Environmental Impact Assessment for the Coastal Protection of Reethi Beach, B. Fonimagoodhoo

Proposed by:

Mahogany Pvt. Ltd.

December 2012

Signature:

Prepared by:

Mariyam Saleem, Thomas Le Berre, Marine Preuvost

SEAMARC
Systems Engineering
And Marine Consulting

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Declaration of the Consultant

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

Name: Mariyam Rozlyn Saleem

Signature: 

Date: 20th September 2012

Declaration of the proponent

As the representative of the proponent of the proposed development I guarantee that I have read the report thoroughly and that to the best of my knowledge all information provided here is accurate and complete. In addition, I confirm our commitment to making sure that the contractor implements all mitigation measures proposed in the present report and adhere to the monitoring schedule given.

Name: Peter Gremes

Signature: 

Date: 31.08.2012

Reethi Beach Resort

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Hon. Dr. Mariyam Shakeela
Minister of Environment and Energy
Ministry of Environment and Energy
Male'
Maldives

Reethi Beach. June 27th 2012

Environmental Impact Assessment
Coastline Reinforcement using Geotextile Tubes at Reethi Beach Resort, B.Fonimagoodhoo

Ref.

Dear Honourable Minister,

As per the requirements of the EIA regulation, we hereby confirm our commitment to implement the mitigation measures according to what is proposed in the EIA report attached herewith.

Yours sincerely,

Peter Gremes
General Manager

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އެގްޒެކެޓިވް ސަމަރީ

1. މި ރިޕޯޓަކީ ބ. އަތޮޅު ފުޅަދޫ ޓޫރިސްޓްރިސޯޓުގައި ބޮޑުބައެއް ހެދުމާއި ގުޅުންހުރި މަސައްކަތްތަކުގެ ސަބަބުން ތިމާވެއްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓެވެ. މި ރިޕޯޓު ހުށަހަޅަނީ ދިވެހިރާއްޖޭގެ ތިމާވެށި ރައްކާތެރިކުރުމާއި ދަމަހައްޓުމުގެ ގާނޫނު (ގާނޫނު ނަންބަރު 4/93) ގެ 5 ވަނަ މާއްދާގެ ދަށުން އަދި ތިމާވެއްޓަށް އަސަރު ފޯރާނެ މިންވަރު ބަޔާންކުރާ ރިޕޯޓު ހެދުމާބެހޭ ގަވާއިދު 2012 ގެ ދަށުންނެވެ. ރިޕޯޓުގައި މި މަޝްރޫޢު އާއި ގުޅިގެން ކުރަންޖެހޭ ސާރވޭ އަސަރުތަކާއި، މިއަސަރުތަކުގެ މިންވަރު ކުޑަކުރާނެ ގޮތްތަކާއި، މަޝްރޫޢުގެ ބަދަލުގައި ހިންގިދާނެ ބަދަލު ގޮތްތަކާއި އަދި މަޝްރޫޢިން ލިބޭނެ ފައިދާތަކާއި އަސަރުތަކުގެ މަޢުލޫމާތު ބަޔާންކޮށްފައި ވާނެއެވެ.
2. ރިސޯ ބީޗް ރިޕޯޓުގައި ބަޔާންކުރުމުގެ މައްސަލަ ވަރަށް ބޮޑެވެ. މިގޮތުން ބަޔާގެ އިރުމަތީ ފަރާތުގައި މިކަން ވަރަށް ބޮޑުކޮށް ފާހަގަކުރެވިފައެވެ. ފަޅުމަގުގެ ރިޕޯޓަކަށް ހުރި ފަރުން ބަޔާންކުރެވުނު ކަމަށް ކުރުމަށް ހިނގި ކަންތައް މަސައްކަތްތެރިކަމުގެ ދިރާސާ މަސައްކަތްތަކުގެ ކަނޑައެޅިފައިވާ މިގޮތުން އިރުއޮޅުގެ އަދި އިރުދެކުން ފަރާތުގައި ދިގަށް އަދި ހަރަކަތް ތަފާތު ބީޗުތަކުގެ ތެރެއިން ލިބިދެއެވެ. މި ބީޗުތަކުގެ ސަރަހައްދު ބަޔާގެ ގޮނޑުދޮށް ފުޅާމިން ވަނީ ހަމަވެފައެވެ.މިގޮތުން އިރުދެކުން ކުރީގައި ހުރިފައިވާ ބީޗުގެ ސަރަހައްދު ދިރީ އަތިރިމަތީ ބަޔަށް ވީއްލޭ ކަމަށް ވަނީ މި ނިރީކްޝަން އިރުވައި މޫސުމުގައި ފާރަގަ ކުރެވިފައެވެ. ވުމާއެކު، މިކަންތައްތައް ބަލައި ކުރުމަށް ތިރީގައި އެވާ ކަންތައްތައް ވަނީ ޢަމަލުކުރެވިފައެވެ.
   - a. ބަޔަކު ލަފާކޮށް ހުރި އަސަރު ކުޑަކުރުމަށް ބަޔާގެ އިރުއޮޅުގެ އިރުދެކުން ފަރާތުގެ މޫދު އަތޮޅުގައި ޖިއޯ ޓިއުބް ބެހެއްޓުންނެވެ. މިޖިއޯ ޓިއުބްތައް ވަރުގަދަ ކުރުމަށް ބަޔާގެ އުތުރު ފަރާތުގައި ދިން ޖިއޯ ޓިއުބްތަކެއް ބެހެއްޓުން.
   - b. އިރުމަތީ ފަރާތުގެ އިރުދެކުން ފަރާތުގައި ލުއިފެއިކުރި ބީޗުތަކާއި ވެލި ޕަމްޕްކޮށްފައިވާ މަރާމާތު ކުރުން.
   - c. ބޮޑުބަނދަރު ހުރިހާއިރު ހިފެހެއްޓި ބީޗަށް ފަރުވާކަމަށް ބަޔާގެ ވިލުން ވެލި ޕަމްޕު ކުރުން.
3. ޖިއޯ ޓިއުބަކީ ވެލި އަޅާ ބަސްތަ ކުރާ ބޮޑެތި ކޮތަޅު ތަކެކެވެ. މި ކޮތަޅުތަކަށް ވެލި އަޅާ ބަސްތަ ކުރުމަށް ކޮތަޅުތައް މޫދަށް ފައްސާ މުޅިކާ ނަމަ ހިސާބުގައި ގެނުގެ މަތީގައި ބަހައްޓައިގެންނެވެ. ސޮލިޑް ކޮންކްރީޓް ދެމެހެން ކުރުމުގައި ބަޔާގެ ބެލެހެއްޓުމަށް ބަލާ ޖިއޯ ޓިއުބްގެ އުސްމިން އެންމެ ބޮޑު ދިމާ އާއިހަމައަށް ހެދުނެވެ.
4. ފަޅުގަނޑު އެންމެނި ބީ. އައިޑީގެ އިރުމަތީ ފަރާތުގައެވެ. ބަނޑު އެއްނަ ހިސާބުގެ ގޮތުން ކަނޑުން އަނބަނަ ބޮޑުތި ހަމަޖެހުމަށް ބަލާ ހަދައިގެން ފެށިއެވެ. އަދި ދެމުސުމުގައި ވައިގެ ނިޒާމުން ހަރު ރަނގަޅުގެ ނަމޫނާ ވެލިގެ ފޮލަސް ފަސް މިހާރުގެ ބޮޑުބަނދަރު ތަރުގައެވެ. ވޭވްސް ބަނދު ވަރަށް ހަރުގާން އޮއިރުގެ ފަށައި ވައިމަތި ކާނުއި ފައިދާ ކުރާ ބޭނުމަކަށް ބަލައެވެ. މިން ފަރުގަނޑުން، އޭރު އިރުއޮޅުގެ ދަތުރު އަދި ހުޅަނގުން އަނބަނަ ފުރުމަށް ހަރުކަތްތަކާއި ފަރާތް އެއްވެސް ހިމާޔަތް ނުދޭއެވެ.
5. ބެންތިކް ސަރވޭ ބޭއްވުނު ސައިޓުގައި ފޮޓޯ ޓްރާންސެކްޓް ހެދިފައިވެއެވެ. ކޯރަލް ފޮޓޯއެއްވެސް އެނަލައިޒް ކުރުވައިފައިވާ 25 ފްރޭމްޖޫ ރީފްތަކުގެ ބާރުން ކޯރަލްގެންނެވެ. މިގޮތުން ފަރުގެ ސަބްސްޓްރޭޓް ފަރަކާއިގާތާ ދިރުން އިންސައްލެއްގެ ގޮތުގައި ބެލުމަށްހިފައިވާނެއެވެ.ދިރޭ ގަލުގެ ނިސްބަތަކީ ސަރާސަރީ ކުރުމުން ހިސާބުގެ 9.32±2.46% އެވެ. މި ދިރުމުގައި ވަނީ މަސިވް (4.36±1.47%) އަދި ސަބް-މަސިވް (2.73±1.09%) ބާވަތްތަކެވެ. މުރަކައިގެ ބާވަތްތައް ވަރަށް މަދުވެ(0.76%). މިއީ މިބާވަތުގެ ފުރަތަމަ ކުރުތައިގައި ވަރަށް އާދައިގާ ހިމެނު ކަމެކެވެ. ތަފާ ކުރުވާ ގޮތުގައި ބޮޑުވެސް މިއީ ފަޅުމަގުގެ ފަހައިގެންވާ ހިސާބުގައި ބޮންގަނޑުގެ ބްލީޗިންގް މަދުކުރުންނެވެ. ދައްކާގޮތުން މިހިސާބުގައި ބްލީޗިންގް ހުންނަނީ 30°C އަށް ވުރެ މަތިވެގެންނެވެ. މިގޮތަށް ބްލީޗިންގް މަދުވުން މުރަކައިގެ ބާވަތްތައް ހުރުވާ ވަރަށް ފަސޭހައިން މަރުވުން އެކަށީގެންވެއެވެ. ދިރޭ ގަލުގެ އިންސައްތަ 2006

(10.16±1.77%) އާއި 2012 (10.30±1.77%) އާއި ދެމެދު މާބޮޑު ބަދަލުތަކެއް އައިސްފާ ނުވާކަން ފާހަގަ ކުރެވެއެވެ. ރަށް ވަނައިގެން ވެލި ދުރުމަތީ ފެހެސް މިކަމަށް އަސަރުކުރާނެކަން ކަމެކެވެ. އެއީ ކުރި މުދަލަ އާލާވުމަށް ހުރަސް އަޅާލައެވެ.

6. މަހުގެ ތަފާސް ހިސާބު ހޯދުމަށްޓަކާ ބޭނުން ކުރެވިފައިވާ ފިޝްވޮޗް މޮނިޓަރިންގ މެތަޑޮލޮޖީއެވެ. މިގޮތުން 15 މިނެޓުގެ 3 ފިޝް ކައުންޓް ކޮންމެ ސައިޓެއްގައި ހެދިފައިވާނެއެވެ. ޓްރާންސެކްޓް ކުރާ މީހާގެ ދުވަހާތުން 2.5 މީޓަރާއި ބޮޑުކަން 5 މީޓަރުގައިވާ މަސްތަކެއް ޖަހާފައި ކުރެވުނެވެ. މިގޮތުން 6 ސައިޓެއްގައި 5 މީޓަރާއި 10 މީޓަރުގައި ތަފާސް ހިސާބު ނެގުނެވެ. ފިޝްވޮޗްގައިވާ 76 ބާވަތުގެ ތަރައިން 14 އާއިލާއަކަށް ނިސްބަތްވާ 42 ބާވަތުގެ މަސް ފެނިފައިވެއެވެ. އެންމެ ގިނައިން ފެނިފައިވަނީ (38.10%) *Lutjanus gibbus* ، *Caranx melampygus* (7.47%) އަދި *Zanclus cornutus*(7.14%) އެވެ. *Caranx melampygus* ނުވަތަ ފަނިހަނދި މިއަދަދަށް ފެންމަތީ ސިއްހަތު ދަރަޖަ މަސް ކޮމިއުނިޓީއެއް ޒޯވުގެ ނިޝާނެކެވެ. ކާނާމަސް ނުވަތަ ކިޔަނަސޭ ގެ އަދަދު ވަރަށް މަދުވެ (9.20%). މިއީ ދިރޭ މުޅަކަ މަދުވާ ހުރި ގެރެމުއްކަމަށް ބެލެވެއެވެ. އޯކިޑިއަރޓީ (ކަޅުކާބު އާއިލާ) ފަސް ވަރަށް މަދު ކަމަށް ފާހަގަ ކުރެވުނެވެ (1.19%). މިއީ ދިރާގާ މަދުވެފައި ފުރިޔާފައި އެންނަ ހިސާބު ތަކެއި އާދައާ ހިލާފު ކަމެކެވެ. އެއީ މިމަހުގެ ބާވަތަކީ ފުރިހާ ބާވަތަކަށް ވާލީއެވެ. މިސާލަށް ފެނިފައިވަނީ އާދައިގެ ފެންނަ ކަނޑުކާގެ ބާވަތްތަށް ނުވަތަ ސްޕީޝީސްއެއް ނޫނެވެ.

7. މި މަސްދުވުން އާއި ގުޅިގެން ތިމާވެއްޓަށް ކޮންމެފެން އަސަރުތަކުގެ ތެރޭގައި ފެޝަނަލް ބޭނުންކުރުން އަދިވެސް ކޮންސްޓްރަކްޝަން އިމާރާތްކުރުމުގެ (ވަސްދުވުން ނުވަތަ އަޑުގަދަވުން، ތިރީ ދިޔާވުން، ގަދަ ހައުސް ގެސް އުފެއްދުން) ހިމެނެއެވެ. އަދި ކޮންސްޓްރަކްޝަން މަސައްކަތުން ދިމާވާނެ ކަންތައްތަކުގެ ތެރޭގައި ޓްރާފިކް ކިޔަނެބުޅުން އަދި ރަށް ކައިރީގައި ކަނޑުބިމަށް ކޮންމެ އަސަރުތައް ހިމެނެއެވެ. މީގެ އިތުރުން ރަށް ވަނައިގެން ޓްރާފިކް ދާއި ނިޒާމަށް ދުވުމާއިބެހޭ މާތަކަށް ބަދަލު އައުން އެކަށީގެންވެއެވެ.

8. މި ދިރާސާގައި މަސްދުވުމުގެ ތަފާތު ބައިތައް ހިންގާފައި ތަފާތު މާތްތަކަށް ބަލާ ކޮންމެ ކަމަކާއި ގުޅޭ ހުރި ހާލަތު އަދި ނުރަވާ އަސަރުތަކަށް ބަލާ ނުރަވާ އަސަރުތައް ކުޑަކުރުމަށް ފިޔަވަޅުތަކަށް ބަލާލުމަށްވެސް ހުށަހަޅާފައިވެއެވެ. މިހާރު ފެނިފައިވާ ވަރުވެރިވާ ތިމާވެއްޓާއި އެކަކު ގުޅުން މިހާރު ހާލަތު ދުވަސް ތަކެއް މައިން އޭގެ ހާލު ގާތަކަށް ކުރެވިފައިވާ މަސައްކަތް ތަކެއް ނިންމާއެވެ. ފިލާއިކު ތަފާ ކުރެވިފައި މި މަސްދުވުން ކުރަވާ މަސައްކަތަށް ގުޅުންހުރި ހިމާޔަތް އިތުރުވާނެކަން ޔަގީންކުރެވެއެވެ.

9. މިމަސްދުވުން ކޮންމެ އަސަރުތަކެއް ބަލާ ދިރު މުއްދަތުކަން ތިމާވެއްޓަށް އަހިސާބާ ބަދަލުތަކެއް ބަލާ ފިޔަވަޅު އުފުމަންޓަކައި މޮނިޓަރިންގ ޕްރޮގްރާމް ހެދިފައިވާނެއެވެ.

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Executive Summary

1. The present report is the Environmental Impact Assessment (EIA) regarding the construction of a breakwater, implementation of revetment and headland, and the replenishment of the beach on Fonimagoodhoo Island in Baa Atoll. The report has been developed in compliance with the Environmental Protection and Preservation Act of Maldives (Law No. 4/93, article 5a) and the Environmental Impact Assessment Regulation 2012 requiring such an assessment study before implementation of any activity that may have a significant impact on the environment. The assessment exposes the solutions and preferred alternatives as well as mitigation measures to minimize any negative impacts whilst trying to derive the maximum positive impacts from the project.
2. Reethi Beach Resort is threatened by erosion, particularly on its east side. The management of the resort has been taking different measures to prevent erosion around the island. The protection actions that have been already implemented on the northeast and southeast side consist of structures that are parallel and perpendicular to the shore, resulting in a poor aesthetic aspect to the beach. Moreover, a structural sand leak has been noticed during the NE monsoon and is being exacerbated by the existing structure. Consequently, the planned works are designed to remedy this situation in the following ways:

    1) Large submerged geo-tubes will be laid on the rock bed in the northeast and southeast of the island in order to break the waves before they reach the shoreline.
    2) Three other geo-tubes will be implemented on the north beach as revetments to prevent direct erosion.
    3) Building groynes in the east and southeast to impede the sand movement and to seal off the sand leak.
    4) Pumping sand from the lagoon in order to replenish the beach and cover the previous unasthetic coastal structures.

3. The proposed structure will be secured using sand filled containers known as geo-tubes. These are deployed on a rocky base and filled in situ. The designs have taken into account the bathymetry of the area in order for the top of the bag to reach the highest tide level.
4. Fonimagoodhoo is located on the east of Baa Atoll. It is mostly susceptible to the oceanic swell and to the wind waves modulated by the monsoon, generating sand transport and geomorphologic changes between the windward and the leeward sides. This is most apparent in three particular directions, one in the northeast sector, another one in the south and one in the west sector are clear of any direct obstacles, enabling higher energy swells and wind waves to reach the reef system.

5. 10 photographic transects were used to assess the benthic cover of 10 sites. Each picture is analyzed using 25 point grids to obtain quantitative substrate cover data of morphological

characteristics of the reef community. Living corals represent9.32±2.46% of the whole area surveyed comprising mostly of massive and sub-massive species (4.36±1.47% and 2.73±1.09% respectively). Surprisingly, *Acropora sp.* represents only 0.76% of the substrate. This low abundance may be due to the high seawater temperatures (> 30°C) measured around Fonimaagoodhoo engendering coral with bleaching which affects mainly *Acropora sp*. From 2006 to 2012, the coral cover has stayed constant (10.16±1.77% to 10.30±1.77% respectively). The sand movement around the island may avoid recruit settlement hindering development of the coral reef.

6. For the fish community survey, data was collected using the methodology outlined by FishWatch Maldives, where 3 x 15 minute fish counts were carried out at each site. Surveyed area is a band of 2.5m on either side of the recorder and 5m up the water column. Surveys were carried out at 2 different depths (5 and 10 meters) on 6 sites. 42 of the 76 FishWatch target species were recorded among 14 families. *Lutjanus gibbus* (38.10%), *Caranx melampygus* (7.47%) and *Zanclus cornutus* (7.14%) showed the greatest densities. The significant presence of the predator *Caranx melamgypus* is an indicator of a healthy fish community. The weak density of Chaetodontidae (9.20%) may be related to the generally poor coral cover. Acanthuridae were very poorly represented (1.19%) and this is in contradiction with the fact that the substrate is mainly rocky with a cover of turf algae which should normally support a healthy herbivorous community. This may be due to the fact that the 5 species counted in this protocol are rare compared to other more common Acanthuridae such as *Ctenochaetus striatus* or *Acanthurus leucosternon*.
7. The main potential environmental impacts identified associated with the new developments are construction impacts, in relation to the use of machinery (smell and noise disturbances, oil spillage risks, green house gas emission) and with the construction works themselves (temporary rise in turbidity and modification or damages to the seabed through direct physical damage), as well as permanent modification of the hydrodynamic regime of the whole area.
8. The pros and cons of alternative options are considered as well as mitigation for the impacts highlighted. Given that the present configuration of the coastline is the result of different ad-hoc initiatives, it is expected that the works will improve the coastal protection of the islands and promote rationality in dealing with this issue.
9. A monitoring plan has been proposed in order to assess the impact of the works over the years and long term changes to the environmental conditions. The plan will aid in implementing mitigation measures during construction and operation of the project.

1 Introduction

1.1 Objectives of EIA

The present report assesses the potential environmental impacts associated with the implementation of coastal structures for shoreline protection and associated beach replenishment on the north-east and southern side of B. Fonimagoodhoo.

1.2 Justification of the project

Since 2000, Reethi Beach Resort has experienced erosion and several structures have been implemented to maintain the beach and threatened buildings. Erosion is severe especially on the southern and northern tip of the island. Over the years a number of ad hoc structures have been implemented. However, the structural sand leak present during the Northeast monsoon (Figure 1) has continued to cuase problems. In 2010, the resort decided to tackle the problem in it's entirety and carried out the first phase of the present project. Unfortunatly, the existing protection arrangement gives a poor aesthetic aspect to the beach (Figure 2). It is important to Reethi Beach Resort to have a beuatuful island that the guests can appreciate as well as be sensitive to envrionmenal issues, this phase of the project will ensure that both of those critira are met. The structures will vastly improve the stability of the island coastline and provide the visual beauty that guests coming to the Maldives have come to expect.

Figure 1: Fonimagoodhoo Island and the southern sand leak in the red zone.

Figure 2: Existing coastal erosion protection at Reethi Beach Resort.

The present project is looking at more permanent solutions to ensure the aesthetic of the beach and the satisfaction of the guests, and is the second phase of the full plan implementation. The present project aims to further improve the coastal protection at the southern tip and implement some on the north-eastern corner of the island.

At times, beach replenishment may need to be carried out, if left alone the coastal improvements should allow sand to accumulate in the desired places, but this could take several years. So the present report is also a request to approve this activity for the next two years as permitted by the EPA.

1.3 Procedure and Extent of EIA

The article 5 (a) of the Environmental Protection and Preservation Act of Maldives (Law No. 4/93) and the Environmental Impact Assessment Regulation 2007 require an impact assessment study to be submitted to the Environmental Protection Agency (EPA) before implementation of any activity that may have a significant impact on the environment. As the introduction of coastal structures and use beach replenishment on Fonimagoodhoo in Baa atoll is anticipated to have some positive and negative impacts on the surrounding natural environment, the contractor has to submit such an EIA and obtain permits from the relevant agencies before commencement of any work.

A scoping meeting was held at the Environmental Protection Agency (EPA) on 24th of May 2012. The Terms of Reference for the study were issued by the EPA in July 2012. An intensive field survey of the proposed project site and its surroundings were undertaken from 27th

April to 1th of May 2012 to investigate the activities proposed as part of the project and to analyse the environmental conditions in order to forecast the impacts. After submission and evaluation of this document, if approval is granted, the proponent will abide by the guidelines provided by the Ministry and make every effort to minimize impacts of the development on the environment. The required monitoring will be carried out accordingly and reports will be submitted to the relevant government agencies.

1.4 The proponent and consultant

1.4.1 The proponent

Magic Kingdom Resorts Pvt Ltd. has its head office at G. Rosary View, 6th floor, Husnuheena Magu, Male' 20-03, Rep. of Maldives. The company has been in operation since May 2000 and has been operating Reethi Beach Resort as their only resort in the country ever since. The extended main lease agreement to operate Reethi Beach Resort effective 1st June is under Mahogany Pvt Ltd, which is an associated company of Magic Kingdom Resorts.

1.4.2 The consultant

Seamarc Pvt. Ltd. is a company registered at the Ministry of Economic Development of the Government of the Republic of Maldives, under the act no. 10/96, since June 2000. The aim of the company is to provide quality advice on dealing with environmental problems arising from the rapid developments in infrastructure taking place in the Maldives. Seamarc Pvt. Ltd has been appointed as the consultant for this project by the proponent.

2 Study area

The study area is delimited by the reef surrounding the island of Fonimagoodhoo (Figure 3) in Baa atoll. The survey area covers the area which could be impacted by the proposed works and associated sediment plumes.

Figure 3: Fonimagoodhoo Island with part of the associate coral reef system. The study area (red zone) covers only the reef surrounding the island which may be affected (source: www.flashearth.com).

3 Project Description

3.1 Project location

Reethi Beach Resort is located on the island of Fonimagoodhoo, on the north eastern part of Baa Atoll (Figure 4). The house reef of Reethi Beach consists of a rather narrow reef flat and an almost vertical wall on the western side wheareas patchy reefs are present on the eastern or lee side of the island.

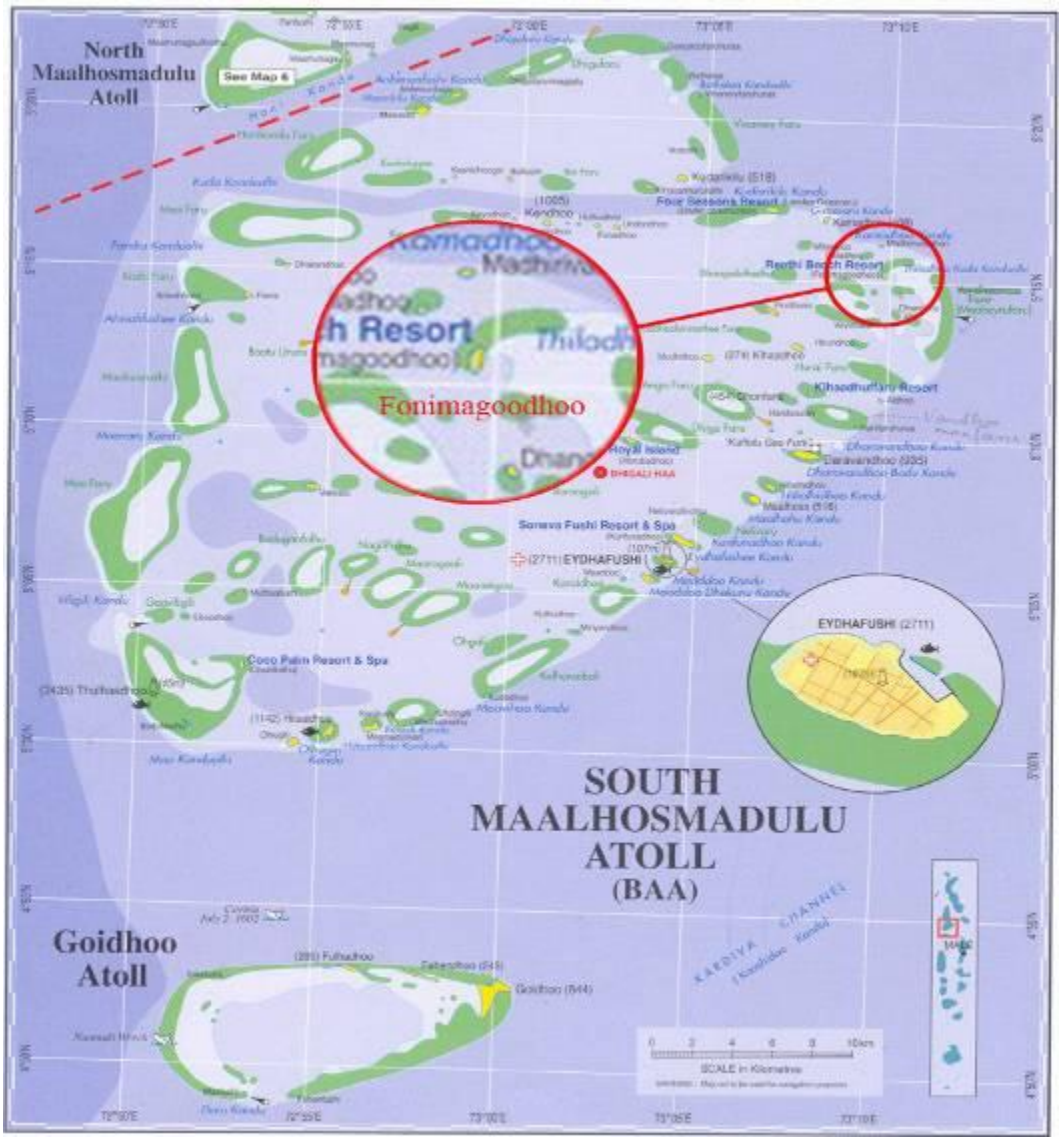


Figure 4: Baa Atoll, Fonimagoodhoo (Reethi Beach Resort).

3.2 Project boundaries

The project area is comprised of the eastern side of the island from the northern to the southern tip including the reef and lagoon on this side of the island. Figure 6 shows the coastal structure design of the project. On the site plan, the structures drawn in red already exist and will be maintained as additional coastal protection. The new structures, drawn in black, will be made of Elcorock Beach Protection system, which are very durable sand filled containers. Geo-tubes (Figure 5) will be installed to create different revetments and breakwaters as highlighted in the drawing. The northern revetment will be built out of geo-tubes filled with sand.

Figure 5: A beach protection revetment installed in K. Bolifushi.

Some beach replenishment will also be carried out once the coastal structures are built to enhance the visual aesthetics of the island; this will help the areas near the construction recover quicker than if it were left to accumulate sand naturally.

Figure 6: coastal structure designs at B. Fonimagoodhoo

3.3 The proposed works

3.3.1 Overview

The project is composed of four different components, which are:

- Deploying submerged geo-tubes laid on the sea bed in order to decrease wave energy before reaching the coast on the north east side of the island;
- Placing geo tubes along the coastline to prevent coastal erosion and to extend the beach on the north-eastern and southern sides;
- Modifying the existing groynes to prevent the sand movement and to retain it on the coast on the southern and south-eastern sides;
- Pumping sand from the designated borrow areas in order to replenish the beach and cover the existing unaesthetic coastal structures.

3.3.2 Geo-tube Placement

3.3.2.1 Background on geo-tubes

The proposed structures are made of large geo-tubes, 25 meters in length, laid on a hard substrate foundation, either natural or created (Figure 6a). The tubes are made of a very durable synthetic cloth material with a wiry layer on the outside to promote growth of algae and other organisms which will eventually help camouflage the tube. These large geo-tubes are also referred to as “mega tubes”. The tubes are filled in-situ using a sand pump; material from the reef flat is used to fill the bags, as can be seen in the adjacent figure (Figure 6b).

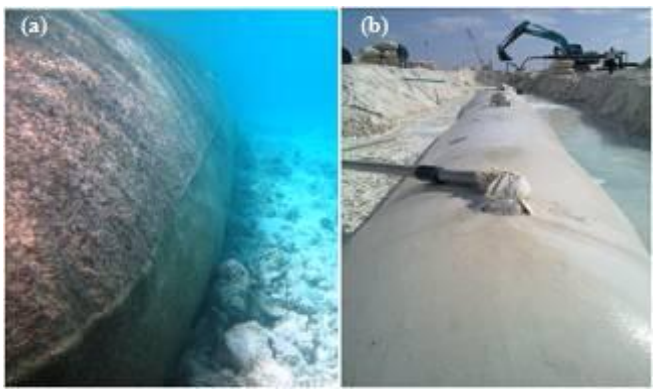


Figure 6: A geo-tube implemented on a hard natural substrate (a), a geo-tube being filled in-situ (b).

The bed on which the tubes will be laid will have an appropriate thickness in order for the top of the geo-tube to be just submerged at high tide as shown in the following figure (Figure 7).

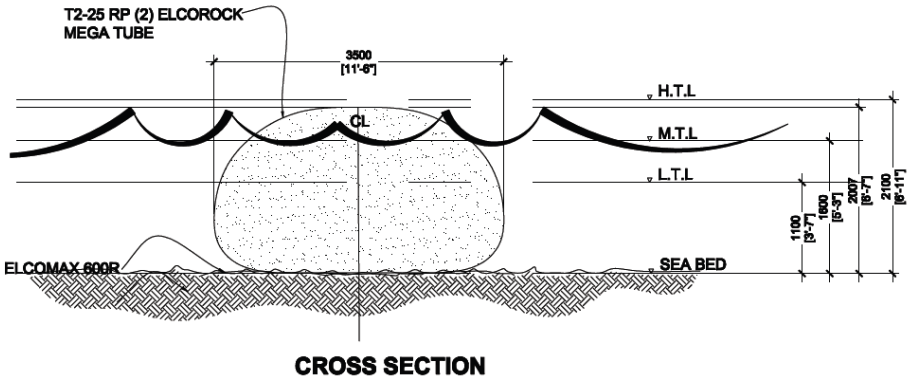


Figure 7: geo-tube laid on a hard natural substrate.

3.3.2.2 Changes to phase 1 geo-tubes and implementation of a headland on the southern tip

One of the existing geo-tubes implemented during phase 1 of the project will be removed on the southern side of the island as it has not proven very efficient to counter beach erosion (Figure 9). Four of the previous geo-tubes implemented during phase 1 will be kept as they have effectively diminished wave action on this part of the coastline (Figure 9, right).

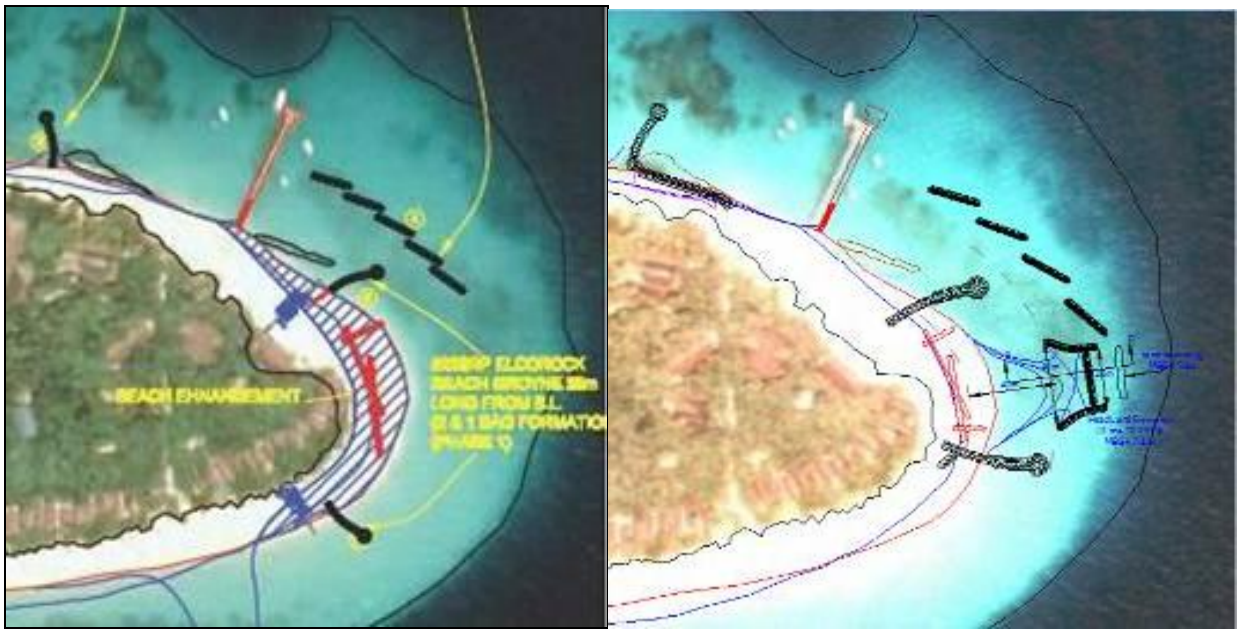


Figure 8: Design of the previous geo-tubes (left) and new groynes (right) arrangement in the southern tip of Fonimagoodhoo Island.

In order to achieve a sustainable and permanent solution to this issue, three additional geo-tubes filled with sand will be implemented on the southern tip in order to create a headland. This will ensure that the pumped sand remains in this area of the coastline. (Figure 9)

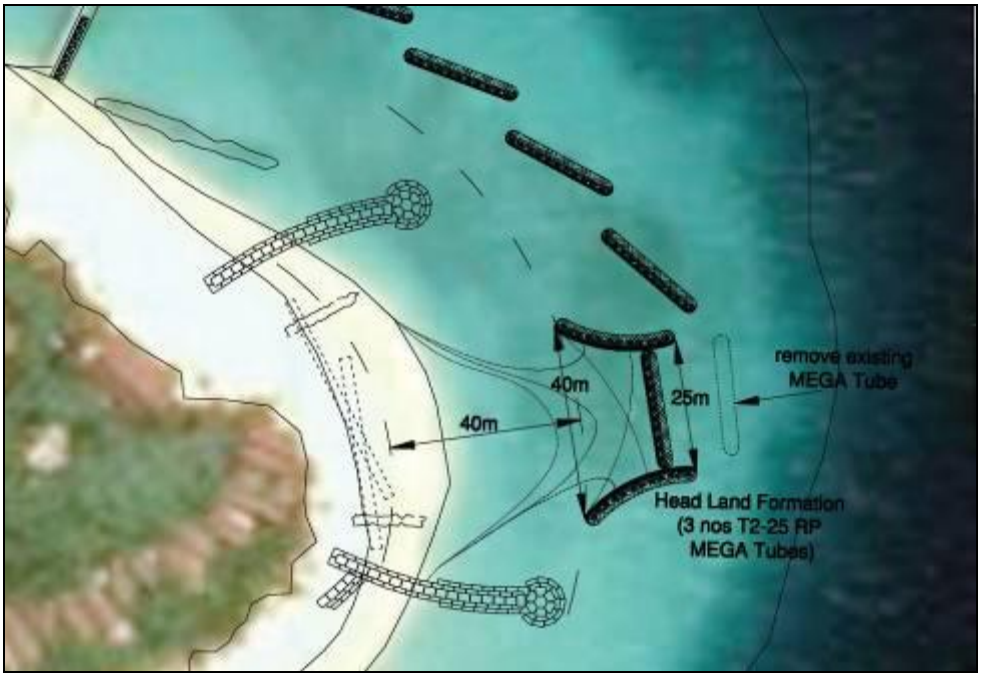


Figure 9: Design of the geo-tube arrangement in the southern part of Fonimagoodhoo.

3.3.2.3 New geo-tube breakwater on the northeastern corner

The north-eastern corner of the island has been eroding during the northeast monsoon and some desperate ad hoc measures have been implemented in the past (Figure 10). The present study explores a permanent solution for this area of the coastline. Two geo-tubes filled with sand will be installed on the north-eastern beach rock (Figure 11). Three other geo-tubes will be used as a revetment in the north because the beach is highly eroded.

Figure 10: North east area is badly eroded and is in need of a permanent solution

Figure 11: Design of the geo-tube arrangement in the northerneastern part of Fonimagoodhoo.

3.3.3 **Modification to phase 1 groynes**

The existing groynes implemented during phase 1 will be reinforced with geo-bags filled with sand, pumped from a sand barge. The direction of the groyne on the eastern side will be changed to a northerly directionas can be seen in Figure 12.

Figure 12: The picture on the right is the new proposed groyne design, and the picture on the right is the old design.

3.3.4 **Beach replenishment and borrow areas**

Sand will be pumped from the lagoon in order to replenish the beach and to cover the existing structures which provide a positive visual aesthetic to the beach in the southeast and in the northeast coastlines. The material will be taken from a close-by offshore site, but distant enough so that beach stability will not be compromised. These areas are represented in red on (Figure 13) the coordinates of which are in Table 1. It is estimated that 2500m^{3}of sand will be required for beach replenishment and filling of the geo-tubes. The volume of each geo-tube is 176m^3.

Figure 13: Sand pumping area location delimited by ABCD and EFGH coordinates.

Table 1: Sand pumping area coordinates.

Point	Latitude (°)	Longitude (°)
A	5.251642	73.164114
B	5.251542	73.163838
C	5.251659	73.163785
D	5.251743	73.163991
E	5.258527	73.166718
F	5.258439	73.166492
G	5.258625	73.166392
H	5.25872	73.166625

Beach replenishment may be necessary at certain times of the year when the beach is more prone to erosion and it is required to extend the authorization for sand pumping to the maximum 2 year period.

3.1 Detailed construction works method statement

3.1.1 Mobilization & site setup

3.1.1.1 Manpower

It is expected that 15 workers will be on site to carry out the project. They will be living in the staff quarters of the resort and eating at the staff canteen. Therefore no temporary housing or facilities will be required.

3.1.1.2 Machinery

The project will make use of an Excavator SK200, Elcorock 5tn Filling Plant, Sand Barge System, and Flat-top Sand Barge, as well as different tools used to fill the Elcorock bags. Approximately 10 skilled persons will be required and 1500 ltrs of fuel will be consumed per day.

3.1.1.3 Transportation of machinery, material and work force

Mobilization will be in a single effort, with the supply of necessary material, machinery and manpower all occurring at the same time. This is possible as the existing logistics and infrastructure of the resort will be utilized.

3.1.1.4 Establishment of project site management facilities

The resort will house the staff and provide meals to the workforce and therefore the resort will be catering for electricity, water as well as waste water and solid waste management.

3.1.2 **Project time frame**

The project is expected to be approved in January 2013. The project will start as soon as approval is granted and the works will be completed within 6 months.

4 Legislative and regulatory considerations

This section outlines the relevant environmental legislation, existing plans, policies and guidelines and international conventions pertaining to the development under study.

4.1 Environment Protection and Preservation Act of Maldives (Law no. 4/ 93)

The Environment Protection and Preservation Act of the Maldives (EPPA; Law no. 4/ 93) provide the legal basis for environmental protection, preservation and conservation in the country. Being an umbrella law, it gives extensive power to Ministry of Housing and Environment (MHE) in matters concerning the environment.

The following articles are addressed in the EPPA:

- The guidelines and advice on environmental protection in accordance with the prevailing needs and conditions of the country shall be provided by the concerned government authorities.
- In areas of environmental protection and preservation that do not already have a designated government authority, MHE shall be the responsible authority to formulate policies, rules and regulations.
- MHE shall be responsible for identifying and drawing up legislation for conservation of protected areas and natural reserves.
- An environmental impact assessment has to be submitted to MHE before implementation of any project that may have an impact on the environment. MHE shall formulate the guidelines and determine the projects that require such an assessment.
- MHE has the authority to terminate any project that has an unfavorable impact on the environment without compensation.
- Disposal of waste, oil, poisonous gases or other substances harmful to the environment is prohibited within the territory of the Maldives. In the event that disposal of such substances become necessary, they shall be disposed of within the area designated for the purpose by the government.
- Disposal of hazardous, toxic or nuclear waste is prohibited within the territory of Maldives and a permit shall be obtained before any trans-boundary movement through the Maldivian territory.
- The penalty for defying the law is stated in the Law.

- The government of Maldives has the right to claim compensation for any damages caused by activities that are detrimental to the environment.

4.2 The EIA process

- Under Article 5 (a) of the EPPA, an Environmental Impact Assessment has to be submitted by the developer of a project which may have potential impacts on the environment, to MHE for approval before commencement of the project.
- The EIA process is coordinated by the Environment Protection Agency of the MHE with consultation from other relevant government agencies and the National Commission for the Protection of the Environment (NCPE). The EIA process is initiated when the proponent submits a Screening Form to the Ministry. This stage identifies if the project requires an Initial Environmental Examination (IEE) or a full Environmental Impact Assessment. Subsequently, the scope of the EIA will be discussed in a Scoping Meeting attended by representatives from the Ministry and the proponent. Once the scope is identified, baseline surveys will be carried out and a report submitted to the Ministry according to the guidelines provided in the EIA Regulation. The main components of the report are project description, existing environment, public consultation, impact assessment, alternatives, mitigation and monitoring. A decision statement is then issued by the Ministry stating whether the project is approved, needs further information or is rejected. The EIA process is schematically shown on Figure 12. The development of all new resorts is included in the list of activities requiring an EIA (Schedule D) of the EIA Regulations. Thus, this project need not go through the screening process but can go directly to the scoping stage.

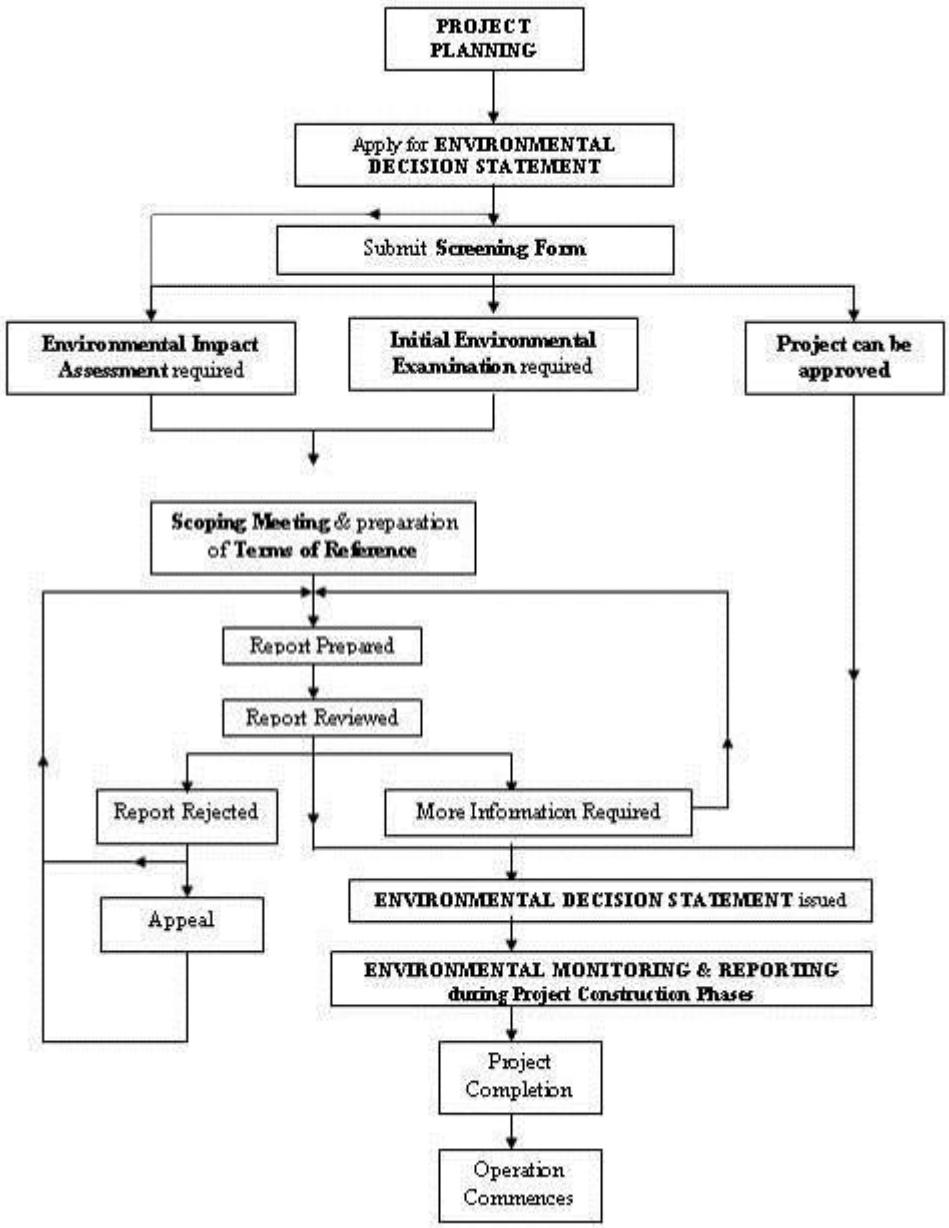


Figure 14: The EIA process in the Maldives

4.3 Biosphere reserve

Baa Atoll was recognized as Biosphere Reserve on 28th June 2011 by UNESCO (United Nations Educational, Scientific and Cultural Organization). Baa Atoll UNESCO Biosphere Reserve is the first Biosphere Reserve established in Maldives. The main functions of the Biosphere Reserve are: conservation, sustainable development and learning.

The Baa Atoll Conservation Fund (BACF) is a collaborative effort between the Global Environment Facility (GEF) and the Government of Maldives. Majority of tourist resorts operated in Baa Atoll have pledged to donate an annual contribution to the fund, which in turn will finance projects to conserve the environment in Baa Atoll as well promote sustainable livelihood opportunities.

4.4 Maldives Tourism Act (Law no. 2/99)

This act encompasses the issues related to the development of tourism in the Maldives. It came into effect on the November, 1999, repealing the Law on Tourism in the Maldives (Act No. 15/79) and the Law on Leasing of Uninhabited Islands for the Development of Tourist Resorts (Act No. 3/94). Act No. 15/79 was the primary legislation that was passed by the Citizen's Majlis in November of 1979 and the main aim was to provide for the collection of a bed tax from the visiting tourists and to control their movement in the Maldives. While this Act only dealt with tourist resorts, hotels and guest houses, the amended act (Act No. 2/99) incorporates the determination of zones where tourism development can occur, as well as the development and management of marinas and the operation of tourist vessels, diving centres and travel agencies. This is evidence that the tourism industry has expanded since the enactment of the initial laws, both in magnitude and in the diversity of facilities that are provided for the visiting tourists.

The environmental legislation that directly applies to the development is outlined under article 15 (a) and (b). Article 15 (a) provides for the felling of Ruh's and trees, dredging of lagoons, reclamation of land or any other activity that may cause permanent change to the natural environment of an island leased as a tourist resort. It states that the activities mentioned above can only be carried out after obtaining written permission from the Ministry of Tourism, Arts and Culture and in accordance with the relevant regulations.

Under Article 15 (b), a justification has to be provided for such an activity, as well as an environmental impact assessment, which has to be submitted to and approved by the Ministry of Housing and Environment.

There are several regulations under the Maldives Tourism Act (Law No. 2/99) and those pertaining to the environment are presented below.

4.5 Regulations under Maldives Tourism Act

4.5.1 Development of tourist resorts

Under article 4 of this regulation, permission is required from the Ministry of Tourism, Arts and Culture before felling of trees.

4.5.2 Carrying capacity for islands to be developed as tourist resorts

A set of standards has been imposed under this regulation to ensure preservation of the natural beauty and the environment of the islands as well as the consumer's image of the islands. As such, the following guidelines are provided:

- The felling of trees has to be carried out evenly throughout the island with the intention of conserving the natural façade and the beauty of the island.
- Sufficient trees have to be left untouched when clearing trees for construction in order that they block the view of the buildings. All buildings, including two storey buildings are to be constructed below the highest canopy level so that they are not visible above the treetops.
- The maximum number of buildings to be constructed on the island should be dependent on how much space can be cleared of vegetation, with consideration of the above factors.

The maximum area utilized for the construction of buildings should not exceed 20% of the total land area.

- All buildings should be located at least 5m landwards from the vegetation line of the island. In the event that over water bungalows are built on the reef flat or lagoon, an equal area has to be left free on the island.
- To provide the visiting guests with sufficient beach area, the guest rooms should face the beach with a minimum of 5m of beach allocated for each room.

4.5.3 **Disposal of garbage**

- Garbage from the resorts should be disposed of appropriately to avoid impacts on the environment. Waste disposed of at sea should be thrown away far out to sea, ensuring that it does not get washed back on the beach of any islands.
- All resorts are required to have incinerators and compactors to be utilized for burning all flammable material and compact the cans respectively. Glass is to be broken into small pieces and plastic and polythene bags burnt.
- A fine between Rf100 and Rf2000 is to be charged if the regulation is breached, and the sum doubled for those who violate it a second time.
- In addition to the Maldives Tourism Act and the relevant Regulations, there are Circulars issued by the Ministry of Tourism, Arts and Culture, advising the Tourism industry of their new policies or strengthening the existing ones.
- Circular no. 21/90 (21.04.1990) advices all resorts having filled jetties to be modified so that they allow free flow of currents through them or new jetties composed of reinforced concerted stilts to be built in their place by the end of June 1991.
- Circular no. CIR-ES/98/07 issued on the 27th of January 1998 states that all resorts have to obtain permission from the Ministry of Tourism, Arts and Culture before commencing any coastal modifications. Hard engineering solutions are discouraged while environmentally friendly structures are supported.

- Circular no. 88-ES/CIR/2002/12 (05.05.2002) deals with the proper disposal of garbage from the resorts in response to concerns that floating garbage from resort islands were washing up on beaches of nearby islands.

4.5.4 Maldives third tourism master plan

The Maldives Third Tourism Master Plan (TTMP) was launched in August 2007. The planning horizon is from 2006 to 2010. The strategies recommended will integrate with the policies and strategies for tourism, air and sea transport proposed in the 7th National Development Plan which is also being developed.

The TTMP will focus on the following areas:

- Identification of potential product expansion and diversification and Maldives tourism product review.
- Increasing the share of Maldivians working in the tourism industry.
- Greater community involvement in the tourism sector.
- Improvements in the retention of economic benefits of tourism within the Maldives economy.
- Improvements to the tourism related infrastructure and support services.
- Protecting, preserving and promoting the natural resource base, heritage and culture in relation to tourism development.
- Strengthening the institutional capacity of Ministry for Tourism, Arts and Culture.
- Developing domestic tourism.
- Improving the legislative framework in relation to the tourism industry.

4.5.5 Fisheries regulation of the Maldives

Under Article 1 (d) of this regulation, it is an offence to carry out any fishing activity on the house reef or the lagoon of a tourist resort without prior approval from the management of that resort.

4.5.6 Regulation on sand and coral mining

Under Article 7 (c) of the Regulation on Sand and Coral Mining issued by the Ministry of Fisheries, Agriculture and Marine Resources (MOFA) on the 13th of March 2000, it is an offence to mine sand or coral from the beach, lagoon or reef of any island leased for the purpose of building a tourist resort. Mining of coral or sand for the construction of resorts and associated facilities is discouraged under the policy of the Ministry of Tourism, Arts and Culture, and utilization of alternative construction material is encouraged. As an incentive, import duty is

exempted under Sub clause 3, Article 9 of Law No. 31/79 for the import of cement, iron, steel, roofing sheets and timber for the construction of tourist resorts. However, sand mining is allowed for beach replenishment projects, predominantly from the immediate lagoon of the resort and in the case of a lack of sand on the island, from an area that is decided by MOFAMR.

4.6 International Conventions

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

UNFCCC is the first binding international legal instrument that deals directly with the threat of climate change. It was enacted at the 1992 Earth Summit in Rio de Janeiro and came into force on the 21st of March 1994.

Signatory countries have agreed to take action to achieve the goal outlined in Article 2 of the Convention which addresses the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system," Thus all Parties to the Convention are committed under Article 4 to adopt national programs for mitigating climate change, promote sustainable management and conservation of green house gas (GHG) sinks such as coral reefs, to develop adaptation strategies, to address climate change in relevant social, economic and environmental policies, to cooperate in technical, scientific and educational matters and to promote scientific research and exchange of information.

The Kyoto Protocol entered into force on the 16th of February 2005 and is an international and legally binding agreement to reduce GHG emissions globally. It strengthens the Convention by committing Annex I Parties to individual, legally-binding targets to achieve limitations or reductions in their GHG emissions. Maldives has signed and ratified both the Convention and the Protocol.

4.6.2 United Nations Convention on Biological Diversity (UNCBD)

The objectives of the UNCBD are "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources." The Convention entered into force on the 29th of December 1993. Maldives has ratified the Convention and has prepared the National Biodiversity Strategy and Action Plan in 2002.

4.6.3 United Nations Convention to Combat Desertification (UNCCD)

The objective of the UNCCD is to "combat desertification and mitigate the effects of drought in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership

arrangements, in the framework of an integrated approach, which is consistent with Agenda 21, with a view to contributing to the achievement of sustainable development in affected areas (article 2).” To achieve this goal the Convention focuses on improving land productivity, rehabilitation of land, conservation and sustainable management of land and water resources.
The Convention was adopted in Paris on 17th June 1994 entered into force on 26th December 1996. Maldives has acceded to the Convention in 2002.

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

UNCLOS refers to several United Nations events and one treaty. This treaty provided new universal legal controls for the management of marine natural resources and the control of pollution. UNCLOS provides a legal order for the seas and oceans which will facilitate international communication, and will promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment

4.6.5 Role of Stakeholders

There are many parties that can affect or can be affected by development projects. Various national agencies are responsible for environmental management and protection including the MHE and MoFA. At the same time, the project proponent has a duty to do their share of conserving the environment by minimising and mitigating impacts arising from the project. The environmental consultants also play a major role in informed decision making by providing the proponent with the information required for this purpose.

4.6.6 Government Agencies

Ministry of Housing and Environment (MHE) and Environment Protection Agency (EPA) are the lead government agency that has the responsibility to implement the Environmental Impact Assessment process. It has the task of ensuring all development projects anticipated to have impacts on the environment undergo the process before implementation. This involves screening the projects and providing approvals and recommendations related to the EIA. MHE is also responsible for ensuring proper implementation of the environmental measures proposed in the EIA including the Environmental Monitoring Plan.

The EIAs and any related documents for resort development are required to be submitted to the MHE through the Ministry of Tourism, Arts and Culture (MTAC). MTAC is the authority that determines the zones where tourism development can occur, as well as the development and management of marinas and the operation of tourist vessels, diving centres and travel agencies. It has the mandate to develop tourism in the Maldives in a sustainable manner and is responsible for ensuring that resort construction and operation abide by the Maldives Tourism Act of

Maldives and the associated regulations. MTAC also has the responsibility to provide authorisation for operation of aerodromes.

Other government agencies having a role in the project include:

Ministry of Housing and Environment has the authority to allocate the land on inhabited islands, including area approval and implementing “no development” buffer zones as well as enforcing planning regulations. The Ministry provides a planning permit to Ministry of Tourism, Arts and Culture which then allows the development of a resort on the island.

Pertinent legislation, regulations and standards and responsible authority jurisdiction

5 Existing Environment

5.1 Climate

5.1.1 Wind

Climate in the Maldives is dominated by the Indian monsoon climate with two predominant monsoons: Southwest (SW) monsoon and Northeast (NE) monsoon. The Indian monsoon system is one of the major climate systems of the world, impacting large portions of both Africa and Asia.

The period of the year during which prevailing winds are from south to westerly direction is known as the SW monsoon(Kench et al., 2009). The period during which prevailing winds are from north-easterly directions is known as NE monsoon. Transitions from NE to SW monsoon and vice versa are distinctly different from SW or NE monsoon. During these transition periods the wind becomes more variable.

The SW monsoon lasts between May and September while the NE monsoon lasts between December and February. The period between March and April is the transition period from the NE monsoon to SW monsoon known locally as the *Hulhangu Halha*, while the transition period from SW monsoon to NE monsoon is known as *Iruvai Halha. Iruvai Halha* is from October to November (Table 2).SW monsoon is generally rough and wetter than the NE monsoon. Storms and gales are infrequent in this part of the globe and cyclones do not reach as far south as the Maldivian archipelago.

Season	Month
NE-Monsoon	December
	January
	February
Transition Period 1	March
	April
SW-Monsoon	May
	June
	July
	August
	September
Transition Period 2	October
	November

Table 2: The four seasons encountered in the Maldives

5.1.2 **Waves**

Hydrodynamic features in Maldives have been very poorly studied. Young(1999) shows wave climate data for a ten-year period for each world regional zone. Wave height was measured by satellite (Radar Altimeter), where as a global wave model was used for precise wave directions. It indicates that the dominant swell approaches from southerly directions (Figure 15). On a seasonal basis, swell is from the south-southwest from April to November with a peak significant wave height (Hs) of 1.8m in June, and from the south to southeast directions from November to March with minimum Hs of 0.75m in March. The swell would be originally generated in the intense wave region of the Southern Ocean between Australia and South Africa.

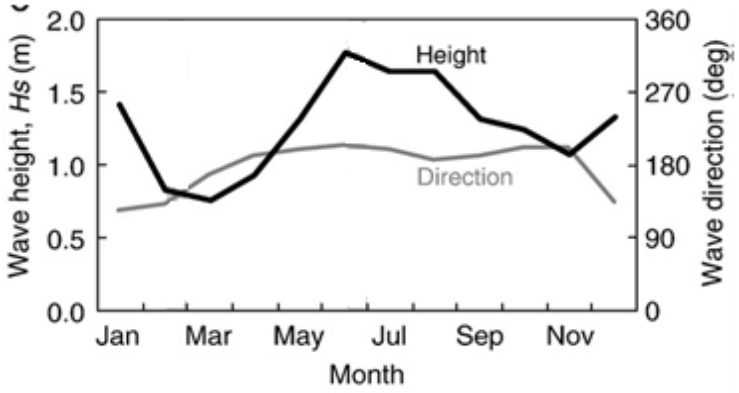


Figure 15: Ten year mean monthly wave height and direction for the central Maldives. Source: Young (1999).

5.1.3 **Ocean Currents, Data and Analysis**

Current data was collected using a drogue system. This device uses a DGPS system that is connected to a floating platform with fins and a weight at the bottom to catch the underwater current. Above the fins on the bottom of the device floatation devices are attached; above this the rover part of the system is fixed to the top of the pole. The device is then put in the water and data points are collected while the device is pushed or pulled by the current. The start and end location is noted as well as the time it takes to travel that distance. Using this information the speed of the current is calculated.

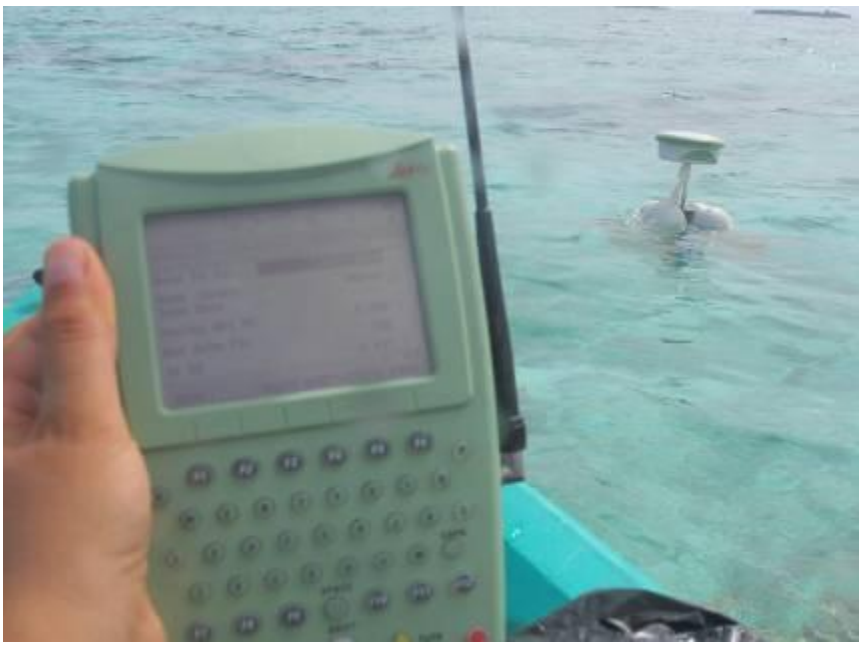


Figure 16: The drogue deployed in the water.

5.1.3.1 Methods and Equipment

Using the Leica DGPS 1200+ and accompanying equipment, a drogue was set up and used to collect current data in strategic areas around the island coast. The "rover" section of the Leica GPS 1200+ was attached to a pole with a fin system to provide drag underwater, as well as floats to keep it on the surface (Figure 16). Care was taken to make sure the top of the device had minimal drag to wind and that the predominant force on it was from the current below.

Data points were gathered every second for approximately ten minutes. Then using the difference in location from the start time to the end time a calculation of the current average was made for that particular time. Two baseline data sets were collected in two different locations.

5.1.3.2 Results

Below is a table (Table 3) showing the start, end, distance traveled and current speed gathered from the two points shown in the image below (Figure 17).

Table 3: Current Data Reethi Beach

Current Data for Reethi Beach					
	Starting Latitude/Longitude	Ending Latitude/Longitude	Distance Traveled (m)	Duration (sec)	Current (cm/sec)
Location 1	5.256499° / 73.165146°	5.256301° / 73.164981°	29.16	528	***5***
Location 2	5.251891° / 73.163561°	5.251765° / 73.163794°	28.55	417	***7***

Figure 17: Locations of current data

5.1.4 Air Temperatures

The temperature in the Maldives does not vary significantly throughout the year and remains almost the same (Figure 18). However, daily temperatures range from around 31^{o} C in daytime to 23^{o} C in night-time. The mean daily maximum temperature for Central parts (Hulhule) of the Maldives is 30.5^{o} C and minimum temperature is 25.7^{o} C. On the other hand, mean daily maximum and minimum temperature for South (Gan) is 30.9 ^{o} C and 24.5^{o} C, respectively. Furthermore, mean daily maximum and minimum temperature for North (Hanimaadhoo) is 30.7^{o} C and 25.2^{o} C, respectively. The highest temperature ever recorded in the Maldives was 36.8° C, recorded on 19 May 1991 at Kadhdhoo Meteorological Office. Likewise, the minimum temperature ever recorded in the Maldives was 17.2° C, recorded at the National Meteorological Centre on 11th April 1978.

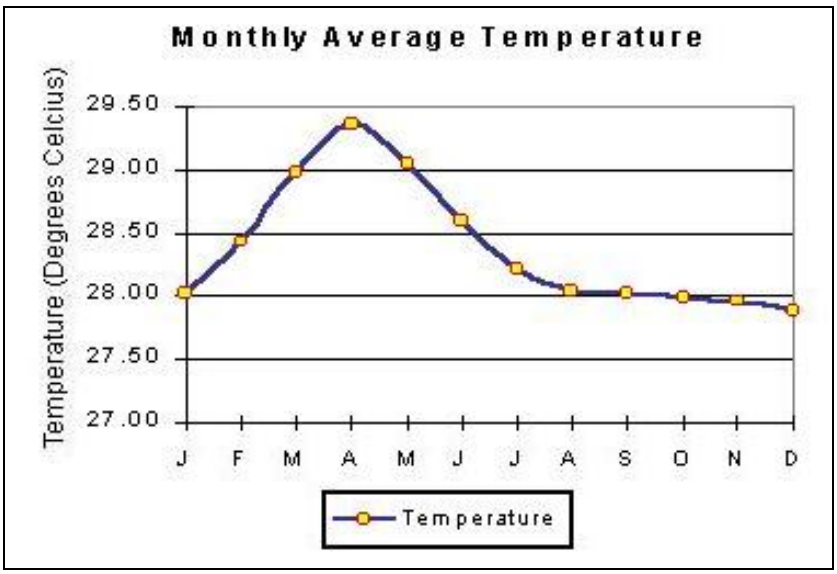


Figure 18: Monthly average temperature. Source: Department of Meteorology.

5.1.5 **Rainfall**

The wet season- southwest monsoon runs from mid-May to November (Figure 19). In this season Maldives experiences torrential rain. Central, Southern and Northern parts of the Maldives receive annual average rainfall of 1924.7mm, 2277.8mm, and 1786.4mm, respectively. The highest rainfall ever recorded in the Maldives with in 24 hour period was recorded on 9th July 2002 at Kaadedhdhoo Meteorological Office and amounts to 219.8mm of rainfall.

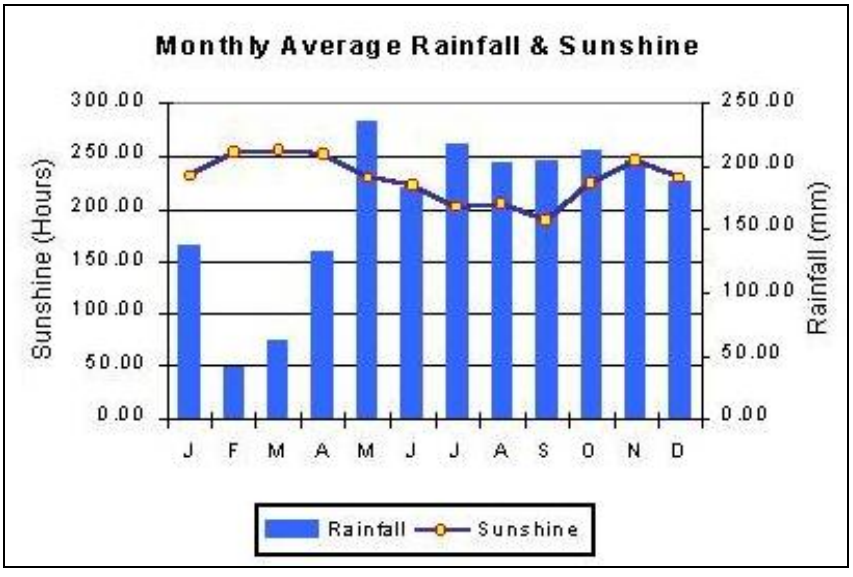


Figure 19: Monthly average rainfall and sunshine. Source: Department of Meteorology.

5.2 Hydrodynamic regime around the island

Reethi Beach Resort is located on the island of Fonimagoodhoo on the most eastern reef system of Baa Atoll. However, the island does not sit right on the edge of the atoll, and is located at the west of a large reef system, which has a number of sand banks on its outer periphery.

The island of Fonimagoodhoo is subjected to the southeast oceanic swell, which passes between North Male' Atoll and Lhaviyani Atoll (Figure 20) but since it is located on the eastern side of the atoll, it is not majorly affected by oceanic swell, which at times is coming from the south-southwest. Moreover, this island is subjected to the wind waves modulated by the monsoon, generating sand transport and geomorphologic changes between the windward and the leeward sides.

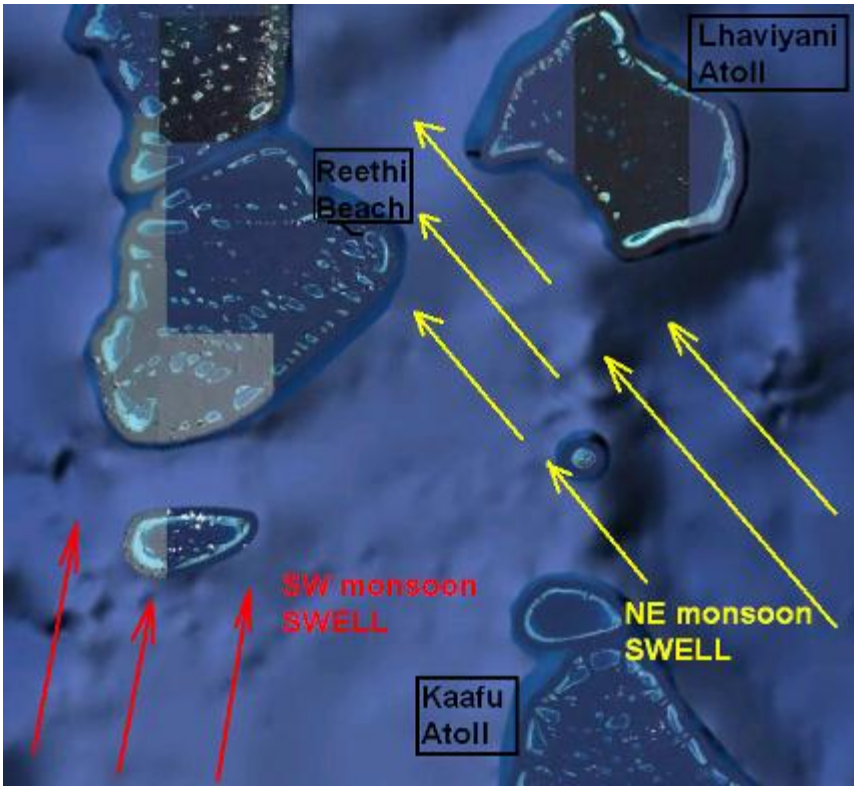


Figure 20: Swell influences in Baa Atoll;

The reef system of Reethi Beach Resort is not closed and two important discontinuities influence the coastal processes around the island. The first one is the channel to the outside of the atoll on the north-eastern side of the island. A component of the diffracted oceanic swell and wind waves pass through this channel, creating waves on the eastern side. The second one is the pass at the south of the system. The swell enters by the channel between Vandhooma Faru and Hurai Faru after which it is diffracted and reaches the south of Fonimagoodhoo (Figure 21a).

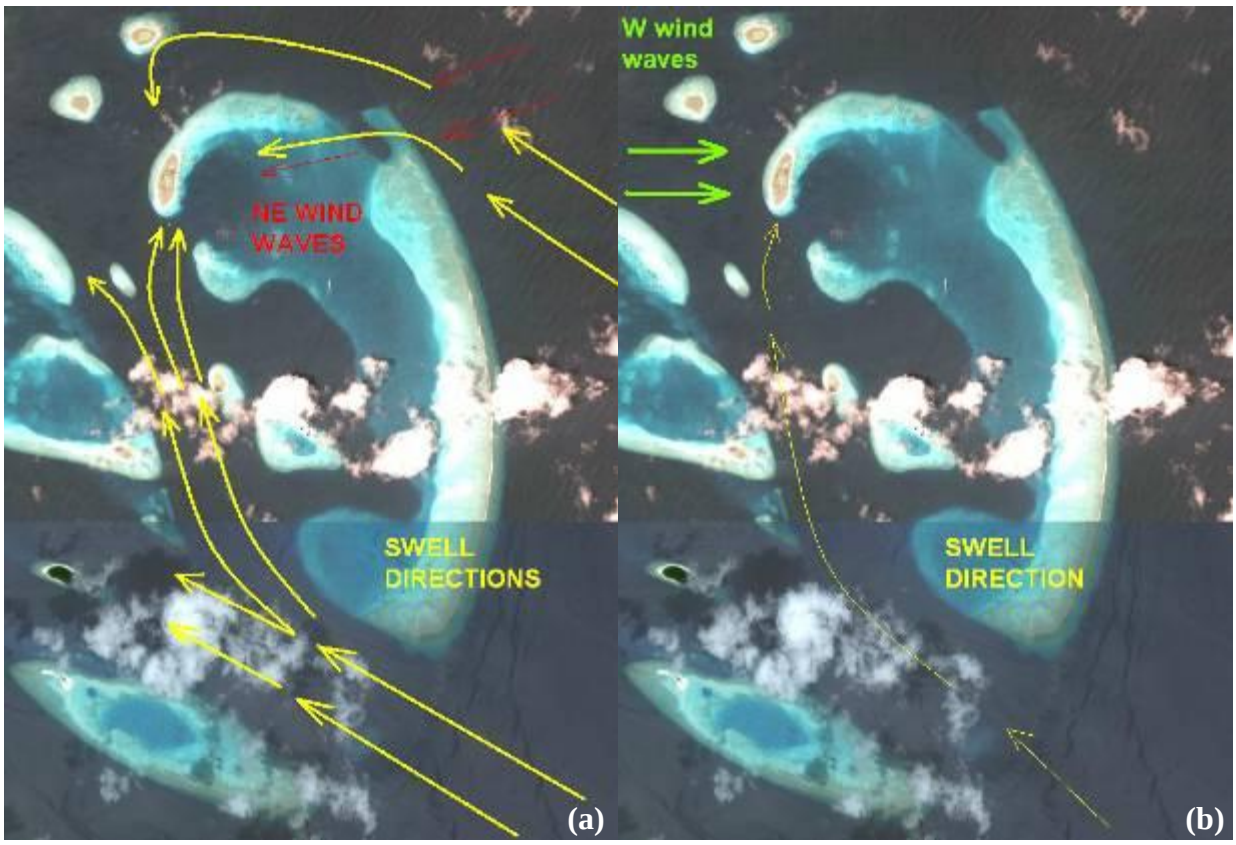


Figure 21: Diffracted swell and wind waves directions around Fonimagoodhoo during (a) NE Monsoon and (b) SW Monsoon.

Figure 22 shows the difference of energy that meets each side of Fonimagoodhoo during both monsoons. A combination of the swell and the wind waves during the NE monsoon hits the eastern side, whereas the west side receives the wind waves during the SW monsoon. This difference explains why the erosion is mainly noticed in the northeast and southeast of Fonimagoodhoo during the NE monsoon.

During the northeast monsoon on the northern tip, the sand accumulated during the southwest monsoon is divided: one part will move to the western side of the northern tip and one part will move down the eastern coastline towards the south. Both the wind waves and oceanic swell hit the eastern part of the island. There are no forces counteracting the north to south sand movement on the eastern shoreline and the sand accumulates on the western side of the southern tip. These sand movements are described in (Figure 22).

During the southwest monsoon, the wind waves hit the western part of the island. This moves the sand from the southwest area towards the eastern coast. Little sand has been noticed to move along the western shore in a northern direction in the past. Nonetheless, sand located on the northern part of the western coast moves towards the northern tip. Depending on the strength of the monsoon, the sand moves further south or north from one year to the next on either side of the island.

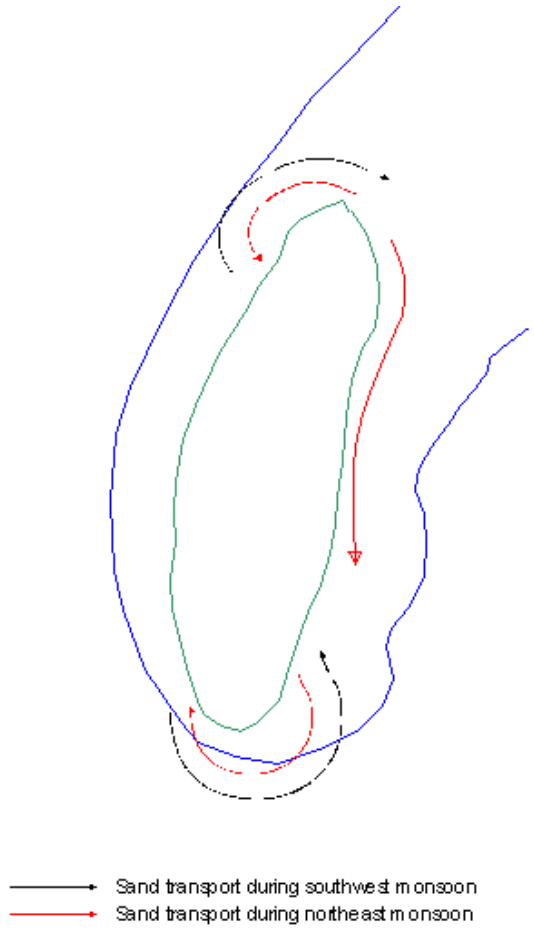


Figure 22: Main monsoonal sand transport;

The tides are periodic shallow water waves. The tidal regime in Maldives is semi-diurnal (high tide every 12 hours) and micro-tidal (tidal range < 2m). The tides provide a period of time for waves to access the shoreline. Kench (2009) showed that shorelines undergo a higher energy wave during the high tidal stages. The rise and fall of the tides are accompanied by horizontal water movements called tidal currents which contribute to the sand transport. These nearshore current velocities are higher during the low tides with peak current reaching 0.3-0.4 m/s (Kench et al., 2009). The tidal current effect is more intense during the spring tides.

5.3 Geology and geomorphology

5.3.1 Coastal geology

The island of Fonimagoodhoo, like all islands in the Maldives is made almost entirely of calcium carbonate stemming from the physical abrading and bio-erosion of coral skeletons, shells and coralline algae. The implementation of hard engineering coastal protection solutions causes a lot of exogenic material to be present on the shoreline, in particular cement and sand bags. Beach rock was seen around the shoreline and it was reinforced by sand bags in certain places.

5.3.2 Coastal geomorphology

At geological scales, it seems that the configuration of the atoll and the influence of the oceanic swell have an influence on the reef system itself. Indeed, the reef shows an extension in the west and north east direction where it is the most exposed. This is due to the water quality being usually better on the exposed side of the reef enabling better coral growth and calcification rates.

The balance of the three main forces (oceanic swell, southwest and northeast monsoons) determines where the island sits. Interferences to counter or increase their influence have a bearing on the sand erosion and accretion patterns, and ultimately the shape of the island and structural integrity of the structures built upon it (Figure 21).

5.3.3 Bathymetry

A bathymetric survey of the study area was undertaken in order to refine the design and set the thickness of the foundation layers of the geo-tubes. In addition, this gives a comparison between existing beach profiles and forecast profile of the beach, which enables the assessment of the efficacy of the structures that will be implemented.

5.3.3.1 Methodology

A topographic survey of the area concerned was carried out using a Leica 1200+ DGPS. Levels were recorded as well as horizontal positions relative to fixed benchmarks on the island. All the survey data was analyzed using Microsoft Excel, IDRISI and AutoCAD. The mean sea level was determined using three hours of records of the sea level on a barge and comparing them to the sea level station monitoring available from Intergovernmental Oceanographic Commission (IOC) of UNESCO (VLIZ for UNESCO/IOC, 2012).

5.3.3.2 Results

The detailed data are present in the figure below (Figure 23). The values on the maps are the elevation from the mean sea level (MSL) at the location where the measure was done. A negative value indicates the depth of the seabed. The shore at high tide is at 0.6 m whereas at low tide it is at -0.6 m.

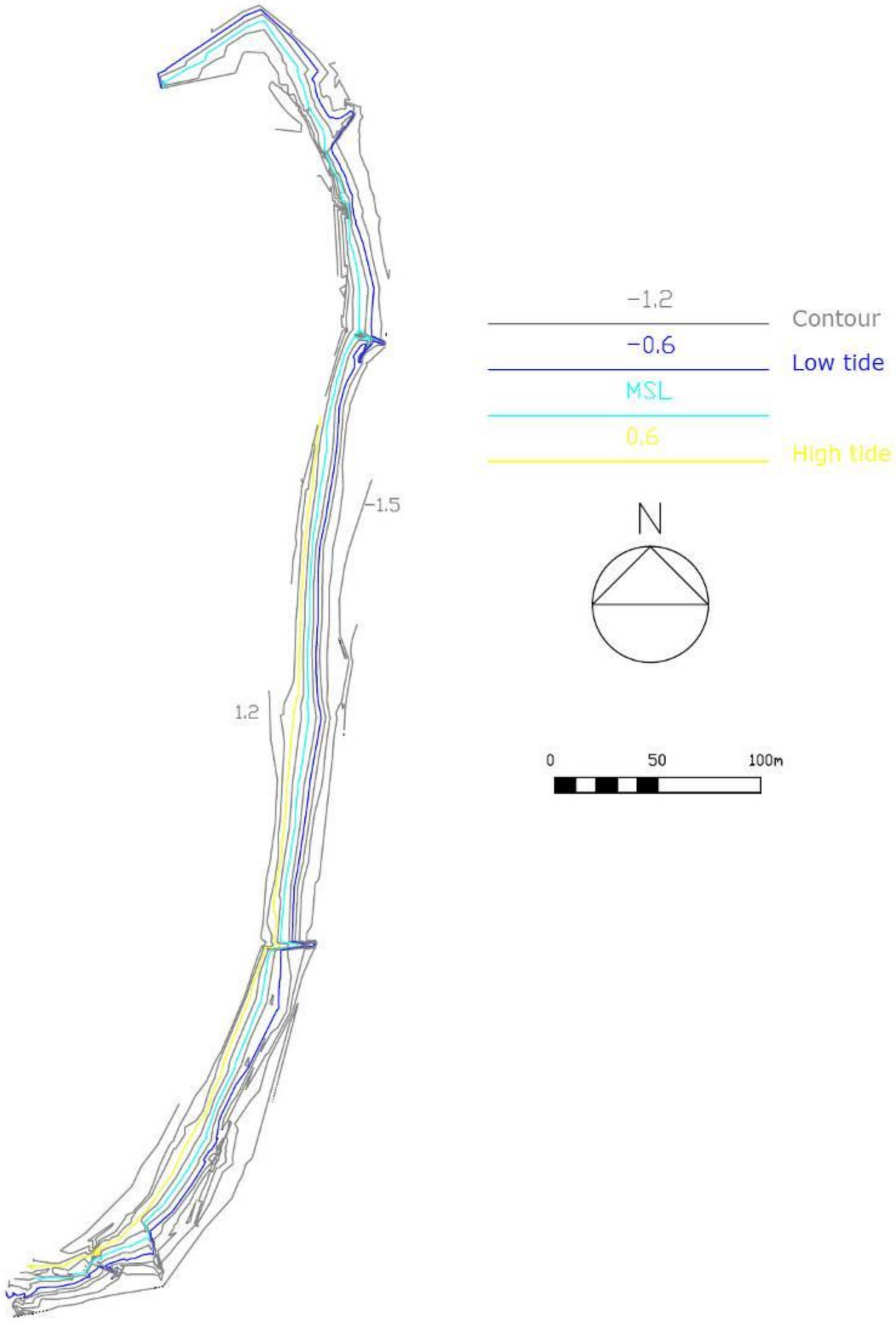


Figure 23: Bathymetry on the eastern side and reef flat of Fonimagoodhoo, levels are relative to MSL

5.4 Marine environment

5.4.1 Introduction

As previously stated, the western side of the island is more exposed than the eastern side. This side is mostly influenced by the western monsoon wind waves rather than the swell, as this is not directly exposed to the oceanic swell. The crest that is present on this side (Figure 24), a much shallower zone with rubbles, is not as significant as the one found in more energetic environments (Figure 25a). It still corresponds to where the waves break. The nearshore is a narrow reef flat mainly composed of rubbles with little sand. Slightly offshore, it shifts to a reef crest where a few colonies of *Porites sp* can be seen (Figure 25b).From this zone to the reef break, coral recruits and small colonies were observed, in particular *Acropora sp* and *Pocillopora sp* (Figure 25c). Nevertheless, most of the substrate is cemented dead coral skeletons, forming a stable hard substrate which should allow new recruits to settle. In this respect, the poor coral cover is of concern, and the reef may be recruitment limited. The transition from the reef to the almost vertical wall is sharp. Both benthic and pelagic fish are very common along the wall (Figure 25d).

Figure 24: The western reef includes a reef flat, a crest and a slope. The eastern reef is composed of several patches.

The eastern reef is composed of rock patches spread along the sandy slope (Figure 26). On this side the slope is not abrupt and the patches are mostly seen between 2 and 10 m. Both large and small coral colonies are displayed. Nevertheless, the sand is the most important substrate, which decreases the chance for coral planulae to settle. Moreover, fish life is fairly rich.

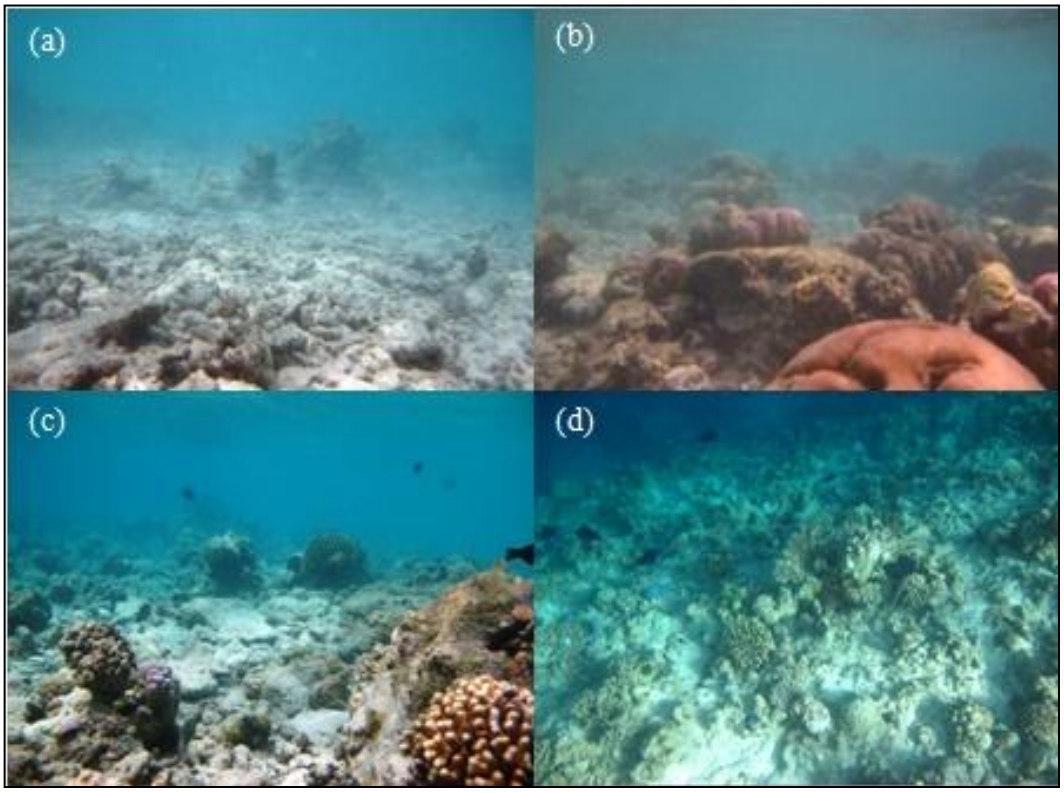


Figure 25: The western reef: the flat characterized by rubble (a), the crest with *Porites sp.* (b), a few coral colonies on the fore slope (c) and the wall (d).

Figure 26: The eastern reef. Patches of rock characterized by bigger coral colonies.

5.4.2 Seawater

5.4.2.1 Sampling method

Sample A was taken at a depth of 1m from the mean sea level whereas sample B was taken at 10 m depth where the sewerage outfall pipe ends (Figure 27 and Table 4). Water samples were analysed by the Public Health Laboratory. Unfortunately, pH and turbidity were the only parameters that could be tested (see letter in Appendix 3).

Figure 27: Water sample locations.

Table 4: Geo-coordinates of the water sample sites.

Sites	Latitude (° N)	Longitude (° E)
A	5.255366	73.164688
B	5.255389	73.165384

5.4.2.2 Results

According to the results (Table 5), the pH of the samples was within the optimal range of seawater pH (8.0-8.3). Turbidity was inexistent, even at pipe outfall. Given these results, seawater quality appeared good in general and there was no significant difference between the samples.

Table 5: Water chemistry analytical results. NTU: Nephelometric Turbidity Units.

Samples	A	B
Date sampled	01/05/2012	01/05/2012
Type of water	Sea	Sea
Physical appearance	Clear with suspended particles	Clear with suspended particles
pH	8.1	8.3
Turbidity (NTU)	0	0

5.4.3 Seawater temperature

5.4.3.1 Sampling method

Two HOBO Pro v2 water temperature data loggers U22-001 (Figure 28) have been used to measure the seawater temperature on either side of Fonimagoodhoo every hour during 10 months (from July 2011 to May 2012). One was fixed on a pipe in 10 meters of depth on the east side whereas the other one was fixed at a buoy at 10 meters on the west side of the island. They have 12-bit resolution and a precision sensor for ±0.2°C accuracy over a wide temperature range. These instruments are equipped with an Optic USB interface for data offload in the field, even when the data logger is wet.

Figure 28: HOBO Pro v2 water temperature data logger U22-001

5.4.3.2 Results

Figure 29 shows the results obtained by the water temperature data logger. The blue line represents the temperature on the west side whereas the red line corresponds to the water temperature on the east side.

No significant difference was observed between the east and west sides. The water temperature was minimal (28°C) during the NE monsoon in January and reached maximum during the SW monsoon in April with more than 30°C.

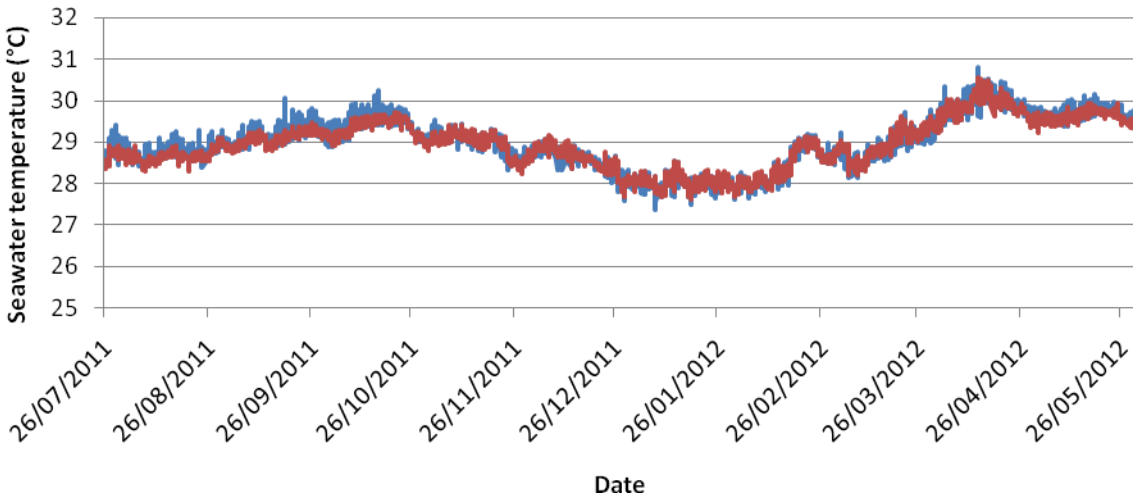


Figure 29: Seawater temperature data on west (blue) and east (red) sides of Fonimagoodhoo given by HOBO Pro v2 water temperature data logger U22-001

5.4.4 Benthic monitoring

5.4.4.1 Methods

The reef assessment used photographic material of the substrate. At each site, 10 high resolution pictures were selected to assess the benthic cover of each site (Figure 30). Each picture was analyzed using 25 points grids to characterize each site with a sample of 250 points per transect. A set of codes introduced by the Global Coral Reef Monitoring Network (English et al., 1997) as well as Reef Check (Reef Check website) was employed to identify the substrate under each point. Quantitative substrate cover data of the morphological characteristics of the reef community was obtained using the CPCe software (Kohler & Gill, 2006) and could be repeated over time to assess variations.

Figure 30: Photographic operator carrying out a transect.

5.4.4.2 Survey plan

For the assessment of the house reef of Fonimagoodhoo, 10 transects have been carried out in 3 different sites. The associated geo-coordinates are given in a table form (Table 6).

The site names are explained as following:

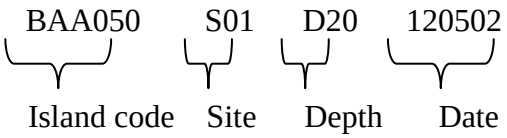


Table 6: Geo-coordinates of the transects at Fonimagoodhoo. Units are decimal degrees.

Transects	Latitude (° N)	Longitude (° E)
BAA050S01D01120427	5.256930	73.165040
BAA050S02D03120427	5.256675	73.166205
BAA050S03D03120427	5.255061	73.165183
BAA050S04D01120429	5.254212	73.165140
BAA050S05D01120429	5.251930	73.163715
BAA050S06D02120428	5.254156	73.161827
BAA050S07D01120429	5.255712	73.161980
BAA050S08D02120429	5.256996	73.162637
BAA050S09D02120427	5.258226	73.163454
BAA050S10D02120428	5.259444	73.164459

5.4.4.3 Results and discussion

Uncertainty of the data

The sampling method is by nature inaccurate. Indeed, it is not possible to measure a physical, chemical or biological unit without error or uncertainty. These errors and uncertainties are from the instrumental error (resolution, accuracy and precision), the human error and other factors such as time and environment.

Some of the results are represented by an estimator and a confidence interval. This confidence interval gives an estimated range of values which includes the true value of the parameter with 95% of certitude. In other cases, such as water quality, the results are provided by third parties, who do not provide such information of accuracy and precision.

Lastly, in some cases, a confidence interval cannot be inferred as the measures are only discreet data describing a varying parameter. In these instances, the raw value obtained is given. Caution has to be taken when relying on this data usually representing parameters that would require long term studies.

In the following tables (Table 7 and Table 8), the CI 95%- and the CI 95%+ represents respectively the lowest and the highest values of the confidence interval. The Mean is the estimator of the parameter value.

Substrates

The results obtained on the different transects are given in the table below (Table 7) as well as in pie chart form (Figure 31). Living corals represent9.32±2.46% of the whole area surveyed.

Table 7: Benthic survey results.

MAJOR CATEGORY (% of transect)	BAA050S01D01120427	BAA050S02D03120427	BAA050S03D03120427	BAA050S04D01120429	BAA050S05D01120429	BAA050S06D02120428	BAA050S07D01120429	BAA050S08D02120429	BAA050S09D02120427	BAA050S10D02120428	MEAN	CI 95%
CORAL (HC)	8.00	4.89	16.00	10.80	2.00	7.60	10.80	12.80	11.11	9.20	9.32	2.46
SOFT CORAL (SC)	1.20	0.44	1.60	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.52	0.48
OTHERS (OT)	1.60	4.00	5.60	9.20	0.00	1.20	2.80	1.20	1.33	1.60	2.85	1.71
NUTRIENT INDICATOR ALGAE (NIA)	0.00	1.33	0.40	0.40	0.00	0.00	0.00	0.00	0.44	0.00	0.26	0.26
RECENTLY KILLED CORAL (RKC)	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08
SPONGE (SP)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ROCK (RC)	34.80	62.67	52.00	50.00	58.00	62.40	60.00	55.20	53.78	44.80	53.36	5.34
RUBBLE (RB)	41.60	23.56	9.20	26.80	32.00	12.40	21.60	25.60	32.00	41.60	26.64	6.69
SAND (SD)	12.80	3.11	15.20	2.40	8.00	16.40	4.80	3.20	1.33	2.80	7.00	3.55
SILT (SI)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The coral cover was constant along the west side of the island varying between 9.20% for S10 and 12.80% for S08 whereas the east side presented a coral cover varying between 4.89% for S02 and 16% for S03.

The main substrate encountered on the hard substrate reef of Fonimagoodhoo was rock with 53.36±5.34% followed by rubble with 26.64±6.69%, bringing the abiotic components to 87 %

(Table 7). The rock is a favourable substrate for the coral larvae settlement and recruitment contrary to rubble which is an unstable substrate. However, rubble is responsible for significant sediment creation.

The coral cover was particularly low in the south of the island with only 2% (Figure 32). Indeed, as mentioned in the hydrodynamic chapter, the sand is taken by the current and covers the coral colonies and recruits preventing their development, even though the sampled area showed an important rocky substrate. The area would otherwise be suitable for coral recruitment and development.

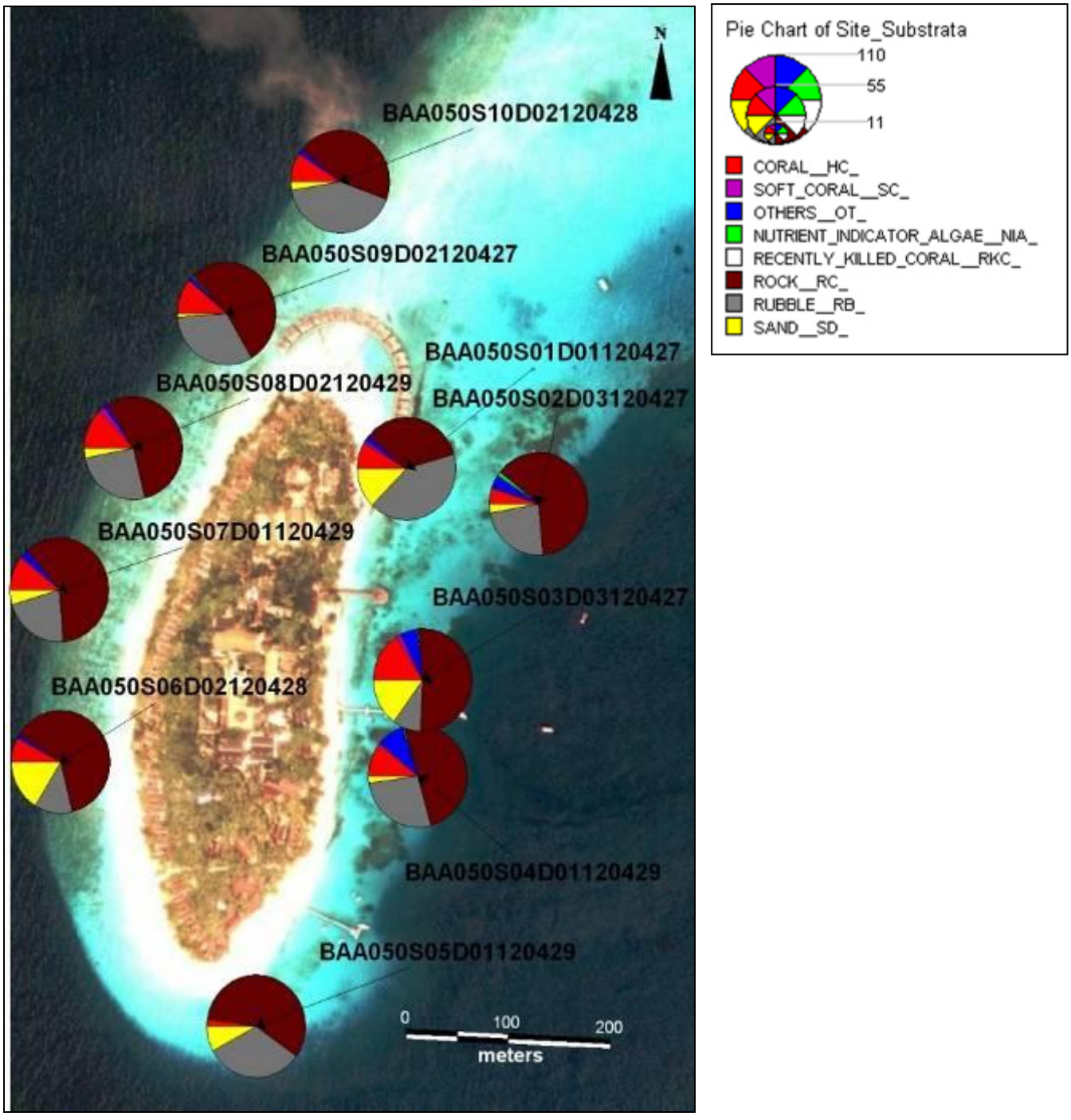


Figure 31: Benthic survey results with pie-chart per site (S01 to S10).

Figure 32: Sand is the main substrate on the southern side of Fonimagoodhoo and appears to be shifting.

A comparison of the percentage of live coral cover on the western reef flat of Reethi Beach Resort is shown on the Figure 33.

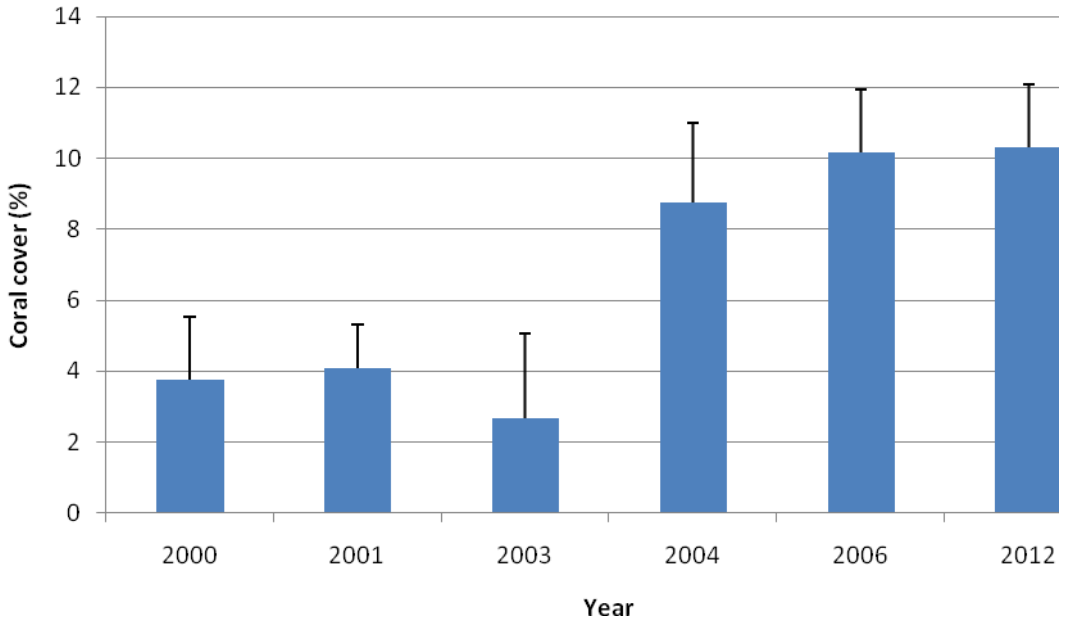


Figure 33: Temporal changes at western side reef flat at Reethi Beach Resort. LIT method was used on 4 sites in 2000, 2001, 2003, point transects were used on 4sites during 2004 and 2006 surveys (three transect per site) and CPCe method was used on 5 sites in 2012.

The increase in live coral cover may be due to the difference in survey methodology from 2003 to 2004. The LIT method did certainly cover more area at each site making the data more consistent and statistically reliable. In general live coral growth has increased on the western side since the 2004 surveys. From 2006 to 2012, the coral cover stayed constant (10.16±1.77% to

10.30±1.77% respectively). The sand movement around the island may avoid recruit settlement affecting the development of the coral reef.

Biodiversity and coral life form categories

The 13 life form categories adopted give an insight into the diversity of the coral community at the site. The following figure and table (Figure 34 and Table 8) present the results from the present study of B. Fonimagoodhoo.

The massive corals were the predominantly represented group with a mean of 4.36±1.47%. This category includes mainly *Porites sp.* With a mean of 2.73±1.09%, the submassive corals represented the second group. Finally, the encrusting corals stood for 1.35±1.02%. Surprisingly, *Acropora sp.* represented only 0.76% of the substrate, all 5 life forms included. In the Maldives, the main coral category is usually *Acropora sp.*

Nevertheless, the general coral cover being quite poor, most of the coral category presented a confidence interval that is large, sometimes superior to the mean itself. Therefore, relative difference between the categories was not statistically significant, except for the predominance of massive species.

Table 8: Coral categories results. CI 95: confident interval at 95%.

SUBCATEGORY (% of transect)	BAA050S01D01120427	BAA050S02D03120427	BAA050S03D03120427	BAA050S04D01120429	BAA050S05D01120429	BAA050S06D02120428	BAA050S07D01120429	BAA050S08D02120429	BAA050S09D02120427	BAA050S10D02120428	MEAN	CI 95%
Acropora Branching (ACB)	0.00	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.17
Acropora Digitate (ACD)	0.40	2.22	2.40	0.00	0.00	0.00	0.40	0.00	0.44	0.00	0.59	0.58
Acropora Tabular (ACT)	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.08	0.16
Coral Massive (CM)	6.40	0.44	5.20	7.60	0.40	4.40	4.40	5.20	3.56	6.00	4.36	1.47
Coral Mushroom (CMR)	0.00	0.00	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.40	0.12	0.12
Coral Submassive (CS)	1.20	0.44	4.00	2.40	1.60	1.60	6.00	3.20	4.89	2.00	2.73	1.09
Coral encrusting (CE)	0.00	0.89	4.00	0.40	0.00	0.80	0.00	4.40	2.22	0.80	1.35	1.02

The eastern reef showed 3 to 5 coral life forms represented on each transect whereas the western reef presented 2 to 4 coral forms. The diversity among coral life forms was quite poor in general.

Finally, submassive and encrusting *Acropora sp*, branching corals (other than *Acropora sp*), foliose corals, *Heliopora sp*. and *Millepora sp.* did not show up in the statistical analysis, even though they were present around the resort in small numbers.

The survey therefore showed that both coral cover and coral biodiversity were limited. In a typical Maldivian configuration, a healthy reef would have many more species of the genus *Acropora* than what was observed by the quantitative survey carried out. The reason for this discrepancy may be the fact that *Acropora* is the genus most affected by bleaching and which heavily suffered during the 1998 extensive bleaching episode.

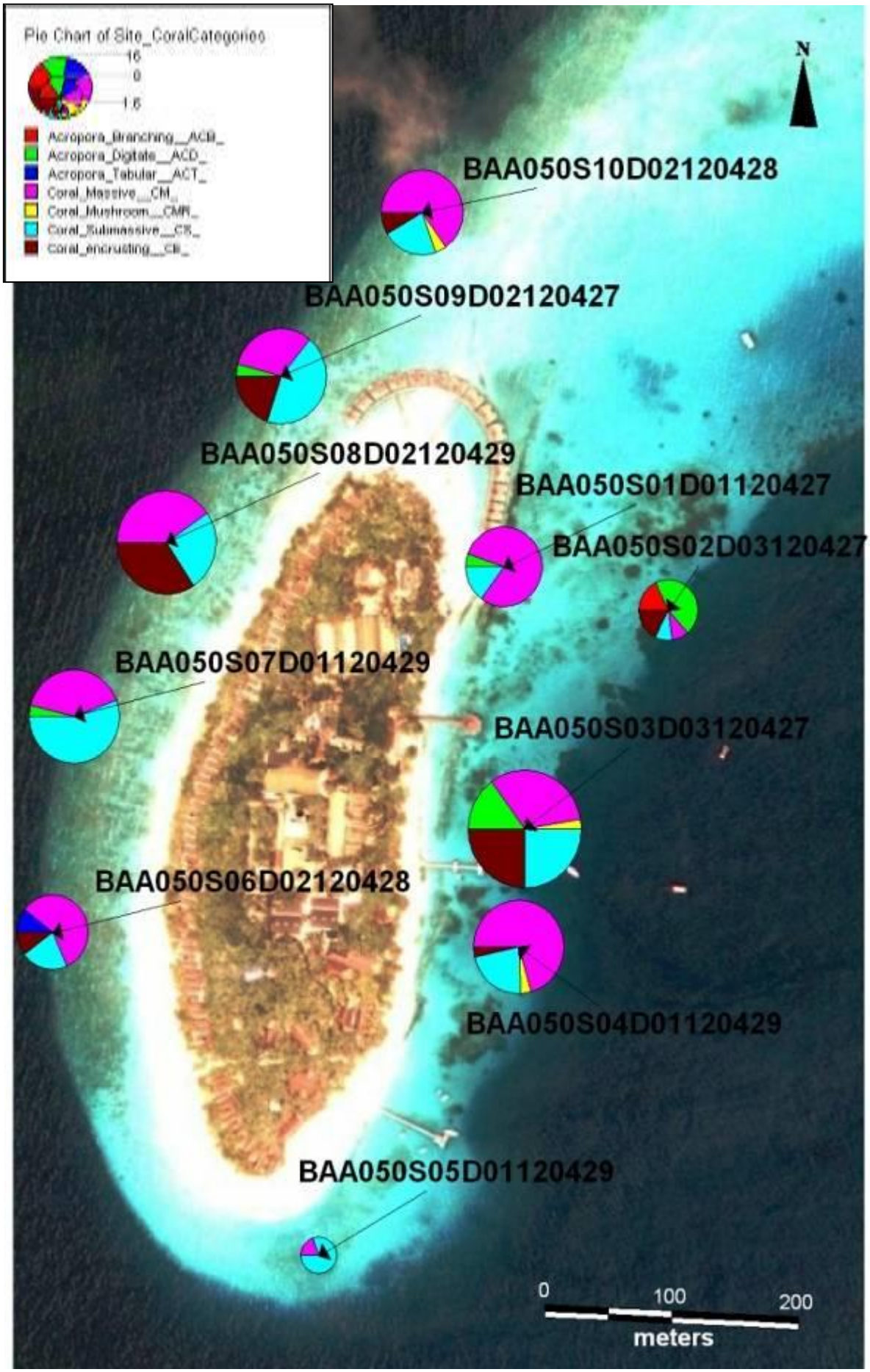


Figure 34: Coral categories results per site.

Coral bleaching

During the CPCe survey (from the 27th to the 29th April 2012), the coral colonies were paler than usual showing signs of a coral bleaching event. The *Acropora sp*. is the genus most affected by coral bleaching. As this genus is poorly represented on the reef with a cover of 0.76%, the coral bleaching was not obvious on the reef (Figure 35a) but more obvious on the coral frames where *Acropora sp*. is more present (Figure 35b).

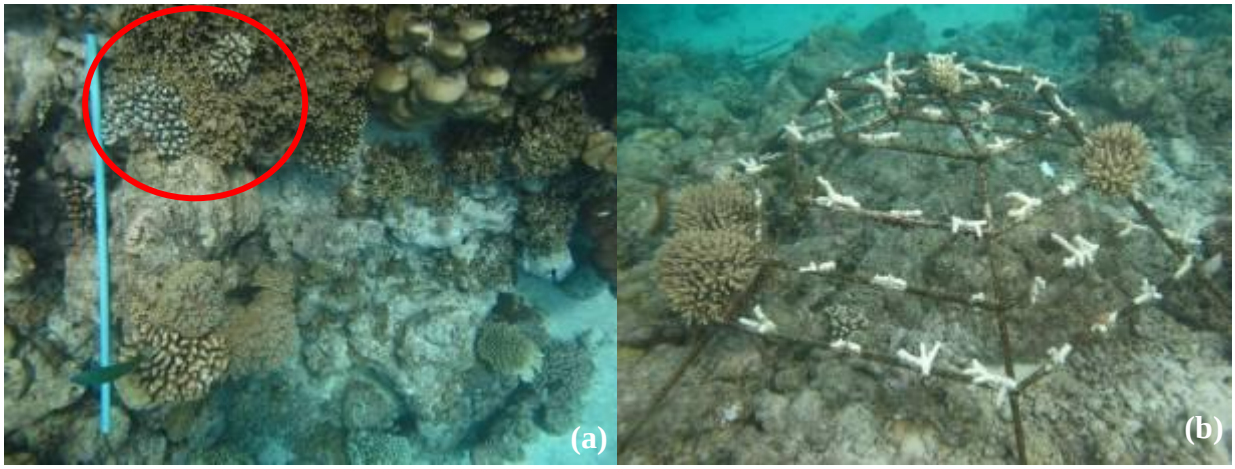


Figure 35: Coral bleaching observed on the reef system in the red zone (a) and on the coral frames (b).

This coral bleaching event corresponds with high seawater temperatures measured by the logger (see part 5.4.3). During April, the results showed temperatures higher than 30°C which is the critical threshold for the algae, zooxanthellae living in symbioses with the coral polyps. At temperatures over 30°C, the coral is known to expel the zooxanthellae.

5.4.5 Fish census

5.4.5.1 Method

For the fish community survey, the data was collected following the methodology of FishWatch Maldives, a nationwide project to monitor coral reef fish. Fish are recorded during timed swims. Each timed swim is exactly 15 minutes long. The target is 3 x 15 minute fish-counts per dive. The area surveyed is a band 2.5m either side of the recorder, and also 5m up in the water column. Each 15 minute survey was 5m wide and estimated to cover 300 m in length.

Fishwatch includes a range of species that are targeted for the aquarium trade or for food. Their habitat preferences vary, and not all would be expected to occur on the house reef, which is sheltered within the atoll.

5.4.5.2 Survey Plan

Surveys were carried out at 6 sites with 2 transects completed at each site at depths of 5 and 10 m. The geo-coordinates for each transect are displayed in Table 9.

Table 9: Geo-coordinates of the fish watch transects carried out at Fonimagoodhoo.

Transects	Latitude (° N)	Longitude (° E)
BAA050F01D05120430	5.258140	73.163172
BAA050F01D10120430	5.258358	73.162882
BAA050F02D05120430	5.257064	73.162383
BAA050F02D10120430	5.257230	73.162107
BAA050F03D05120430	5.255680	73.161867
BAA050F03D10120430	5.256097	73.161807
BAA050F04D05120430	5.254115	73.161724
BAA050F04D10120430	5.253555	73.161710
BAA050F05D05120430	5.255068	73.165149
BAA050F05D10120430	5.255039	73.165624
BAA050F06D05120430	5.256073	73.165921
BAA050F06D10120430	5.256094	73.166305

5.4.5.3 Results and discussion

The results of the fish counts are presented in graphical form (Figure 36) and in tabular form (Table 10) below.

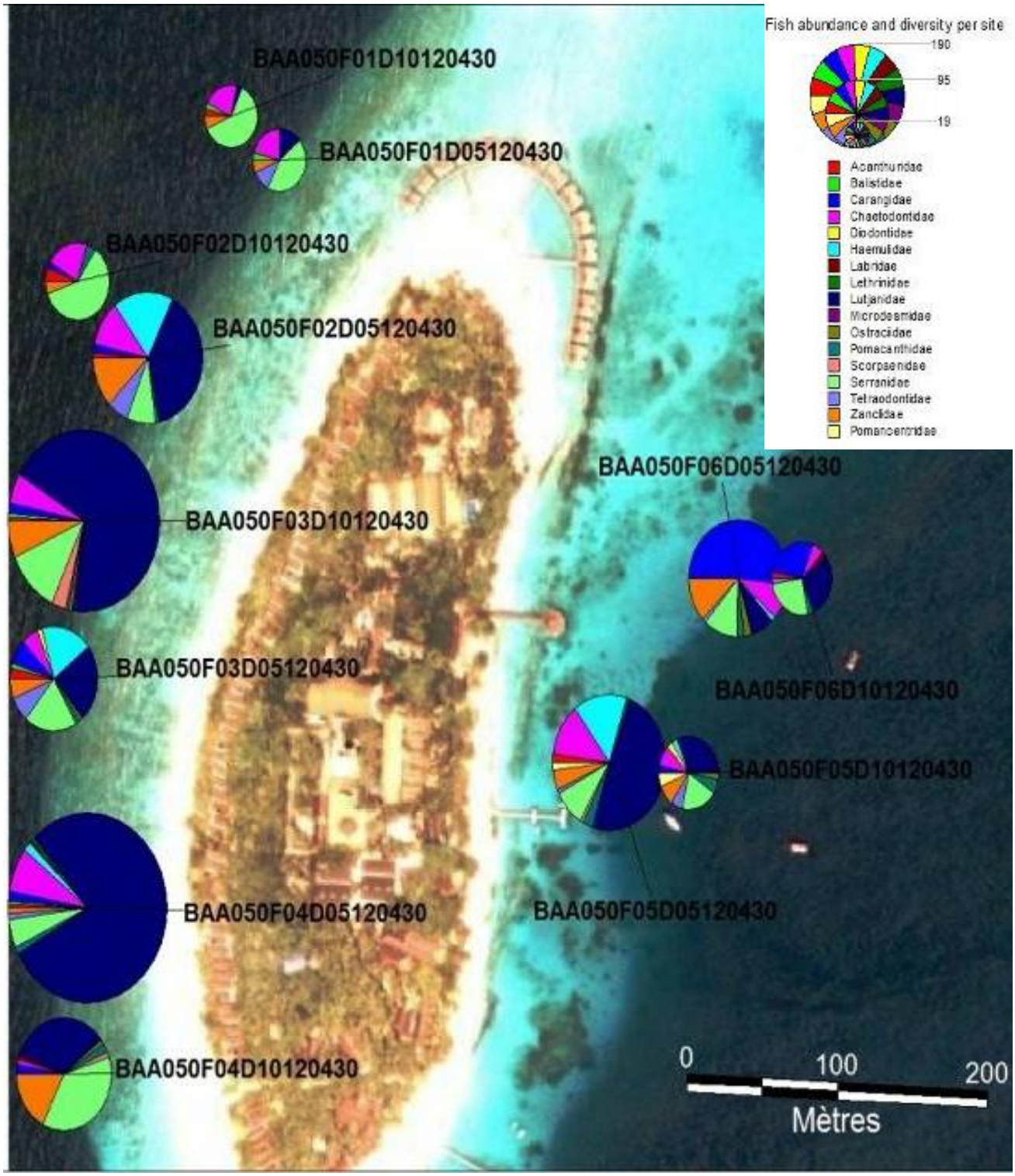


Figure 36: Results of the fish census surveys carried out at B. Fonimagoodhoo

Table 10: Species targeted in the FishWatch survey with total number and density per species and per site.

Family	Species	BAA050F01D05120430	BAA050F01D10120430	BAA050F02D05120430	BAA050F02D10120430	BAA050F03D05120430	BAA050F03D10120430	BAA050F04D05120430	BAA050F04D10120430	BAA050F05D05120430	BAA050F05D10120430	BAA050F06D05120430	BAA050F06D10120430	TOTAL	density (%)
Chaetodontidae	*Chaetodon auriga*	0	0	0	0	0	0	0	0	4	3	1	0	8	0.87
Chaetodontidae	*Chaetodon falcula*	0	0	0	0	0	1	3	0	2	0	2	0	8	0.87
Chaetodontidae	*Chaetodon xanthocephalus*	0	0	0	0	0	0	1	0	2	0	0	0	3	0.32
Chaetodontidae	*Chaetodon madagaskariensis*	0	4	3	8	0	8	6	1	0	0	0	0	30	3.25
Chaetodontidae	*Chaetodon collare*	4	2	5	0	4	0	4	0	2	0	0	0	21	2.27
Chaetodontidae	*Chaetodon meyeri*	0	0	0	0	0	0	0	0	1	0	3	1	5	0.54
Chaetodontidae	*Heniochus pleurotaenia*	2	0	3	0	0	0	0	0	2	0	2	1	10	1.08
Tetraodontidae	*Canthigaster valentini*	3	0	6	0	5	0	2	0	1	2	1	1	21	2.27
Diodontidae	*Diodon liturosus*	0	0	0	0	1	0	0	0	0	1	0	0	2	0.22
Zanclidae	*Zanclus cornutus*	2	2	12	2	4	11	2	13	5	3	10	0	66	7.14
Labridae	*Coris frerei*	0	0	0	0	0	0	0	0	0	0	0	1	1	0.11
Labridae	*Coris frerei*	0	0	0	0	0	0	1	0	0	0	0	0	1	0.11
Serranidae	*Anyperodon leucogrammicus*	0	0	0	0	0	0	0	0	0	0	2	0	2	0.22
Serranidae	*Cephalopholis argus*	5	0	3	1	7	1	5	0	7	2	4	0	35	3.79
Serranidae	*Cephalopholis miniata*	2	7	4	9	0	7	2	7	1	3	1	0	43	4.65
Serranidae	*Cephalopholis sexmaculata*	0	6	0	9	0	6	0	12	1	0	0	4	38	4.11
Serranidae	*Plectropomus areolatus*	0	0	0	0	0	0	0	0	0	0	0	1	1	0.11
Serranidae	*Plectropomus laevis*	0	0	0	0	0	0	0	1	0	0	0	1	2	0.22
Serranidae	*Variola louti*	1	1	1	1	2	2	0	0	0	0	1	0	9	0.97
Serranidae	*Aethaloperca rogaa*	4	3	0	2	3	3	2	7	0	1	1	3	29	3.14
Haemulidae	*Plectorhinchus orientalis juv*	0	0	0	0	0	0	1	0	0	0	0	0	1	0.11
Haemulidae	*Plectorhinchus orientalis ad*	0	0	17	0	12	0	2	0	16	1	1	0	49	5.30
Carangidae	*Caranx melampygus*	0	0	2	1	5	3	3	2	0	1	42	10	69	7.47
Lutjanidae	*Aprion virescens*	0	0	0	0	0	1	0	0	0	0	0	0	1	0.11
Lutjanidae	*Macolor macularis*	2	0	2	0	5	0	4	0	0	0	4	4	21	2.27
Lutjanidae	*Macolor niger*	0	0	0	0	0	0	0	4	2	1	0	0	7	0.76
Lutjanidae	*Lutjanus gibbus*	0	0	35	0	6	100	137	20	45	9	0	0	352	38.10
Lutjanidae	*Lutjanus bohar*	2	1	0	0	4	12	4	1	3	0	2	6	35	3.79
Lethrinidae	*Lethrinus erythracanthus*	0	0	0	0	0	0	1	0	1	0	0	0	2	0.22
Labridae	*Cheilinus undulatus*	0	0	0	0	0	0	0	1	0	0	0	0	1	0.11
Acanthuridae	*Acanthurus bariene*	0	0	0	0	0	0	0	0	0	0	0	1	1	0.11
Acanthuridae	*Acanthurus leucocheilus*	0	0	1	2	2	1	1	0	0	0	0	0	7	0.76
Acanthuridae	*Acanthurus maculiceps*	0	1	0	0	0	0	0	0	0	0	0	0	1	0.11
Acanthuridae	*Zebrasoma desjardinii*	0	0	0	0	0	0	0	0	2	0	0	0	2	0.22
Balistidae	*Balistoides conspicillum*	1	1	0	0	1	1	1	0	0	0	0	0	5	0.54
Pomacentridae	*Amphiprion nigripes*	0	0	0	0	0	0	0	0	2	2	0	0	4	0.43
Scorpaenidae	*Pterois antennata*	0	0	0	0	0	5	0	1	1	0	0	0	7	0.76
Microdesmidae	*Nemateleotris magnifica*	0	0	0	0	0	1	0	0	0	0	0	0	1	0.11
Pomacanthidae	*Apolemichthys trimaculatus*	0	0	0	2	0	0	0	1	0	0	0	0	3	0.32
Pomacanthidae	*Pygoplites diacanthus*	0	0	0	0	0	0	2	0	2	2	2	0	8	0.87
Ostraciidae	*Ostracion cubicus ad*	0	0	0	0	0	1	0	1	0	1	0	0	3	0.32
Ostraciidae	*Ostracion meleagris male*	0	0	0	0	1	0	0	0	0	0	1	0	2	0.22
Ostraciidae	*Ostracion meleagris female*	0	0	0	0	0	0	0	0	0	0	1	0	1	0.11
Pomacanthidae	*Pomacanthus imperator*	0	0	0	0	1	1	0	1	1	0	0	1	5	0.54
Pomacanthidae	*Pomacanthus xanthometopon*	0	0	1	0	0	0	0	0	0	0	0	0	1	0.11
TOTAL		28	28	95	37	63	165	184	73	103	32	81	35	924	100.00

Forty two of the 76 FishWatch target species among 17 families were recorded. The species on the target list with the greatest density are as follows: *Lutjanus gibbus* (38.10%), *Caranx melampygus* (7.47%) and *Zanclus cornutus* (7.14%) (Table 10). Nevertheless, *L. gibbus* has 'clumped' distributions, typically occurring in aggregations around particular features on the reef(Kuiter, 1998). For instance 6 individuals were counted in the transect BAA050F03D05120430 whereas 137 were counted in the transect BAA050F04D05120430, only meters away. Most of the more abundant fish have schooling behaviour. However, *Zanclus cornutus* swims singly, in pairs

and occasionally forms schools (Kuiter, 1998). This species was consequently well represented, being present at all sites.

The high density of *Caranx melampygus* (Carangidae) is unusual. This piscivorous predator is important for the reef balance as they return energy and nutrients derived from open-water feeding to the reef via defecation (Sale, 1991). Serranidae represented 17.21% of all surveys and were represented at all sites. The significant presence of these predators around the island is an indicator of a healthy fish community. Chaetodontidae represented 9.20% and they were observed in larger numbers at 5 m than at 10 m (Figure 36). Their weak density may be related to the generally poor coral cover (9.32±2.46%). Acanthuridae was very poorly represented as well (1.19%). This result may appear in contradiction with the fact that the substrate is mainly rocky, and the turf algae included in this substrate category should support a healthy herbivorous community. This is due to the fact that the 5 species counted in this protocol are rare compared to other more common Acanthuridae such as *Ctenochetus striatus* or *Acanthurus leucosternon*. Haemulidae were never counted at 10 m, except one individual at BAA050F05D10120430.

6 Significant Environmental Impacts and Mitigations Measures

6.1 Impact Identification Methodology

Impacts on the environment are divided into two main categories: impacts during construction and impacts during operations.

6.1.1 Impacts during construction

The impact prediction methodology for constructional impacts starts with the identification of the potential impacted area from the development. There is, in this category a difference made between direct physical damage and indirect impacts which could arise from the activities of the project such as turbidity plumes. Therefore, the extent of the damage area very often follows natural features, such as shoreline and streamline of hydrodynamic patterns.

Once the location is defined, the activities taking place at the site are listed and their impacts on the environment are identified. The impacts are predicted using the following:

- The results of field surveys, along with consultations with project manager and engineers.
- Impact prediction is also based on experience from similar projects carried out previously.

Finally, the magnitude of the impact is inferred based on the conditions at the site and experience from previous projects.

6.1.2 Impacts during operation

For the operational impacts, the process starts with the identification of the factors, which potentially differ from the existing conditions before the operation of the facility. The impacts are mostly linked to the coastal modifications of the island related to the protection structures implemented or utilization of the facility.

6.1.3 Impacts ratings

The results from the survey presenting the natural environment in the considered area are used to assess how the changing conditions will affect the existing environment. The significance of the impacts were predicted based on the experience gathered over years of observations, the magnitude and the duration of the exposure to changing condition as well as the long lasting changes caused to the natural processes. The negative impacts on the environment have been considered in the worst-case scenario in order to emphasize the need for mitigation and try to minimize the impacts. The importance of each impact was rated along a scale from very negative (---) to very positive (+++). When the impact is not very significant, it is stated as negligible.

6.1.4 Limitations in impact prediction

Even though a thorough brainstorming takes place when assessing the impacts, there is always a possibility for some of the impacts to have been disregarded, either that they have not been noticed in the past or that the effects and causes have not been related. Therefore there is an intrinsic limitation due to the limitation of our knowledge itself.

The lack of previous studies or careful monitoring creates a lack of information as to the extent and magnitude of the impacts encountered in other similar cases. Therefore, in many cases it is difficult to ascertain the significance of impacts, which remains subjective to the field experience of the consultant and observations of the proponent.

There is often a discrepancy between the understanding of the consultant and the operation carried on site by the proponent. Even though the environmental follow up of the project is supposed to reduce these discrepancies, it is clear that there is an inherent risk of misunderstanding.

Furthermore, there is always a possibility that uncertainties about related decisions such as planning, negotiation, coordination, etc. affect the accuracy of prediction in EIA process.

6.2 Impacts during construction

6.2.1 Impacts from machinery

The transport of material and sand pumping activities will require the use of different machinery such as the sand pump barge and pipeline. The generator on the barge will usually emit some smoke and green house gases such as CO_2 which will disturb the natural environment and associated flora and fauna. The overall amount produced by these works is very limited and there is at present no regulations regarding this aspect in the Maldives.

The impacts on air quality will be negligible as the works will be carried out in open air areas. Moreover, in order to minimize the emission of pollutants, the engines will be maintained in good working conditions and all machinery will be subjected to regular inspection and maintenance programs.

Noise pollution will be limited as the borrow areas are located away from the island. Underwater noise pollution will also be limited, as the noise is rather regular and not erratic that usually scares the fish life away. Moreover, the use of machinery carries pollution risks, like accidental oil spillage. Frequent controls will be done and measures put in place to prevent and avoid such spillages.

6.2.2 Direct physical damage to corals

The breakwater footprint on the north-eastern side will need to be levelled before the geo-tubes can be installed. As shown on transect BAA050S01D01120427, the coral cover in the area is rather low (8 %) and comprised mostly of massive species.

6.2.3 Sand pumping, filling geo-tubes and bleach replenishment

Sand pumping activities will increase the turbidity in the borrow area and lead to a sediment plume being dispersed downstream. The prevailing winds during the works will be from a northeasterly direction, and therefore, the plume will move towards the near shore on the eastern side and flow in a southern direction to the southern tip. This area is mostly sandy and is not expected to be impacted by this sedimentation.

Moreover, at the outlet of the pipeline, another sediment plume will be created. The geo-tubes are designed to retain the sediment and therefore when filling them, the plume should be limited. It is unlikely that any type of silt screen will improve the situation.

On the northern side, when backfilling the three geo-tubes, these will already be in place and create a bund, and therefore no further mitigation measure is proposed for this aspect.

During the sand pumping, the top layers of the seabed in the borrow area will be disturbed. These layers are colonized by an array of living organisms comprising a variety of different fish, worms, shells and echinoderms etc that will be exposed and suspended into the water column when the sand pump operates. Most of these invertebrates will be eaten by fish, in particular wrasses, which are not hindered by the turbid conditions. On the other hand some fish, such as gobies, will lose their habitat and could fall prey to other fish when they move away in search of a new habitat. In terms of invertebrates, the concerned species usually have very short life cycles, and colonization of the area after the end of the disturbance will be rapid.

6.2.4 Solid and construction waste management

During the work period, it is clear that some waste will be generated including packaging material. As the works will be carried out in a resort in operation, the contractors will follow the procedures of the resort in order to dispose of these wastes. This is especially true for waste sump oil and other hazardous wastes such as batteries. Thus solid and construction waste will be removed from the island regularly and taken to Thilafushi for final disposal.

6.2.5 Aesthetics and recreational aspects

It is expected that the aesthetics of the shoreline will be affected during the construction phase, due to increased turbidity of the nearshore area that they will have to cross in order to reach the coral rich areas. Informative signs will be put up around the resorts providing guests with information on the project, its duration and expressing apologies for the inconvenience caused.

6.3 Impacts during operation

6.3.1 The modification of the hydrodynamic regime

Apart from the breakwaters present on the north-eastern side of the island, the proposed structures are along the shore and therefore will have minimal influence on the water flow. The breakwaters will decrease wave action locally and prevent sediment re-suspension on the coastline opposite where they are installed.

The long shore current should be affected only minimally by the breakwater It is expected that sand will settle in the area even more during the southwest monsoon. During the northeast monsoon, it is anticipated that sand will not leave the area, further avoiding erosion.

6.3.2 Loss and Creation of marine habitats

As the proposed structures are mostly located on the shoreline, the marine habitat will not be drastically changed by the present works. The north-eastern breakwaters are the most significant feature that will affect the existing habitat.

It is expected that some algal growth will occur on the geo-tubes and that this will be an added source of food for the herbivorous fish community. After a settling period during which the structure will be colonized, the habitat will come to a balance with some added hard substrate, but little added sheltering. It is expected that this could profit a transient fish community such as surgeon fish which are herbivorous and common in areas of algal growth.

6.3.3 Aesthetics and recreational aspects

One of the aims of the project is to improve the aesthetics of the shoreline, and this will certainly be achieved. On the southern sandy spit, the different measures taken over the years give a messy aspect to the coastline, and on the north-eastern corner, the erosion and the hastily laid geo bags are a poor sight.

The geo-tubes in the water appear as slightly unnatural, but are located in an area not directly of interest to guests, on the beach rock with relatively significant wave action. However, their presence may encourage some snorkelers to visit the area as they provide a location to sit in the water comfortably to rest.

All the different impacts are presented in table form (Table 11) along with the ratings and proposed mitigation measures.

Table 11: Summary table of impacts and ratings and the mitigation measures proposed for negative impacts.

Activity	Works	Site of Impact	Component	Impacts	Rating	Mitigation measures	Final rating
Use of machinery	All working sites	All working sites	Construction	Smell and noise disturbance	- -	Proper maintenance of the machinery can reduce these impacts	-
				Oil spillage risks	-	Frequent controls	Negligible
				Physical damage to sea bed	--	The machinery will operate from a barge or on the foot print of the breakwater	-
				Green house gas emission	-		-
Sand pumping	Lagoon area	Lagoon area	Construction	Rise in turbidity and sedimentation	-	During the northeast monsoon the plume will flow along the eastern shoreline in a southward direction. Coral life is non-existent where the plume will drift.	Negligible
					--	Recreational aspect is impaired, informative signs will be placed to explain the situation to the guests.	-
Beach replenishment	Land reclamation	Northeastern coastline and southern tip	Construction	Rise in turbidity in the near shore area	- -	The geo-tubes installed in the area will act as a bund wall limiting leakage of sediment.	Negligible
Filling of tubes	Breakwater footprint	Southwestern coastline	Construction	Rise in turbidity in the area	--	The operations are planned and thorough checks to ensure least possible of spillage from the tube in order to increase efficiency	-
Presence of breakwater	Breakwater	Northeastern beach rock	Operations	Increase hard substrate for algal growth	negligible	Maintains a larger population of herbivorous fish	+
				Offers a resting area for snorkelers	+		+

Activity	Works	Site of Impact	Component	Impacts	Rating	Mitigation measures	Final rating
Erosion control	Revetments	Southern and northeastern corner	Operations	The erosion in the proposed area is controlled and the aesthetics and recreational value of the area is improved	++		++

7 Evaluation of Alternatives

7.1 No –Project option

Without the proposed anti-erosion structures the beach in the designated places will continue to face erosion, and the management will be required to have to resort to ad hoc methods on an as needed basis. This often includes beach replenishment which disturbs the marine environment around the island.

Therefore, if the project is not carried out, the aesthetics of the southern tip and north-eastern beach will remain less than satisfactory. The guests will continue to complain about the existing anti-erosion structures on the beach. Therefore the present operational constraints faced by the management will not be improved and the overall product provided by Reethi Beach in Fonimagoodhoo will not be optimized.

7.2 Revetment and breakwaters made of granite

Different construction materials were also considered, in particular granite rocks, which have been widely in use in the Maldives for this type of revetment applications. Even though granite rock is a very durable material, it is often a challenge to keep them in shape when high winds are hitting the structure. Even with some amount of wire mesh, it has often been observed that the structures collapse and need to be reshaped after a few seasons. This entails further disturbances to the environment, and usually detrimental to their colonization by corals or even more mobile life forms such as fish and invertebrates.

In addition, the energy costs of bringing the granite rocks, usually coming from India is significant. It is expected that this option will cause even more greenhouse gases to be emitted than by using endogenic material such as calcium carbonate sand to fill the geo-tubes.

7.3 Continuous beach replenishment

Rather than implementing the proposed structure, an option could be to continue with regular beach replenishment. This method has been used extensively in the past, and has proven to be cumbersome due to the need for continual sand pumping. This option presents disadvantages, in particular in terms of finance, but also on an environmental point of view. Indeed, the continued disturbance amounts to a change in environmental settings affecting in particular factors such as water quality and quality of the substrate for coral recruitment. The system has to adapt on a long term basis, whereas the natural balance can be reached soon after a disturbance if this is not prolonged in time.

7.4 Implementation of more coastal structures

A preliminary design consisted in implementing more revetments around the island as described in the following Figure 37:

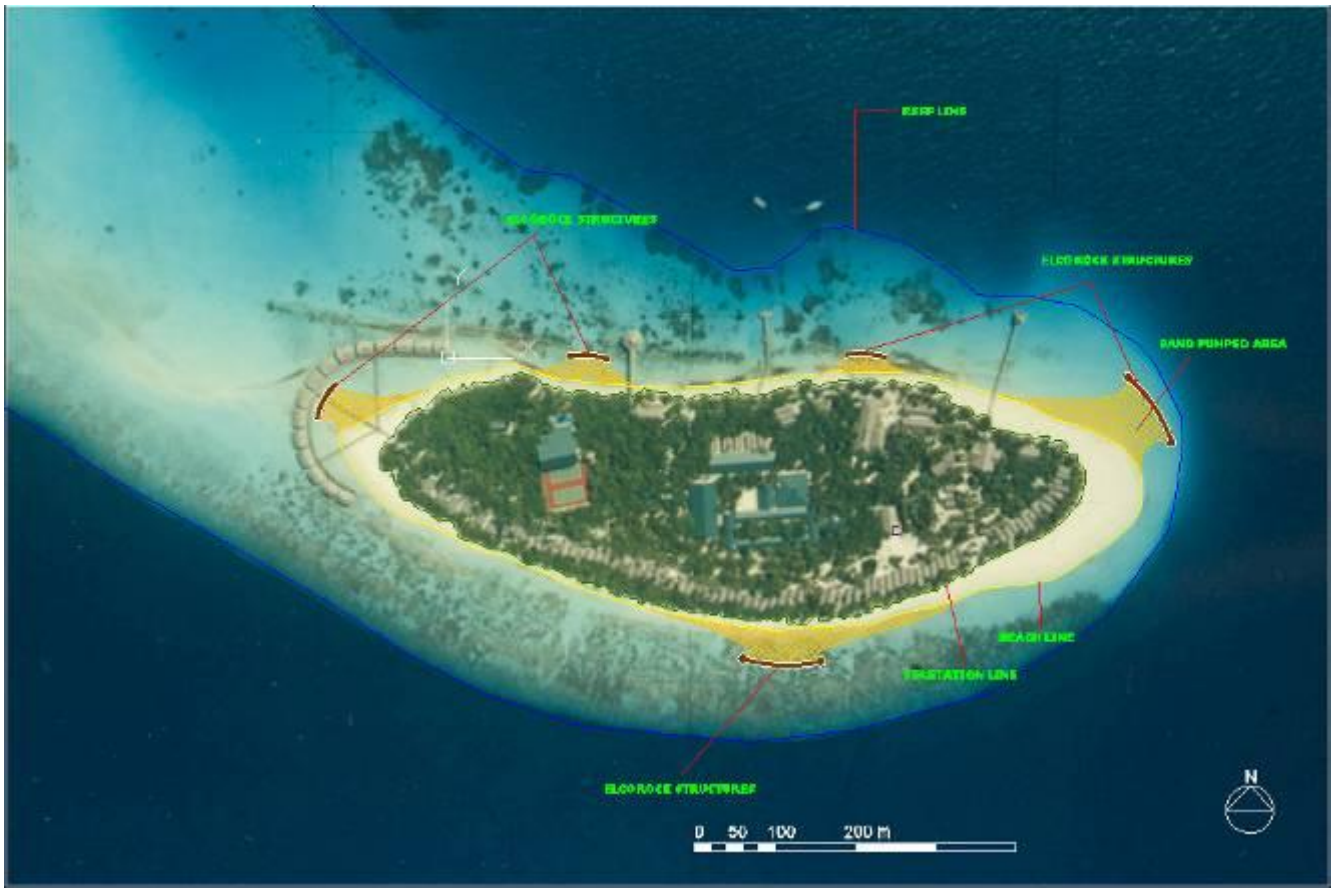


Figure 37: Preliminary design of revetment implementation around Fonimagoodhoo.

Even though this solution would offer a long lasting control of the erosion, it was rejected due to operational and financial constraints.

8 Monitoring Program

Monitoring is the systematic collection of information over a long period of time. It involves the measuring and recording of environmental, social and economic variables associated with the development impacts. Monitoring is needed to:

- Compare predicted and actual impacts
- Test the efficiency of mitigation measures
- Obtain information about responses of receptors to impacts
- Enforce conditions and standards associated with approvals
- Prevent environmental problems resulting from inaccurate predictions
- Minimize errors in future assessments and impact predictions
- Make future assessments more efficient
- Provide ongoing management information
- Improve EIA and monitoring process

The before-impact data collection at Fonimagoodhoo was carried out during baseline surveys in April 2012. Baseline survey is carried out to quantify ranges of natural variation and/ or directions and rates of change that are relevant to impact prediction and mitigation. A set of reference data was obtained from these surveys, which can be used during the construction and operation phases to evaluate whether the predicted impacts occurred and to test the efficiency of the mitigation measures that will be implemented.

To compare predicted and actual impacts occurring from project activities and to determine the efficiency of the mitigation measures, an environmental impact monitoring and a mitigation monitoring are carried out. This type of monitoring is targeted at assessing human impacts on the natural environment. By monitoring the actual impacts, the environmental risks associated with the project can be reduced. Impact monitoring is supported by an expectation that at some level, anthropogenic impacts become unacceptable and action will be taken to either prevent further impacts or re-mediate affected systems. Mitigation and monitoring aims at comparing predicted and actual (residual) impacts, and hence determine the effectiveness of mitigation measures.

In summary, environmental monitoring can:

- Illustrate the extent of environmental effects and resource losses;
- Provide scientific information on the response of the environment to human activities and mitigation measures;
- Provide data that can be used in the environmental auditing for management purposes.

All monitoring activities will be carried out under the supervision of the environmental consultants. The details of the monitoring program are given in Table 12.

Table 12: Environmental Monitoring Plan

Monitoring Parameter	Phase	Methodology	Indicators	Sampling Frequency	Estimated Cost
Coastline	Construction/ Operational	Beach level survey	• Erosion or accretion • Changes to the beach profile • Sand movement around island	Every 6 months	USD 1000/ survey
Coastline	Construction/ Operational	Photography	• Erosion or accretion • Changes to the beach profile • Sand movement around island	Every 6 months	USD 200/ survey
Benthic substrate	Construction/ Operational	Photo transects	• Percentage live coral cover and other benthic substrates	Just after construction and every 6 months following that	USD 1000/ survey
Seawater quality	Construction/ Operational	Test of the seawater parameters	• Salinity, Turbidity, COD, pH, nitrate, suspended solids	Just after construction and every 6 months following that	USD 3000/ survey
Seawater		Temperature loggers	• Temperature	continuously	USD 3000

Monitoring reports will be submitted to the Ministry of Housing and Environment. Monitoring will be carried out every 6 months from the date of approval of EIA (Table 13).

Table 13: Time frame for monitoring and reporting.

Description	Month/ Year
EIA Approval	October 2012
Data collection - 1	April 2013
Report submission to EPA - 1	June 2013
Data collection - 2	December 2013
Report submission to EPA - 2	February 2014
Data collection - 3	August 2014
Report submission to EPA - 3	October 2014
Data collection - 4	April 2015
Report submission to EPA - 4	June 2015
Data collection - 5	December 2015
Report submission to EPA - 5	February 2016

9 Public Consultation

Ministry of Tourism, Arts and Culture and the Baa Atoll Council were consulted during the development of this EIA. The letters from both institutions are below.

9.1 Ministry of Tourism, Arts and Culture

بسم الله الرحمن الرحيم

MINISTRY OF TOURISM, ARTS AND CULTURE
REPUBLIC OF MALDIVES

Ref no: 88-DS/PRIV/2012/134 7

17 September 2012

Mr. Ahmed Rasheed
Reethi Beach Pvt. Ltd
G. Aris
Koimalaa Hingun
Male', Republic of Maldives

Dear Mr. Rasheed,

Subject: Coastal Reinforcement Project at Reethi Beach Resort, B. Fonimagoodhoo.

We refer to your Application dated 04th September 2012, requesting for the approval of concept plan submitted for the coastal works for Reethi Beach Resort, B. Fonimagoodhoo.

A principal approval is hereby granted to the concept plans submitted for the project, subjected to the following;

- *Submission and approval of EIA study for the project.*

Please also note that this approval is also based on the rules and regulations and practices of this Ministry and concerned government authorities. Furthermore, we take this opportunity to remind you to submit detail drawings with the approved EIA and decision note by Environmental protection Agency to this Ministry, in order to obtain construction permit to carry out the works.

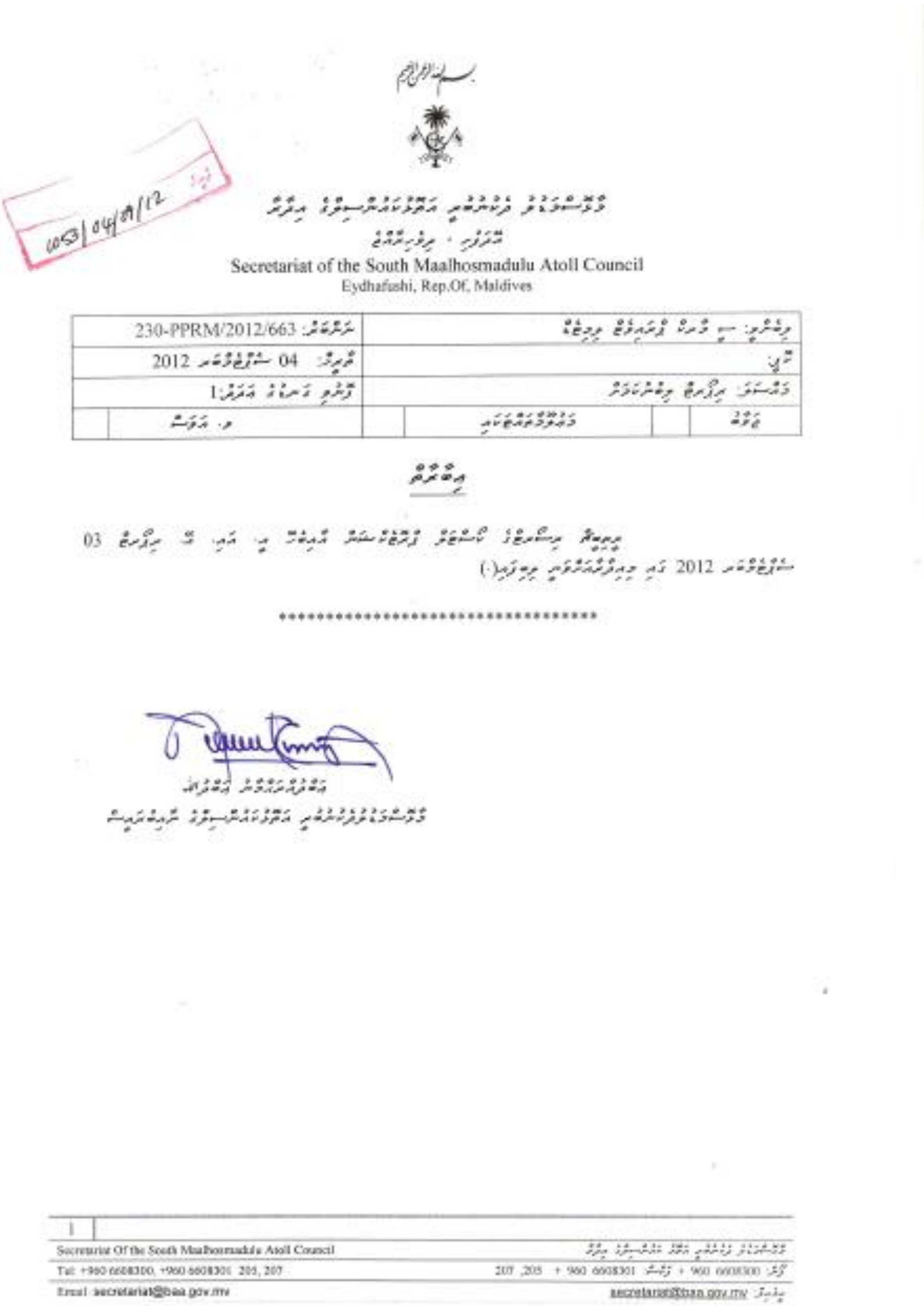
Thank you.

Yours sincerely,

Mohamed Adhly
Assistant Director

Ministry of Tourism, Arts and Culture, Velaanaage, Fifth Floor, Ameer Ahmed Magu, Male', Maldives
Tel: +(960)332 3224, +(960)332 3226, +(960)332 1216, Fax: +(960)332 2512
E-mail: info@tourism.gov.mv, website: www.tourism.gov.mv

9.2 Baa Atoll Council


Secretariat of the South Maalhosmadulu Atoll Council
Eydhafushi, Rep.Of, Maldives

230-PPRM/2012/663	
04 2012	

03 2012

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Secretariat Of the South Maalhosmadulu Atoll Council
Tel: +960 6608300, +960 6608301 205, 207
Email: secretariat@baa.gov.mv

بسم الله الرحمن الرحيم

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Secretariat of the South Maalhosmadulu Atoll Council

Eydhafushi, Rep.Of, Maldives

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10 Conclusion

The proposed solution appears to be the most suitable to tackle the coastal erosion and coastal aesthetics problem faced by the developer. It remains to be seen if the long term impacts which the system will have to face will not have a detrimental effect. This project should limit the sand movement around the island which is anticipated to improve the coral reef development around the island.

Little is known about such impacts quantitatively, and it is necessary that these parameters are monitored so that some improvements in the design are possible over time.

Even though some initial disturbances will disrupt the natural processes, it is expected that the ecosystem will adapt fast to the changes. The final configuration may harbour more fish life in biomass. The new habitat will also provide some ecosystem diversity promoting the overall biodiversity.

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APPENDICES

Appendix 1: list of Acronyms and Abbreviations

CPCe	Coral Point Count with Excel extensions
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPPA	Environmental Protection and Preservation Act
MHE	Ministry of Housing and Environment
MSL	MeanSea Level

Appendix 2: water sample results

National Health Laboratory
Maldives Food and Drug Authority,
Sosun Magu, Male' 200500, Republic of Maldives
Telephone # 3014310, Fax # 3014307

Accreditation No: 1160/61

WATER CHEMISTRY ANALYTICAL RESULTS

REPORT NUMBER: NHL/TR-WC/RC0516

TIME TESTED: 14:23
*COLLECTED BY: -

*NAME AND ADDRESS OF CLIENT: SEAMARC PVT LTD,
M.MAYAA, 7TH FLOOR, GANDHIA KOAI HI MAGU
TEL: (+960)3331626, FAX: (+960)3336575

*PURPOSE OF TESTING: Quality Monitoring

*LOCATION OF SAMPLE	FOAMAGOODHOO ISLAND, BAA ATOLL					TEST METHOD
	B	C	D	E	F	
Requisition Form No:	NHL/WC-2012/RQ0397					
*Date sampled	02/05/2012	02/05/2012	02/05/2012	02/05/2012	02/05/2012	
*Time Sampled	-	-	-	-	-	
*Type of water	Sewage	Sea	Sea	Sea	Sea	
Date tested	02/05/2012					
Sample ID	020512WC05	020512WC06	020512WC07	020512WC08	020512WC09	
PARAMETER TESTED						
Physical Appearance	Clear	Clear	Cloudy with Suspended Particles	Clear with Suspended Particles	Clear with Suspended Particles	Method 4500-S c/d page 65 electrometric method Adapted from standard methods 19th edition for the examination of water and waste water by APHA
pH	7.0	8.1	6.6	8.1	8.3	(Adapted from DR/4000 ** Spectrophotometer procedure manual) Adapted From Hach 2100 N Turbidimeter Instruction Manual
*Turbidity	1 NTU	2 NTU	46 NTU	0 NTU	0 NTU	

COMMENT:

Authorized by

Technical Manager
Khadeeja Nashwa

Date: 03rd May 2012

NOTE: *information supplied by the client
This laboratory is not accredited for the test marked by *.

This Result is valid only for this sample. This report is not for duplicate or advertisement without prior approval from NHL.

Page 1 of 1

Appendix 3: Letter from the Ministry of Health regarding the water analysis.

بسم الله الرحمن الرحيم

MALDIVES FOOD AND DRUG AUTHORITY
Ministry of Health
Male'
Republic of Maldives

08th May 2012

Reference No: 182-NHL/MISC/2012/278

To:
Systems Engineering and Marine Consulting Pvt Ltd ,
7th Floor, M. Maya
Tel: 3331626,
Male', Maldives.

Dear Sir, /Madam

TEST FOR CHEMICAL PARAMETERS

We regret to inform you that the chemical tests "Salinity", "Nitrate", "Phosphates", " Sulphate", "BOD", "COD" and "Ammonia" in water samples sent to NHL on 02nd May 2012 cannot be tested due to unavailability of reagent for analysis.

Thank you.

Yours sincerely

Shareefa Adam Manik
Director General

Maldives Food and Drug Authority, Sosun Magu, Male',Republic of Maldives. Tel.: 3014322, 3014307, Fax : 3312281,

Appendix 4: Terms of Reference

بسم الله الرحمن الرحيم

Environmental Protection Agency
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EPA

Ref No: 203 - FINHUM/PRIN/2012/316

Date: 12th july 2012

Mr. Peter Grames

General Manager

Reethi Beach/ B. Fonimagoodhoo

Dear Sir,

Please to inform you that we hereby send the approved Terms of Reference (ToR) for proposed Coastal Protection Project at Reehi Beach (Fonimagoodhoo).

Yours Sincerely,

Rifath Naeem.
Senior Environment Analyst

Environmental Protection Agency
Min. of Housing & Environment Compound
Ameenee Magu
Male', Rep. of Maldives, 20392
Tel: 333 5949 / 333 5951
Fax: 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

Terms of Reference for Environmental Impact Assessment for Coastal Protection Projects

The following is the Terms of Reference (ToR) following the scoping meeting held on 23/05/2012 for undertaking the EIA of the Coastal Protection at Reethi Beach (Fonimagoodhoo Island). While every attempt has been made to ensure that this TOR addresses all of the major issues associated with development proposal, they are not necessarily exhaustive. They should not be interpreted as excluding from consideration matters deemed to be significant but not incorporated in them, or matters currently unforeseen, that emerge as important or significant from environmental studies, or otherwise, during the course of preparation of the EIA report.

1. **Introduction and rationale** – Describe the purpose of the project and, if applicable, the background information of the project/activity and the tasks already completed.. Objectives of the development activities should be specific and if possible quantified. Define the arrangements required for the environmental assessment including how work carried out under this contract is linked to other activities that are carried out or that is being carried out within the project boundary. Identify the the donors and the institutional arrangements relevant to this project. .

2. **Study area** – Submit a minimumA3 size scaled plan with indications of all the proposed infrastructures. Specify the agreed boundaries of the study area for the environmental impact assessment highlighting the proposed development location and size. The study area should include adjacent or remote areas, such asrelevant developments and nearby environmentally sensitive sites (e.g. coral reef, sea grass, mangroves, marine protected areas, special birds site, sensitive species nursery and feeding grounds). Relevant developments in the areas must also be addressed including residential areas, all economic ventures and cultural sites.

3. **Scope of work** – The report should be categorised into the following components:

Task 1. Description of the proposed project – Provide a full description and justification of the relevant parts of the coastal protection works, using maps at appropriate scales where necessary. The following should be provided (all inputs and outputs related to the proposed activities shall be justified):

- Coastal defence construction and justification;
- Excavation methods, if required for construction purposes including machinery, man power, expertise and scheduling;
- If beach nourishment is performed include sand dredging activities: location of burrow site, justification, volume needed, extraction methods, type of sediment, man power, scheduling and periodicity;
- Emergency plan during spillages;
- Environmental monitoring during construction activities;
- Measures to protect environmental values during construction and operation phase i.e. sedimentation control;
- Project management (include scheduling and duration of the project and life span of facilities; communication of construction details, progress, target dates, construction/operation/closure of labour

4

Ecology

- Identify marine protected areas (MPAs) and sensitive sites such as breeding or nursery grounds for protected or endangered species (e.g. coral reefs, spawning fish sites, nurseries for crustaceans or specific sites for marine mammals, sharks and turtles). Include description of commercial species, species with potential to become nuisances or vector.
- Top reef, Benthic and fish community monitoring around the island (see appendix for monitoring guidelines);

Hazard vulnerability:

- Vulnerability of area to flooding and storm surge.

Absence of facilities in the country to carry out the water quality tests will not exempt the proponent from the obligation to provide the necessary data. The report should outline the detailed methodology of data collection utilized to describe the existing environment.

Task 3. Legislative and regulatory considerations – Identify the pertinent legislation, regulations and standards, and environmental policies that are relevant and applicable to the proposed project, and identify the appropriate authority jurisdictions that will specifically apply to the project. Include permits and approvals in the EIA document. Legal requirements:

- Approval from the Housing and Environment Ministry;
- Approval from Tourism Ministry, if tourism venture;

Task 4. Potential impacts (environmental and socio-cultural) of proposed project, incl. all stages – The EIA report should identify all the impacts, direct and indirect, during and after construction, and evaluate the magnitude and significance of each. Particular attention shall be given to impacts associated with the following:

Impacts on the natural environment

- 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 (overflow) and related to shore protection 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 areas (leaching of salts in the deposited sediments and change in ground water quantity);
- Impacts on unique or threatened habitats or species (coral reefs, sea turtles etc.), and
- Impacts on landscape integrity/scenery.

The methods used to identify the significance of the impacts shall be outlined. One or more of the following methods must be utilized in determining impacts; checklists, matrices, overlays, networks, expert systems and professional judgment. Justification must be provided to the selected methodologies. The report should outline the uncertainties in impact prediction and also outline all positive and negative/short and long-term impacts. Identify impacts that are cumulative and unavoidable.

UNEP WORLD ENVIRONMENT DAY
Forests: Nature at Your Service
Environmental Protection Agency
Min. of Housing & Environment Compound
Ameenee Magu
Male', Rep. of Maldives, 20392
Tel: 333 5949 / 333 5951
Fax: 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv
INTERNATIONAL YEAR OF FORESTS 2011

Task 5. Alternatives to proposed project – Describe alternatives including the *"no action option"* should be presented. Determine the best practical environmental options. Alternatives examined for the proposed project that would achieve the same objective including the "no action alternative". This should include alternative coastal protection measures, alternative designs, alternative materials; alternative locations and alternative borrow sites. The report should highlight how the best location was determined. All alternatives must be compared according to international standards and commonly accepted standards as much as possible. The comparison should yield the preferred alternative for implementation. Mitigation options should be specified for each component of the proposed project.

Task 6. Mitigation and management of negative impacts – Identify possible measures to prevent or reduce significant negative impacts to acceptable levels. These will include both environmental and socio-economic mitigation measures with particular attention paid to sedimentation control and future changes in coastal processes. Mitigation measures to avoid or compensate habitat destruction caused by dredging will have to be considered, e.g. temporal sediment control structures, coral reconstruction and MPA replacement areas. Measures for both construction and operation phase shall be identified. Cost the mitigation measures, equipment and resources required to implement those measures. The confirmation of commitment of the developer to implement the proposed mitigation measures shall also be included. An Environmental management plan for the proposed project, identifying responsible persons, their duties and commitments shall also be given. In cases where impacts are unavoidable arrangements to compensate for the environmental effect shall be given.

Task 7. Development of monitoring plan (see appendix)– Identify the critical issues requiring monitoring to ensure compliance to mitigation measures and present impact management and monitoring plan for coastal modification, beach morphology, sediment movement around the island. Ecological monitoring will be submitted to the EPA to evaluate the damages during construction, after project completion and every three months thereafter, up to one year and then on a yearly basis for five years after. The baseline study described in task 2 of section 2 of this document is required for data comparison. Detail of the monitoring program including the physical and biological parameters for monitoring, cost commitment from responsible person to conduct monitoring in the form of a commitment letter, detailed reporting scheduling, costs and methods of undertaking the monitoring program must be provided.

- Coastal erosion and accretion changes around the island;
- Water quality, especially turbidity;
- Impacts from sedimentation on nearby coral reefs, benthic system, seagrass beds and fish and invertebrates communities;
- Condition of the sensitive ecosystems and marine resources;
- Re-colonization of the benthic organisms in the borrow areas;
- Environmentally sound site clearance;

* This TOR contains an outline of the parameters that have to be tested (see appendix). All projects are different, therefore additional or less data will be collected for recovery and impact assessments.

Task 8. Stakeholder consultation, Inter-Agency coordination and public/NGO participation) – Identify appropriate mechanisms for providing information on the development proposal and its progress to all stakeholders, government authorities such as Ministry of Housing, Transport and Environment, Planning Council, Tourism Ministry, Finance Ministry, government agencies, NGOs, engineers/designers, development managers, staff and members of the general public. The EIA report should include a list of people/groups consulted, their contact details and summary of the major outcomes.

Environmental Protection Agency
Min. of Housing & Environment Compound
Ameenee Magu
Male', Rep. of Maldives, 20392
Tel: 333 5949 / 333 5951
Fax: 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

Presentation- The environmental impact assessment report, to be presented in digital format, will be concise and focus on significant environmental issues. It will contain the findings, conclusions and recommended actions supported by summaries of the data collected and citations f or any references used in interpreting those data. The environmental assessment report will be organized according to, but not necessarily limited by, the outline given in the Environmental Impact Assessment Regulations, 2007

Timeframe for submitting the EIA report – The developer must submit the completed EIA report within 3 months from the date of this Term of Reference.

Environmental Protection Agency
Min. of Housing & Environment Compound
Ameenee Magu
Male', Rep. of Maldives, 20392
Tel: 333 5949 / 333 5951
Fax: 333 5953
Email: secretariat@epa.gov.mv
Website: www.epa.gov.mv

Appendix 5: Environmental Impact Assessment Team

The EIA for the coral propagation project was carried out by Seamarc Pvt. Ltd. with an experienced professional team led by Ms Mariyam Saleem (EIA Consultant No. EIA05/12). Following are the Curriculum Vitae of the team members (Mariyam Saleem, Thomas LE BERRE, Marine PREUVOST and Mélinda CHOUA):

CURRICULUM VITAE of MARIYAM SALEEM

PERSONAL DETAILS

Name: Mariyam Saleem
Nationality: Maldivian
Gender: Female
Date of Birth: 1st of September 1974

Marital Status: Married with two children
Languages: Dhivehi (mother tongue) English (Fluent) French (Intermediate)

Present address for communication:
3rd FL/ M. Honey Dew
IzzudheenMagu
Malé
Republic of Maldives
Tel: (960) 3337945 (H)
(960) 3331626 (W)
(960) 7783694 (M)
(94) 774229997 (M)
Fax: (960) 3336575
Email: marie@seamarc.com

EDUCATIONAL QUALIFICATION

SECONDARY EDUCATION:

1991-1993 Woodstock School, Mussoorie, Uttarkhand, India
High School Diploma
May 1993 - **Advanced Placement**

1981-1991 Aminiya School, Malé
Republic of Maldives
GCE O' level

TERTIARY EDUCATION:

Master of Applied Science (Protected Area Management)
James Cook University February 2002 – April 2004
Conferred in **May 2004**

Bachelor of Science (Marine Biology)
July 1996 - June 1997 - University of the South Pacific, Fiji
July 1997 - July 1999 - James Cook University, Australia
Conferred in **August 1999**

EMPLOYMENT HISTORY

28.06.00 – Ongoing	Environmental Consultant	Seamarc Pvt. Ltd.
20.02.08 – 13.09.09	Reef Ecologist	Marine Research Centre Ministry of Fisheries and Agriculture

08.05.04 – 20.02.08	Senior Research Officer	Marine Research Centre Ministry of Fisheries, Agriculture and Marine Resources
28.07.99 – 08.05.04	Research Officer (Grade 3)	Marine Research Centre Ministry of Fisheries, Agriculture and Marine Resources
29.11.94 - 30.06.96	Research Assistant	Marine Research Section Ministry of Fisheries, Agricultur and Marine Resources
23.08.93 - 28.11.94	Marine Biology Trainee	Marine Research Section Ministry of Fisheries, Agriculture and Marine Resources

RECENT WORK EXPERIENCE

Thematic Lead – Waste management and community engagement for the IUCN/ KUONI/ SEAMARC Project for Enhancing the resilience of coral reefs and assessing vulnerability of ecological and social communities to climate change. This project involves in implementing a public awareness and education program for marine conservation and coral reefs in the resorts and associated inhabited islands, training and empowering local capacity to monitor and manage coral reefs and assessing vulnerability and adaption potential of different sectors and local communities dependent on coral reefs. (Ongoing).

Consultant for the Management of Solid Waste Project for B. Kamadhoo, B. Kihaadhoo and B. Dhonfanu. The project aims to implement a system for solid waste management on the islands whereby waste is segregated at the household level and non-biodegradable waste is collected from the islands regularly for disposal at Thilafushi. The project is funded by Four Seasons Resort at LandaaGiraavaru. (Ongoing).

National Coordinator for the Socmon South Asia Project, Maldives component implemented by IUCN and funded by NOAA, USA. The project supported natural resource and biodiversity management and community development in South Asia. This involved building capacity among stakeholders to conduct socioeconomic assessments using regionally agreed protocols, undertaking socioeconomic baseline surveys at target sites and increasingthe ability to apply such information in decision-making among a broad range of stakeholders. Theoverall objective of the project was to support management and development that can enhance the livesand livelihoods of local natural resource dependent coastal communities in South Asia. (October 2011 – March 2012).

On-screen guide for the Maldives part on the BBC documentary series “Indian Ocean”. This is a six-part series presented by Simon Reeve, which follows a journey around the perimeter of the Indian Ocean. The programmes combine travelogue and current affairs, exploring topical issues which affect the countries we travel through. The series is about the ocean, and portrays stories linked to the sea and coastal communities. (September 2011)

National Consultant for the preparation of National Report on Coastal Pollution Loading and Water Quality Criteria for the Bay of Bengal Large Marine Ecosystem Project. (July – September 2010).

Project Manager for the Youth Awareness and Training Program of Baa Atoll Youth at Fourseasons Resort, LandaaGiraavaru. This project aims to increase the capacity and awareness of youth of Baa Atoll to facilitate implementation of environmental projects on their respective islands and to help in the enforcement of existing environmental regulations. The group is now involved in implementation of co-management at Hanifaru Protect Area in Baa Atoll. Ongoing.

Member of the event management team for the 350 Campaign, Maldives, 24th October 2009.Male', Maldives.

Assisted in the development of NAPA Project Document: Integrating Climate Change Risks into Resilient Island Planning in the Maldives for GEF Funding. UNDP/ MHTE. (August – September 2009).

Coral Reef Expert to the workshop on Regional Economics of Climate Change in South Asia: Part 1, Cleaner Technologies and Options. Asian Development Bank. (16 August 2009).

Member of the Panel of Judges to select Climate Ambassadors to attend the Children's Climate Forum, Copenhagen. (June 2009).

Research on the status of the shark fishery for management. My work was focused on implementing baseline and long term monitoring of reef sharks. This involved development of monitoring protocols and data collection sheets. It also required good communication skills to involve the dive schools and make a network of monitoring teams to carry out volunteer monitoring. (2003 – 2009).

Preparation of an Issue Paper on the Status of the Shark Fishery in Maldives for the Fisheries Advisory Board (FAB). My role was to coordinate the project and involved organizing and carrying out field trips to the northern and southern atolls of Maldives to collect socio-economic data on the fishery. The data was then compiled, analysed and a report was formulated recommending phasing out the fishery and the implementation of an export ban. The recommendations were endorsed by the FAB and all shark fishing within the EEZ of Maldives has been banned from the 15th of March 2010, with subsequent ban of all trade of shark products from July 1st 2010. (2009).

Project Manager for the Darwin Reef Fish Project. I collaborated with the Marine Conservation Society of UK and successfully procured funding from the Darwin Initiative for a 4 year project to establish monitoring for preparation of reef fishery management plans. This project will result in fisheries management plans for the aquarium and food fish reef fisheries. (2009).

Management of the Aquarium Fishery of the Maldives. It involved working closely with the exporters and Maldives Customs Services to develop tools and guidelines for monitoring and management. (2003 – 2009).

Preparation of a paper on the Environmental Impacts of Tsunami Restoration in the Maldives. This involved consultation with the donors and government agencies and report writing. IUCN. (February 2009).

National Consultant to the "Assistance to the Economic Valuation component of the broader Atoll Ecosystem Conservation" project. This involved coordinating and carrying out household interviews in Baa atoll inhabited islands and in Male' on valuation and willingness to pay of the marine biodiversity. It also required the formulation of three reports: Willingness to pay for biodiversity at the national level, Willingness to pay of tourists visiting the Maldives and also a report on value of biological resources in Baa Atoll. IUCN March (August 2008)

Consultancy to prepare a paper on "Status of Shark Fisheries in the Maldives Exclusive Economic Zone for the Bay of Bengal Programme Inter-Governmental Organisation. This involved formulating a report on the status of shark fisheries in the Maldives and presenting it at the Regional Consultation on Preparation of Management Plan for Shark Fisheries. (March 2008).

National consultant to assist the Country Programme Environment Outcome and Renewable Energy Project Evaluation 2007, UNDP. (September 2007).

Preparation of a report on Cost Estimation and Willingness to pay for waste management in Baa Atoll as National Consultant for Atoll Ecosystem Conservation project funded by UNDP and GEF. This involved research on waste management systems and cost estimation of all components required for such a system in Maldives. My team and I carried out household surveys in all the inhabited islands (13 islands) of Baa Atoll to collect information on the status of and willingness to pay for waste management in the atoll. The resorts operating in the Atoll were also consulted. (2006).

As part of my Masters special project, I worked on the preparation of a report on the Aquarium Fishery of Maldives. This involved compilation and analysis of export data and interviews with exporters. The output was a report giving comprehensive information on the fishery and also recommendations for improving the monitoring and management of the fishery. (2003 – 2004).

RECENT WORKSHOPS AND SEMINARS ATTENDED

Pew Global Shark Conservation Summit, Washington DC, 1-2 June 2011.

Regional Workshop on Integrated Coastal Management (ICM) Best Practices and Lessons Learned, Colombo, Sri Lanka, 28 – 29 July 2010.

BOBLME Regional Coastal Pollution Workshop, Male', Maldives, 2 -3 June 2010.

30th Annual Symposium on Sea Turtle Biology and Conservation, Goa, India, 27 – 29 April 2010.

Bay of Bengal Large Marine Ecosystem Project Inception Workshop, Male', Maldives, 24 – 25 February 2010.

Regional Economics of Climate Change in South Asia: Part 1, Cleaner Technologies and Options. Maldives National Experts Workshop, ADB.Bandos Island Resort, Maldives, 16 August 2009.

2nd Regional Consultation on Preparation of Management Plan for Shark Fisheries, 9-11 August 2009.

Indian Ocean Cetacean Symposium, Paradise Island Resort, Maldives. 18 – 20 July 2009.

National Workshop on Monitoring, Control and Surveillance in Marine Fisheries, Male', Maldives, 22-23 March 2009.

Training Programme on Integrating Environmental Safeguards into Disaster Risk Management, 16-19 March 2009, IUCN, Waikkal, Sri Lanka.

11th International Coral Reef Symposium, 7 – 11July 2008, Fort Lauderdale, Florida

Training Course on 'Exploring Marine and Coastal Protected Areas - Tools for Management', 4 – 7 June 2008, Paradise Island Resort and Spa, Maldives

Mangroves For the Future (MFF) Regional Review Forum, 21-24 April, Heritance Hotel, Ahungalla, Sri Lanka

Regional Consultation on Preparation of Management Plan for Shark Fisheries, 24 – 26 March 2008, Beruwela, Sri Lanka

Applying the Ecosystem Approach to Managing Atoll Ecosystems in the Maldives, 11 March 2008, Hulhule' Island Hotel, Maldives

Management Planning Workshop for Olhugiri and Dhigaliha Protected Areas, 3 – 5 March 2008, Baa Atoll Eydhafushi, Maldives

Second Regional Coordination Workshop – South Asia MCPA Project, 25 – 27 July 2007, Colombo, Sri Lanka

National Consultation on the Fisheries Sector Master Plan, May 2007, Islamic Centre Conference Hall, Male', Maldives

Workshop on the Development of a Grouper Management Plan, April 2007, Dharubaaruge, Male', Maldives

SAARC Expert Group Consultation on Coastal Zone Management, April 2007, Dharubaaruge, Male', Maldives

Environment and Disaster Risk Assessment of Islands in the Maldives, December 2006, Hulhule' Island Hotel, Maldives

Regional Resource Coordination and Mobilisation Workshop for the Long-term Management and Conservation of MCPAs in South Asia, September 2006, Colombo, Sri Lanka

Roundtable on Coastal Erosion and Disaster Risk and Vulnerability, September 21, 2006 - Male, Maldives

NAPA Workshop on Identifying and Prioritisation of Adaptation Measures, September 2006, Bandos Island Resort, Maldives

National Biodiversity Strategy and Action Plan (NBSAP) and National Development Plan 7 Review Retreat – Atoll Ecosystem Conservation Project and National Climate Change Project, July 2006, Paradise Island, Maldives

Second Workshop on the Development of a National Waste Management Strategy May 2006, STELCO Seminar Room, Male', Maldives

First Workshop on the Development of a National Waste Management Strategy December 2005, Hulhule' Island Hotel, Maldives

Inception workshop on Atoll Ecosystem Conservation – AEC Baa Atoll Project July 2005, Hulhule', Maldives

Inception workshop on the "Preparation of National Adaptation Plan of Action" (NAPA) Project 25 November 2004, Hulhule', Maldives

Technology Needs Assessment for Climate Change: First Workshop on Technology Needs Assessment Methodology 22 – 24 November 2004, Hulhule', Maldives

10th International Coral Reef Symposium 28 June – 2 July 2004, Okinawa, Japan

Workshop on Code of Conduct for Responsible Fisheries January 2004, Male', Maldives

ADDITIONAL SKILLS

Computer literate - Fluent in Microsoft Windows
PADI Open water and Advance certificate

REPORTS & PUBLICATIONS

Ushan, M., Wood, E., Saleem, M. and S. A. Sattar. (2012). Maldives Sharkwatch report for 2009-2010. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9-13 July 2012. In Press.

Saleem, M. (2012). Socioeconomic Monitoring for Coastal Managers of South Asia: Field Trials and Baseline Surveys, NassimoThila and Banana Reef, Kaafu Atoll, Maldives.

Anderson, R.C., Adam, M.S. and M.R. Saleem. (2011). Shark longline fishery in the northern Maldives. Prepared for the Bay of Bengal Large Marine Ecosystem Project of the FAO.

Saleem, M. (2010). Coastal Pollution Loading and Water Quality Criteria: Maldives. Prepared for the Bay of Bengal Large Marine Ecosystem Project of the FAO.

Sattar, S.A. and M. Saleem. (2010). Willingness-to-pay for Shark Watching, Management and Conservation in the Maldives.Marine Research Centre, Ministry of Fisheries and Agriculture, Male', Maldives.

Saleem, M.R. and F. Islam. (2009). Management of the Aquarium Fishery in the Republic of the Maldives. In: B.M. Riegl and R.E. Dodge (eds). Proceedings of the 11th International Coral Reef Symposium, Ft. Lauderdale, Florida, 7-11 July 2008. CD-ROM Proceedings.

Saleem, M.R. and S.A. Sattar. (2009). Study on post-tsunami restoration and conservation projects in the Maldives. Ecosystems and Livelihoods Group, Asia, IUCN.

Saleem, M.R. and M.S. Adam. (2009). Status of the Shark Fishery of Maldives. Dhivehi report prepared for the Fisheries Advisory Board of Maldives.

Emerton, L., Baig, S.P. and M.R. Saleem. (2009). Valuing Biodiversity.The economic case for biodiversity conservation on the Maldives.AEC Project, Ministry of Housing, Transport and Environment, Government of Maldives and UNDP Maldives.

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Married

2 children

Main Compétences

- **Trilingual** (French (mother tongue) / English (fluent) / Dhivehi (Maldivian)), **bicultural:** French-Maldivian.
- Environmental consultant, coastal oceanography, Programming (Delphi)
- Worked overseas (Maldives, Australia).

Education

1995 -1998 **Engineering Diploma (ENSTA, Paris),** a 3 year-formation,admission after preparatory classes, ending Baccalaureat + 5 years. Participated in two exchange programs with KTH, Stockholm, Sweden (6 months in second year), studies in groundwater management and fluid mechanics, and JCU, Townsville, Australia (1 year in third year), studies in environmental engineering, coral reef geology and fluid mechanics.

1992 -1995 **Mathematic superior and special : Preparatory classes for selective examination to the french engineering schools (major in Physics and Chemistry)** LycéeChateaubriant, Rennes. This is to prepare the selective examination to enter the french "GrandesEcoles".

1992 **Baccalauréat C (Math-Physics, distinctions)**. Lycée Lesage, Vannes. French equivalent to A-levels

Professionnal experience

1999 - 2008 **Setup and run an Environmental Consultancy in the Maldives - Seamarc Pvt. Ltd.** (Systems Engineering and Marine Consulting)

The major contracts in which I was involved were:

- Environmental Impact assessment and design for coastal development of VabboaHuraa (Four Seasons Resort, HPL)

- Coral Monitoring of T. Vilufushi, which was undergoing major dredging operations, dredging works and consultancy for Boskalis International.
- Environmental Impact Assessment for the development of a fisheries project in Addu Atoll, for MIFCO (Maldives Industrial Fisheries Company)
- Environmental Impact Assessments for the development of Herethere as a tourist resort, for MTDC (Maldives Tourism Development Corporation).
- Work as national consultant for the development of the Integrated Climate Change Strategy. Includes GEF (Global Environmental Facility) NAPA (National Adaptation Plan of Action) project, NCSA (National Capacity Self Assessment) project and TNA (Technology Need Assessment) project. Remains member of the National Climate Change Technical Team.
- Environmental Impact assessment and design for coastal redevelopment of KudaHuraa (Four Seasons Resort, HPL)
- Environmental Impact Assessment and coastal designs for the redevelopment of K. Kandooma. redevelopment works not yet started (Leisure Hollidays, HPL Maldives)
- Erosion control at Baa LandaaGiraavaru (upcoming Four Seasons resort, LGPL) (on going).
- Coral translocation as a mitigation measures for development impacts at Baa LandaaGiraavaru (upcoming Four Seasons resort) (on going).
- Setting up of a fish laboratory to breed *Amphiprionnigripes* and other ornamental species at Baa LandaaGiraavaru (upcoming Four Seasons resort) (on going).
- Supervising clearing of 45 hectares plot in L. Gan for the French Red Cross utilizing man power from the IDP camps and villages in L. Gan.
- Constructed a 50 feet boat in the Maldives in order to carry out research and tourism activities. Subsequently managed this activity (on going).
- Bid documents for a number of resort islands, regularly obtained among top ranking for environmental concepts.
- Local Environmental counterpart for BCL (Bangladesh Consultant Limited) for a IDB funded project for the government of Maldives about Focus Development Islands.
- Research on *Amphiprionnigripes*(Maldives clownfish for aquarists) and export of 500 individuals maricultured by the Marine Research Center of the Government of Maldives.
- Bid document and Environmental Impact Assessment for the development of a hotel/marina in H.A. Dhonakulhi for Turquoise Pvt. Ltd.
- Environmental and research programs for restoration and rejuvenation of reefs affected by global warming and bleaching using Reef Balls, for Four Seasons Resort (on going).

- Consultancies for the dredging operations and coastal works at Medhufinolhu (One & Only at Reethi Rah).
- Database design and programming for coral reef resources management for the governments of India, Sri Lanka, and the Maldives, for IOC/UNESCO through the GCRMN (Global Coral Reef Monitoring Network)
- Analysis of salinity and temperature profile data at the mouth of the Herbert and Burdekin River in North Queensland, Australia, for James Cook University.
- Environmental auditing of tourist resorts for Velavaru (Turtle Island Resort) and Fonimagoodhoo (Reethi Beach Resort) since 2000.
- Feasibility study for power generation with wind mills in the Maldives.
- Translation into French of books pertaining to the Maldives (Marine Life of the Maldives, by Neville Coleman, Dive Maldives, by Tim Godfrey).

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Main Compétences

- **Bilingual** (French (mother tongue) / English (fluent))
- Environmental consultant, coastal oceanography, marine biologist.
- Worked overseas (Maldives, Polynesia and Australia).

Education

Master of Sciencedegree in Biodiversity and Sustainable Development, Marine Biology and Ecology emphasis with distinctions, 2011
Université of Perpignan, France

Bachelor of Science in Biology of Organisms with distinctions, 2009
Université of La Rochelle, France

Exchange student program with distinctions, 2009
University of Newcastle, Australia

Professionnal experience

April 2012

Marine biologist
Systems Engineering and Marine Consulting (SEAMARC), Maldives
- Environmental Impact Assessments
- Fish and Coral monitoring (FishWatch and CPCe methods)
- Coral transplantation
- Guest awareness in resorts

Feb-Aug 2011

Estimation of commercial holothurians stocks in Moorea island lagoon and recommending management actions
Internship, CRIOBE USR 3278 CNRS-EPHE, French Polynesia
- Carrying out my own the sampling plan, field survey (free-diving and scubadiving)& data analysis
- Cooperation with local fishermen
- Knowledge of tropical reef and marine island ecology

July-Aug 2010

Underwater trail guide
Marine Reserve of Cerbère-Banyuls, France
- Fish monitoring

Mar-June 2010

Monitoring of the fan mussel *Pinna nobilis*

Internship, Marine Reserve of Cerbère-Banyuls, *France*

- Scubadiving survey: locating and measuring specimens of a population
- Cartography (GIS): organizing GPS data on a geocoded map

Mar-June 2009

Preliminary assessment of the likely increase of sharks in the estuaries of New South Wales

Internship,University of Newcastle, Australia

- Good English writing/speaking/reading skills

July-Aug 2008

Maritime Zone Management

Aztech Marine, Corsica, France

-Boat driving experience and coastal law enforcement