecological and social criteria have to be identified.

Monitoring and evaluation

In the EIA report an environmental monitoring plan must be presented, for both the construction phase and long term. This plan must include monitoring of at least:

- Turbidity;
- Sedimentation rates on nearby coral reefs, benthic system and sea grass beds;
- Condition of the sensitive ecosystems and marine resources;
- Re-colonisation of the benthic organisms in the borrow areas;
- Erosion and accretion;
- Environmentally sound site clearance;
- Environmentally sound removal of dredging and other equipment including construction materials, and
- Employment of available local labour force.

The monitoring plan must indicate the institutions responsible for its implementation and the way implementation is funded. It must also include a description of where, how and when (duration and frequency) the sampling and monitoring should be conducted.

A project evaluation plan has to be included in the EIA report, indicating which institution will be responsible for evaluation. The main item of evaluation will be to which extent project objectives have been fulfilled.

Format and presentation of the EIA report

The EIA report will be written in format as described in Schedule E of the EIA Guidelines (2007) of the Maldives. A non-technical summary must be included; it must address the major subjects of the EIA report and be written in such diction that it provides non-technicians with a clear insight in the issues treated.

Hydronamic bv
Port and Waterway Engineers

To	From	Date
EPA	J.W.H. van de Meene	10 December 2009
Copy	**Reference**	
	09093-01-M-02-JMEN	

Memo

Subject: Three Islands Project – TOR's EIA's

Scoping meeting for the Three Islands Project

On 8 December 2009 a scoping meeting for the above project was held at the Environmental Protection Agency. The objective of the meeting was to establish the Terms of Reference (TOR's) for the Environmental Impact Assessments (EIA's) to be made for the project, based on the Initial Environmental Examinations submitted earlier and on discussions with stakeholders present during the meeting.

The scope of the EIA's for the first projects (Thulhaadhoo, Hinnavaru and Thulhusdhoo) is attached to this memo. Please note that Thulhusdhoo, although formally included in the project, is the island with the lowest priority. Plans for two other islands with higher priority (Velidhoo and Dhidhoo) are currently being made.

In addition to the topics already addressed in the TOR's, the following items were mentioned during the meeting. These issues will be addressed in the EIA's.

General:
- Sewerage: indicate outlets. Existing outlets should not be blocked.
- Describe possible effects on Marine Protected Areas, Resorts and Island communities.
- Address possibilities for dhoni beaching area.
- Address possibilities for sea bathing areas (natural beaches).
- Monitoring: sediment traps at sensitive locations (a.o. near resorts and on house reefs).
- Consult Resort Operators and Dive Schools.

In addition, the following island specific items were mentioned.

Thulhaadhoo
- Address erosion on the SW-part of the island
- Large harbour dimensions will have consequences for the required breakwater dimensions.

Hinnavaru
- Location sand borrow area: make sure not to affect the wave breaking function of reef.
- Harbour will be extended in other project.
- Level existing island is lower than the new land. Address possibly required additional drainage and protection.

Dhidhoo
- Design: deep part west of the island affects possibilities for reclamation.
- Try to keep island shape intact as much as possible.
- Address erosion at SW-part of the island.

Appendix 3

1 ENVIRONMENTAL MANAGEMENT PLAN FRAMEWORK

1.1 General

Boskalis International bv is one of the working companies of Royal Boskalis Westminster nv. As such Boskalis International bv subscribes the statements of and works according to the standards and policies set by Royal Boskalis Westminster nv based on the relevant ISO-standards (9001 and 14001) and the International Safety Management code (ISM). As such the Environmental Management Plan (EMP) is based on Boskalis Standards with the inclusion of project specific requirement and conditions.

The Environmental Management Plan forms an addition to the Boskalis' Policy Statement HS&E (RBW-002).

1.2 Responsibilities

The ultimate responsibility for the environment on the Project remains with the Project Manager, who will or will ensure that:

- The Project Environmental Plan meets local safety regulations.
- Sufficient qualified people are on site/board.
- The Project Environmental Plan is available to all persons with permission to frequent the site.
- Undertake random spot-checks on site to verify compliance with the Project Environmental Plan.
- Administer, update and revise the Project Environmental Plan.
- Prior to the start of the works and on a regular interval during the execution of the works, the Project Manager will hold environmental meetings to inform and instruct all personnel about the environmental regulations in force at the site.

1.3 Laws, notices and permits

The works will be carried out according to prevailing laws, notices and permits within the designated project working area. Special reference is made to the Environmental Monitoring program.

1.4 Avoidance of nuisance

All works and movement of plant will be carried out in such a manner as to cause as little inconvenience and disturbance as possible, to the residents.

The site will be maintained in a clean tidy condition, and all materials will be stored in an orderly manner. Provision for the discharge or disposal of all wastewater products will be made, in consultation with the Client and any concerned local authorities.

All temporary works and structures will be removed from site upon completion.

1.5 Water quality control

The works will be carried out in such a manner as to minimize adverse effects on the water quality during the execution of the works. The method of working will be arranged in such a way as to minimize adverse effects at the site itself, on transport routes, and at loading, unloading, dredging and reclamation areas.

The vessels will bunker at the site. During bunkering activities oil spillage is the main incident through which the aquatic environment may be affected. The following measures will be taken to prevent spillage:

- Bunkering activities will only take place under safe weather conditions.
- The fuel tank will be sounded regularly during the bunkering operation to avoid overspill.
- All hoses will be sufficiently drained before being stowed.

For wastewater originating from a/o the engine room, pump room and decks (bilge water), the dredger is provided with a separator. In this way water containing oily substances can be separated into sludge oil and purified water. The sludge oil will remain on board and later disposed of through the concerned local (Port) authority.

A potential risk for water pollution is the chemicals on board the dredger. This concerns mainly fuel, lubricant oil, hydraulic oil, grease, anti-freeze, degreasing products and paint. However, the quantities of these chemicals are low and they will be properly stored in the engine room, engine room store and paint storeroom. There is a requirement that containers in which dangerous substances are supplied have clearly visible signs showing the chemicals particulars.

For dredging activities the working method will aim to achieve the following:

- Minimize disturbance to the seabed as far as practicable and possible, other than in the actual area being dredged and reclaimed.
- Minimize loss of material during the dredging process, transportation and discharge.
- Ensure that discharge takes place only in the areas designated for such purposes
- Minimise deterioration in water quality, which could cause adverse effects on marine life.

Plant will be designed and maintained in a condition that will minimize the risk of material being released into the water or being deposited at locations other than those designated.

1.6 Air quality control

Measures will be taken to avoid pollution of the atmosphere by ensuring that fuel-burning equipment does not produce unacceptable levels of exhaust gases, etc. Air quality may be affected by the emission of pollutants in the exhaust gasses of dredging equipment. The exhaust gas consists of the following pollutants:

- soot particles
- sulphur oxide
- nitrogen oxide
- hydro carbons
- carbon monoxide

The quantity of the sulphur emission depends directly on the sulphur content of the fuel. The rate of emitted soot particles, carbon monoxide and hydro carbons results from incomplete combustion. The quantity of emitted nitrogen oxides is influenced by the load and the number of revolutions.

The floating equipment is subject to the Dutch shipping inspectorate and thus complies with Dutch norms for air emissions. Due to the open nature of the working areas (enough ventilation) the impact is assumed to be light. Nevertheless, the following actions should be undertaken in order to ensure that pollution of the atmosphere is minimised:

- The engines will be maintained in good working conditions, so that exhaust emissions of pollutants will be kept to a minimum.
- With complete combustion, emissions of soot particles, hydro carbons and carbon monoxide are minimised.
- The vessels will be subjected to regular inspection and maintenance programs as regular practise.

Since the dredging activities take place entirely in a wet environment dust problems will not be encountered.

1.7 Noise control

All practical measures will be taken to ensure that the dredger and support vessels will not cause unnecessary or excessive noise. Engines will not be permitted to run idle for excessive periods. Normal measures, based on good reasonable practice, for limiting noise, such as silencers, mufflers, acoustic linings, shields or screens, will be used where circumstances require.

Noise originates from mechanical sources such as winches, gearboxes, hydraulic pumps and engines. Working personnel of the dredges are properly protected from noise according to proper Health and Safety Procedures. The floating (dredging) equipment is subjected to the Dutch Shipping Inspectorate (the Dutch Government), and thus complies with its norms for noise emissions.

The effects of noise on fauna, like birds and fishes should be local, temporary and of small magnitude. Prior to deployment the condition of the selected equipment is checked and during the execution of the project the engines are not permitted to run idle for excessive periods.

1.8 Waste disposal

All inert waste shall be segregated, collected, brought ashore and disposed of at an allocated, public dumping site. All non-inert waste will also be sorted into various categories, collected, brought ashore where applicable, and disposed of through the relevant Port authorities in Maldives or abroad in accordance with local "Waste Disposal Regulations".
No garbage, refuse, waste oil, or other deleterious matter shall be discharged from any vessel, but shall be sorted, collected and disposed of in a manner befitting its nature.
No heated water shall be discharged form any vessel in areas where such a discharge could adversely affect the ecological balance.

Reference is made to the following sections of Boskalis' procedures:

- Safety instruction Booklet (appendix I): paragraph 1.31 'Waste dumping';
- CTD-Procedure EQP-301: 'Garbage Collection, Storage Disposal';
- RBW-516-01c: 'Sludge and Garbage Disposal';

1.9 Spillage control

Liquids, such as fuel and lubricants, shall be stored in leak proof containers, and where appropriate, such as when emptying, or filling containers, drip trays shall be used.
During bunkering operations precautions shall be taken to ensure that no spillage takes place during uncoupling of hoses, and that all hoses are suitably drained before being stowed.

1.9.1 Steps to minimize oil spillage

1.9.1.1 Preventive measures

The prevention of oil spills should be regarded as a high priority in any dredging operation. The most commonly recorded cases of operational spills are, bunker overflows, pipeline leakage and oil spray from tank vents.

If despite the adherence to proper procedures, an oil spill does occur, all bunker
operations should be stopped by the quickest possible means and should not be re-started until the source of the leak has been identified, rectified and all hazards from the oil released have been eliminated.

1.9.1.2 Tank Overflow

Should a tank overflow occur, the flow to the tank should be stopped immediately and the level in the tank lowered by the most practical means.

1.9.1.3 Pipeline Leakage

Should a leakage occur from the dredger on-deck pipe work the bunker operation should be stopped immediately and pressure relieved from the leaking section of line. The line content may be dropped if necessary pumped into an empty or slack tank.

1.9.1.4 Oil Spray from Tank Vents

In case an oil spray occurs from the tank vent, the flow should be stopped. The cause of the oil entertainment in the vapour flow should be established and the necessary measures taken to rectify this.

1.9.1.5 Containment on Board

In the event of an oil spill on deck, the following steps should be taken to prevent or minimise overboard pollution.

1. Stop source of leak.
2. Place drip trays to catch leakage.
3. Soak up oil with absorbent material, sawdust etc.
4. Ensure scupper plugs are tight and any excess water drained off.

1.9.2 Spills resulting from casualties

1.9.2.1 Priority Actions

In the event of a casualty the Captains and Senior Dredge Masters prime concern will be for the safety of the ship and its crew, and taking whatever measures are necessary to prevent escalation of the incident. When spillage has occurred immediate measures should be taken to prevent fire and explosion.

1.10 Dangerous materials handling

Handling of dangerous materials in relation to dredging and reclamation operations are described in several Boskalis' safety and environmental procedures, the most relevant procedures:

- Safety instruction Booklet (appendix I): paragraph 1.30 'Dangerous Materials';
- CTD-Procedure EQP-209: 'Working with Radioactive Sources (ISM vessel)';

All vessels under Dutch flag (ISM) are to comply with ARBO-regulations (Dutch Occupational Health and Safety Act) regarding handling of dangerous materials and goods, and thus comply with its norms for handling of dangerous materials and goods.

1.11 Flora and fauna

Except with the express permission of the Client, and if appropriate any relevant
Authorities, no vegetation, plants, shrubs or trees shall be removed from any part of the site. Care will be taken to ensure that disturbance to any bird or animal life in the vicinity is kept to the minimum, compatible with the nature of the construction activities. Co-operation will be sought with conservation bodies, all instructions and guidelines relating to ecological protection will be observed, and our activities so organised as to cause the least practical interference with the local wildlife population.

1.12 Environmental account

Diesel and lubrication oil delivered on board the cutter dredger and the cutter section dredger is registered on the daily log sheets of the engine room. The fuel and lubrication oil received is

registered through approved delivery notes from the supplier. The supplies are checked by means of sounding of the fuel and lubrication tanks.

Waste oil is being registered in the Oil Record Book which correspond with Marpol reg.20 Annex I. The consumption of fuel is measured on a daily basis and recorded in the daily log sheets.

1.13 Reporting of environmental accidents and dangerous situations

Before commencing work on site the requirements of environmental protection and all applicable legislation will be explained to all employees.

- In the event of such an accident, the following emergency procedure must be activated:
- The Project Manager will be informed
- Call Project Manager phone number (to be defined) and forward:
  - The address and location of the accident
  - Project Name/Identification
  - Type of accident, fuel, oil, personnel involved
  - Time of accident
- Project Manager will notify the relevant authorities and the nearest pollution combat unit.

All personnel and equipment accidents, near misses, damages and environmental calamities will be reported to Boskalis' head office in the Netherlands. Specific procedures apply, as outlined in RBW-585 'Accident/Damage/Sopep Reporting'. An investigation into the cause of the accident or damage will be conducted followed by taking appropriate actions to prevent similar situations in the future (see also next paragraph).

1.14 Utilisation of recorded data

All reported accidents to the environment will be analysed, in order to determine the cause, and if practical, their effect on the environment. The results of such analyses will be documented. Dependent on the nature of the accident and its cause, consideration will be given to one or more of the following courses of action to ensure that such an accident do not occur again:

- Revise or adapt method of working.
- Take additional preventative measures.
- Re-instruct and/or retain involved persons in existing methods of working.
- Draft / revise documented procedure / work instructions.

The actual course of action to be followed will be in line with existing environmental laws and regulations, the requirements of the contract specification, and the instructions of the Client.

1.15 Project specific requirements

1.15.1.1 Water quality management and Ecosystem protection

As standard practice of Boskalis International bv, dredging and reclamation activities will be carried out in a manner so as to minimize disturbance to the environment, and in fully accordance with relevant legislation and regulation on environmental matters. Target and goal of Boskalis International is to plan, carry out, check, review and improve the Environmental Management Plan in order to keep environmental short-term impacts to an acceptable level in keeping with the practical nature of the operations.

Boskalis International will prevent pollution to seawater and operate in accordance to best international practices. As stated in the Policy Statement of Boskalis international, all employees will execute their work with proper concern for the protection of the environment.

Special areas of interest in the vicinity of the dredging works are seagrass and coral, which are described in Chapter 6. The impact of the dredging and reclamation activities on the environment

and mitigating measures that may be necessary are described in Chapter 8, the subsequent monitoring program are presented in Chapter 11.

1.16 Oil spill management

Reference is made to paragraph 1.9.2.

According to the standards of MARPOL 73/78, Annex I, Regulation 26, the crew is promptly trained to apply the Shipboard Oil Pollution Emergency Plan (SOPEP), under the responsibility of the Chief Engineer.

1.17 Personnel environmental training programmes

Workforce personnel undergo regular safety and environmental training programmes. Most important courses include:

- In-house Boskalis courses by HS&E Department;
- Full VCA course, detailing safe working with hazardous goods;
- SOPEP-training (Shipboard Oil Pollution Emergency Plan);
- Shipping Transport College courses; 'Working with contaminated soils and dredge material';
- Marine fire fighting course (including dangerous and toxic goods handling);
- First Aid Course.

For site staff personnel different safety and environmental related training programmes and courses apply, some examples:

- At Bureau Veritas the Environmental Management Systems Training have been followed
- DLP (Professional Leadership for Projects) course
- Intercultural management course;
- Communication course;
- First Aid Course.

Both workforce and staff personnel are obliged to keep their knowledge up to date by attending HS&E (refreshment) courses on a regular basis.

1.18 Promotion of environmental awareness

Boskalis applies the slogan 'Safety is in your hands' for promotion of personnel safety and environmental awareness. Several posters are available to be put up at site (offices) and at dredging spreads. Moreover a safety booklet and HS&E stickers (RBW-511) are available. All Boskalis' project-personnel have been handed out the Safety instruction Booklet, updates will be provided as new versions are released.

Appendix 4

Land Use Plan

DRAFT

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LEGEND:

EXISTING:

- RESIDENTIAL
- INSTITUTIONAL & COMMUNITY FACILITIES
- COMMERCIAL
- INDUSTRIAL
- C — CONSERVATION SITE 'GHAZEE MISKIY'
- PUBLIC SPACES
- LANDS NOT IN USE (Allocated for Industrial use)

PROPOSED:

- RESIDENTIAL PLOTS (B1-B9) (FOR IMMEDIATE ALLOCATION)
- FUTURE RESIDENTIAL PLOTS (B9-B39) (REQUIRES LAND RECLAMATION)
- INSTITUTIONAL & COMMUNITY FACILITIES
- COMMERCIAL ZONE
- HARBOUR AREA ACTIVITIES
  - 01- LOADING AND UNLOADING
  - 02- BOAT REPAIR
- STORAGE & WARE HOUSING
  - 03- STORAGE AND WAREHOUSING
- LIGHT INDUSTRIAL
- UTILITY & MUNICIPAL SERVICES
  - 04- WASTE MANAGEMENT SITE
  - 05- POWER HOUSE
- RESERVED FOR FUTURE USE
- PARK / RECREATIONAL AREA
- GREEN AREA / BUFFER ZONE
- 2.4M HIGH GREEN BELT
- LOWER DRAINAGE AREA (WITH RECREATIONAL FACILITIES)

ENVIRONMENTAL PROTECTION ZONE (EPZ)

- PEDESTRIAN ROUTE
- HARBOUR BASIN
- EXISITING ISLAND SHORELINE

PROPOSED LANDUSE PLAN
K. THULUSDHOO

NATIONAL DISASTER MANAGEMENT CENTRE
PLANNING UNIT
DATE: 22 MARCH 2006

SCALE 1:4000

Appendix 5

Letter from MTHojgaard

MTHøjgaard

TO WHOEVER IT MAY CONCERN

11th December 2009
Tel +94 11-286 2444
Fax +94-11-287 6522
jj@mthojgaard.dk

Dear Sir/ Madam

3 ISLANDS PROJECT - MALDIVES

We have been supplying various types of rock materials for all our projects in the Maldives through our quarry operators in the state of Tamil Nadu, India, for the last more than eight years.

We will be identifying the required quarries from the same areas that we do operate now, for the supply of rock materials for the above project.

We do confirm that to the best of our knowledge, during the several visits that we have made to these areas, we have not come across any sign of forced or child labour deployed by our quarry operators.

We also ensure that in any quarry that would be selected as source/s of rock material for the proposed project, no forced and / or child labour shall be engaged by our sub contractors or operators.

The same shall apply to all forms of sub contractual works with regard to quarry operations and transport.

Yours faithfully,
MT Hojgaard a/s

MT HØJGAARD A/S

Jonas Jacobsen
Commercial Manager

MT Højgaard a/s
94A, Jayanthipura
Battaramulla
Sri Lanka

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CVR No. 12 56 22 33

Appendix 6

Letter from Ministry of Housing, Transport and Environment

بسم الله الرحمن الرحيم

ހިދުމަތްތެރި ގޭގެ ސަރަހައްދު، ޤައުމީ ދިރާސާ ހިންގުން ހާއްސަ ވަޒީފާ ދާއިރާ

Ministry of Housing, Transport and Environment

ރިޕޯޓް ދާނެ

OFFICE MEMO

From:	Engineering and Project Management Section		
To:	Environmental Protection Agency		
Copy:			
Subject:	3 Island Reclamation Project		
Number:	138-ES/INT-MEMO/2010/14	Date:	18 January 2010

Ministry of Housing, Transport and Environment as the proponent of the Reclamation project awarded to Contractor Boskalis International, hereby confirm our commitment to carryout the environmental mitigation measures and monitoring program for the post – construction phase of the project.

Yours sincerely,

Shifaz Ali
Senior Engineer

Ameenee Magu,
Maafannu,
Male', 20392,
Republic of Maldives.

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Website: www.mhte.gov.mv ،ވެބްސައިޓް

ހަމީދީގޮޑި،
ފަ ފަންނޫ،
ދާދި، 20392،
ދިވެހިރާއްޖެ.

2010 International Year of Biodiversity