ENVIRONMENTAL IMPACT ASSESSMENT

For Proposed Redevelopment Development of Kudahithi Island Resort, North Male' Atoll, Maldives

Proposed by
Sun Land Hotels pvt .ltd

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Non Technical Summary

- This report discusses the findings of an environmental impact study undertaken by Water Solutions Pvt. Ltd. upon request from Sun Land Pvt. Ltd in order to fulfill obligatory requirements of the National Environment Protection and Preservation Act, Law No. 4/93 for the redevelopment of Kudahithi island resort in Male' Atoll, Maldives.

- This project is proposed by Sunland Hotels to develop; A Master Residence, 2 support Bungalows, Main Pavilion, staff centre, service centre, mosque, desalinated water storage tanks, fuel storage tanks and undertake coastal protection and beach nourishment to replenish the lost beach at the island as part of the redevelopment project. The project also requires demolishing the existing buildings on land and the removal of the columns that had been placed in the water. These facilities will be developed in such that it blends with the natural setting of the island without disturbing the island's natural setting. All buildings and walkways are planned to avoid disrupting major trees to the greatest extent possible to ensure conservation of trees. Walking tracks are made as narrow as possible in order to minimize the impacts on the island vegetation. Buildings on the coastal zone are planned as such that the natural hydrodynamics of the coastal zone is not affected.

- This report has identified that the impacts of the project will be felt on the terrestrial environment as almost all the new structures proposed will be on land. The impact on the marine environment will be felt through the coastal protection and beach nourishment component and the removal of the columns that had been placed in the lagoon. The direct impact on the marine environment would be the sedimentation and siltation caused by the construction activities in the lagoon during the construction period. Baseline data has, therefore, been collected in order to monitor the changes to the marine environment which need to be identified in periodical monitoring reports. The most significant impact will be felt on the lagoon bottom.

- Other impacts during the construction period are impacts related to construction waste, dust emission and impacts related to temporary workforce. Operational impacts are expected to be related to energy generation, water production and solid waste and wastewater generation. Details of these impacts are discussed in the relevant sections.

- The mitigation plan has identified appropriate measures to minimize the identified impacts from the proposed redevelopment at the island of Kudahithi. These measures reflect the general aspects of the construction phase for the resort that involves both land and marine based development activities. Important measures that will be undertaken to minimize the damage on the ecosystem include, better pre-planning during the construction stage and minimizing cutting of trees during construction stage, especially young trees among other measures. The conceptual design of the resort has already been planned so as to minimize the amount of trees that will be cut or removed.

- In the operation phase, the emphasis will be to minimize the impact due to operation and guest activities on to the environment. An Environmental Management Plan for the operation need to be developed to integrate environment protection and conservation into the operation of the island.

- In the operation stage of the development, staff awareness programmes could be in place and activities to increase the environmental awareness to the guest and to minimize the environmental impact due to the tourist activities will be undertaken.

- Alternatives to the project have also been considered and several alternatives to the proposed project were considered, including alternative methods for construction and alternative locations. The advantages and disadvantages of these alternatives have been discussed.

- Towards, the end of the report, a monitoring programme has been suggested which mainly covers the marine environment. These include coral cover and marine water quality among many other parameters. As the impacts are felt on the marine environment, it is important to undertake this monitoring.

1 Introduction

This Environmental Impact Assessment report (EIA) has been prepared to fulfil the requirements of the Environmental Protection and Preservation Act, law no. 4/93 for the proposed redevelopment of Coco Palm Kudahihti resort, located in North Malé Atoll.

1.1 Structure of the EIA

The report has been structured to meet the requirements of the EIA regulations 2007 issued by the Ministry of Environment, Energy and Water.

The major findings of this report are based on qualitative and quantitative assessments undertaken during site visit in June 2010. The impact assessment methodology has been restricted to field data collected, consultations, experience and professional judgment and available long term data.

1.2 Aims and Objectives of the EIA

The objective of the report is to:

- Assist in mitigating impacts caused due to the construction of Master Residence, Support Bungalows, Staff Centers and Service Centers
- Promote informed and environmentally sound decision making
- To demonstrate the commitment by the proponent on the importance of environmental protection and preservation.
- To fulfill the obligations of the proponent to undertake an EIA under Clause 5 of the Environmental Protection and Preservation Act of the Maldives and requirements of the Tourism Regulations.
- Undertake the project work with minimum damage to the environment.

1.3 EIA Implementation

This EIA has been prepared by a local environmental consulting firm, Water Solutions. Water Solutions have been chosen by the proponent as the environmental consultants for this project. The team members were:

Ahmed Jameel, Environmental Engineer (EIA Registration No: EIA 07/07)

Verena Wiesbauer, MSc (Zoologogy/Marine Biology) Marine Biologist

Abdul Aleem, BSc, MPH – Mapping and GIS (EIA Registration No: EIA 09/07)

Mohamed Mazin, Surveyor

1.4 Terms of Reference

The terms of reference for this EIA have been attached as an annex. This EIA has been prepared based on these terms of reference.

2 Policy, Legal and administrative Framework

2.1 Overview

This section outlines the relevant environmental legislation pertaining to this project.

2.2 Applicable Policies, Laws and Regulations

2.2.1 Environmental Protection and Preservation Act

Article 5. (a) of the Environmental Protection and Preservation Act (Law No. 4/93) addresses the submission of an EIA. It states that an EIA shall be submitted to MEEW before implementing any developing project that may have a potential impact on the environment.

2.2.2 Protected Areas and Sensitive Areas

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

There are no protected sites or resources such as protected birds, reefs and trees in the island environment.

2.2.3 Regulation on sand and aggregate mining

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

Neither sand nor aggregate will be mined for this project. This regulation would not have any implication on the proposed project.

2.2.4 Tourism Act (Law no. 2/99)

This Act provides for the determination of zones and islands for the development of tourism in the Maldives:

This EIA has been developed in accordance with the Tourism Act

2.2.5 Ministry of Tourism Regulations and Circulars

The Tourism Regulations in the Maldives ensure that carrying capacity of the island and atoll ecosystems are well within limits and the negative effects of the development are minimal. The Ministry also issues circulars on several occasions and when necessary to discourage activities such as sand and coral mining, developing on the coastal environment and waste disposal which may cause harm or damage to the natural environment, which is the main tourism product.

Tourism regulations strictly discourage modifications to the natural movement of sand around the islands. Therefore, Tourism Regulations require that special permission from the Ministry of Tourism, Arts and Culture be sought before commencing any coastal modification works on any tourist resort. It is also stated that hard engineering solutions are not encouraged and construction of solid jetties and groynes be controlled and shall only be undertaken after conducting an Environment Impact Assessment study. Similarly, design of boat piers, jetties and other such structures are required to be in such a way that these shall not obstruct current and sediment circulation patterns of the island.

The Ministry also issues circulars on several occasions and when necessary to discourage activities such as sand and coral mining, developing on the coastal environment and waste

disposal which may cause harm or damage to the natural environment, which is the main tourism product.

The conceptual plan and drawings have been approved by the Tourism Ministry. Details of the cross section and other drawings have been attached as an appendix.

2.2.6 Environmental Impact Assessment Regulation 2007

The Ministry of Environment, Energy and Water has issued new EIA regulation on May 2007, which guides the process of undertaking the Environmental Impact Assessment in the Maldives – This guideline also provides a comprehensive outline of the EIA process, including the roles and responsibilities of the consultants and the proponents. This regulation outlines every step of the IEE/EIA process beginning from application to undertake an EIA, details on the contents, minimum requirements for consultants undertaking the EIA, format of the EIA/IEE report and many more.

The guidance provided in this Regulation was followed in the preparation of this EIA report. The EIA has also been prepared by registered consultants.

2.2.7 Applicable Criteria

The Maldives Environmental Protection and Preservation Act, Law No. 4/93, the Tourism Law, Law No. 2/99, the Tourism Regulations and the circulars from the Ministry of Housing, Transport and Environment on Protected Areas and Protected Species and circulars of the Ministry of Tourism, Arts and Culture are of relevance to the development of any tourism project in the Maldives.

The proposed redevelopment on Kudahithi is similar in nature to various other tourist resort redevelopment projects in the country, standing as a self-sufficient facility providing all necessary tourist facilities on its own. The resort will cater for the high-end tourism market thereby reducing the negative effects of mass tourism. The Tourism Regulations in the Maldives ensure that carrying capacity of the island and atoll ecosystems are well within limits and the negative effects of the development are minimal.

3 Project Description

3.1 Project Proponent

This project is proposed by Sunland Hotels. The project is to undertake redevelopment in Kudahithi. Sunland Hotels is a company known for its service in the hospitality industry in the past two decades.

3.2 Project Location and Study Area

The Kudahithi is located close to the western rim of North Male' Atoll approximately 31km from Male'. Longitude and latitude of Kudahithi are approximately 4°26´N and 73°23´E respectively. The closest island to Kudahithi is Boduhithi located approximately 1.3km NW of Kudahithi. Rasfari is located approximately 5km SW and Henbadhoo (Taj Coral) is located approximately 6km north of Kudahithi. Other islands within the locality are beyond a 6km radius of Kudahithi.

3.3 Geography

The Kudahithi is located close to the western rim of North Male' Atoll approximately 31km from Male'. Longitude and latitude of Kudahithi are approximately 4°26´N and 73°23´E respectively.

There are two large reef systems and a number of smaller reef systems within a 6km radius of Kudahithi. One of the large reef systems is Rasfari reef system extended from south-west to approximately 1.5km west of Kudahithi and the other large reef system is approximately 2km north of Kudahithi. These two large reef system forms a channel to the open sea on eastern rim of the atoll. Kudahithi is located in the mouth of this channel inside the atoll.

3.4 Need and Justification

3.4.1 Need to Redevelop and Upgrade the Resort

The philosophy of the proposed redevelopment is to transform Kudahithi into an island sanctuary for rejuvenation and rediscovery of nature by restoring its natural environment, committing for conserving its fragile environment and stewardship in involving the local island communities in harmonizing the use of common resources for the benefits of all.

It is proposed that the resort will be developed with 1 villa and two support villas.

3.4.2 Development Concept and Built Environment

The proposed redevelopment is based on an environmental management system development for the island, which had been planned in line with the Governmental policies on environment, committed to restore the lost natural environment and to maintain the island's natural wealth and preservation of its ecological integrity, apply the environmental best practice whenever and wherever possible, committed to minimize the generation of waste, conservation of energy and water through innovation and application of environment-friendly technologies.

3.4.3 Replenishment of the eroded beach

Kudathithi has undergone sever erosion in the past 10 years. According the survey that was carried out by Water Solutions in June 2010, the total land area of the island has reduced by 3,015 m^2 that of the registered land area at the Ministry of Tourism. The reduction of the land areas has been mainly due to the erosion that is seen in the eastern and western side of the island. Hence, it is proposed to replenish the beach with 6,030 m^3 of beach sand. The sand would be borrowed from the shallow lagoon east of the island. The replenishment would be carried out as such replenished area's berm would have a height of at least 0.5m. The land area of the kudahithi would not increase as that of the registered land area after the replenishment of the beach.

3.4.4 Reusing coral from demolition waste

Twenty years ago, the most common material for the construction of the resorts was corals. These were mined from reefs with a permit when the island was developed. As such, kudahithi was also built with legally obtained corals. However, due to the demolition of old buildings at kudahithi would generate corals in the demolition waste stream. It is estimated 99.15 cubic meters of corals would be recovered from the demolition waste stream. Hence it is proposed to reuse the recovered corals, if EIA Decision Statement approves, in the demolition waste stream, as decorative materials on the outer walls of the buildings that would be constructed in the guest area.

3.5 Development Concept and Built Environment

The philosophy of the proposed redevelopment is to transform Kudahithi into an island sanctuary for rejuvenation and rediscovery of nature by restoring its natural environment, committing for conserving its fragile environment and stewardship in involving the local island communities in harmonizing the use of common resources for the benefits of all.

3.6 Environmental Design Considerations

The environmental design considered in the redevelopment planning process for the development is to transform Kudahithi into an island sanctuary for rejuvenation and rediscovery of nature by preserving the natural environment of the island. The facilities on the island will be redeveloped in order to reflect and blending with the natural setting of the island without disturbing the island natural setting. All buildings and walkways have been planned to avoid disrupting existing trees to the greatest extent possible to ensure conservation of trees. Walking tracks will been made as narrow as possible in order to minimize the impacts on the island vegetation. Buildings on the coastal zone are planned as such that the natural hydrodynamics of the coastal zone is not affected.

3.7 Site Planning

All buildings have been planned and located so as to minimize disruption to the natural environment of the island. The concept adopted in the site planning is to have 'minimal de-landscaping' for construction to maintain the mature vegetation rather than artificial landscaping. The Main Residence and support residence has been located in areas where existing buildings are located.

3.8 Guest Facilities

Guest facilities have been designed so as to blend with the natural setting of the island. Environmental factors such as natural lighting and ventilation were taken into consideration in the design so as to minimize the consumption of energy at these facilities. Additionally energy and water conserving fixtures and equipments will be installed as environmental infrastructures in the guest facilities. The guest facilities include Master Residence and two support bungalows.

3.9 Staff Facilities

The staff facilities which will be developed as part of the redevelopment include staff centre, Service complex and Mosque.

3.10 Service Facilities

These include Administrative Office, Power House, Desalination House, Laundry & House Keeping, Stores Waste Management Centre, Water Storage Tanks, Fuel Storage Tanks, Incinerator House at the Service complex.

3.11 Description of the project components

This project involves two components; upgrading and redevelopment component. See the attached site plan appended.

3.11.1 Upgrading of existing facilities

3.11.1.1 Energy Generation

Power will be generated by diesel generators installed at the island. The diesel generators installed will be the type that are commonly used in the Maldives and have low emission and high thermal efficiency. Hence Diesel will be the main source of energy at the island.

Electricity at 400 volt, 3-phase, 50 Hz is generated for the proposed resort via 2 x 40KVA 1 x 50 KVA. The 400-volt supply will be distributed throughout the island.

A fully computerised panel board will be installed at the powerhouse to synchronise the energy generation and load sharing. The computerised panel board will optimise electricity generation to meet the load requirement and facilitate fuel consumption and hence increase fuel efficiency.

The powerhouse would be redesigned with appropriate insulation to minimise the radiation of heat, soot filters at the chimneys and chimneys height appropriately to minimise the soot emission and effective dispersion outside the boundaries of the island environment. The powerhouse is proposed to be adequately sound proofed to achieve the allowable limits of 70 -75 dB (A) at 3 meters radius.

Fuel storage tanks of the resort will be redeveloped with appropriate bunding wall to contain the fuel in case of spill and oil recovery trenches at the power house floors. The bunding will hold 110% of the total capacity of the fuel tank. The demand for diesel is estimated to be 200 cubic meters monthly during peak operation.

Waste oil from the generators will be collected and will be taken to the waste management centre for incineration.

3.11.2 Water production and distribution

The primary water generation method on the island will be desalination using reverse osmosis. One desalination plants with a capacity of 50 cubic meters per day has been proposed to be installed as part of the redevelopment.

3.11.3 Waste Management Centre

The source-separated waste collected from all areas will be taken to the waste management centre where the waste will be further sorted out by different type of waste. Waste will be separated into plastic, metals, paper, glass and organics. The source separated waste from Kudahithi will be transported to Boduhithi for further treatment. The Boduhithi waste management centre has an incinerator, bottle crusher, metal compactor, shredder and a composting system.

3.11.4 Arrival and Service Jetty

The arrival jetty and service jetty which is located at the island would be refurbish as part of the redevelopment.

3.11.5 Replenishment of the beach

Kudathithi has undergone sever erosion in the past 10 years. According the survey that was carried out by Water Solutions in June 2010, the total land area of the island has reduced by 3,015 m^2 that of the registered land area at the Ministry of Tourism. The reduction of the land area has been mainly due to the erosion that is seen in the northern and southern side of the island. Hence, it is proposed to replenish the beach with 6,030 m^3 of beach sand. The sand would be borrowed from the shallow lagoon east of the island. The replenishment would be carried out as such replenished area's berm would have a height of at least 0.5m.

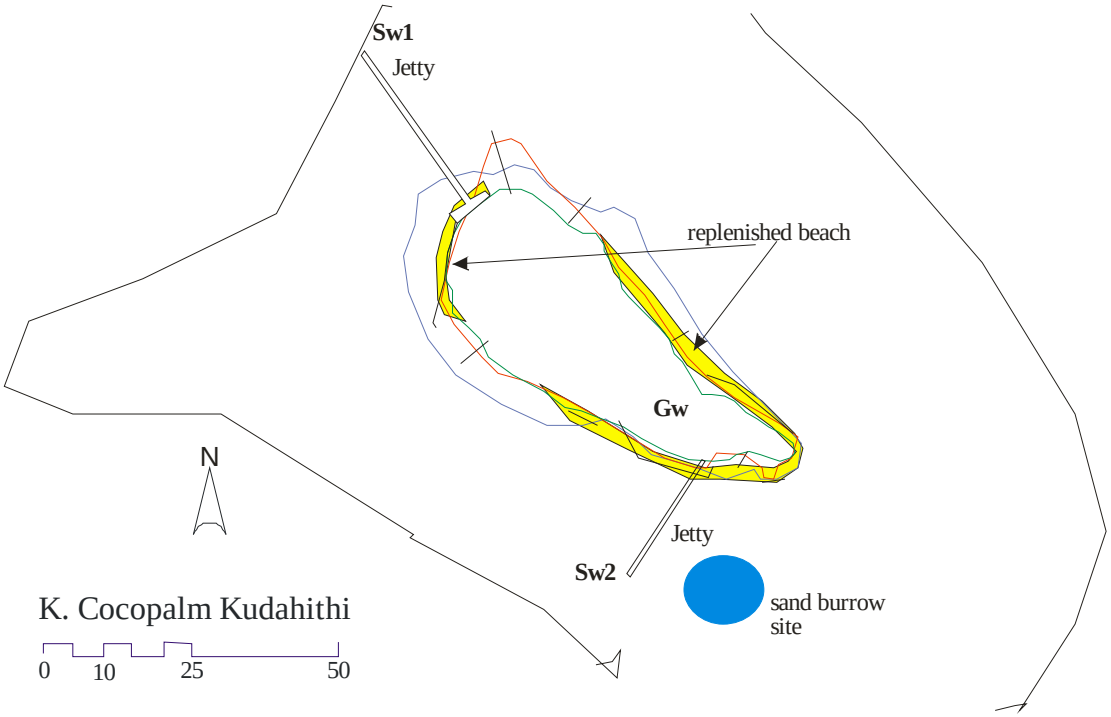


Figure 1: Beach replenishment plan for kudahithi

3.11.6 Demolition of the existing buildings

3.11.6.1.1 Demolition of the existing guest bungalows

The redevelopment would demolish 7 existing beach bungalows at the island. It is expected that this would generate 496.30 m3 of demolition waste. Out of this, 99.15 m3 would be coral that could be recovered from the waste stream.

3.11.6.1.2 Removal of the columns which were placed in the lagoon

Development of water villas was planned for the previous development. However, this plan was abandon. Hence, the redevelopment will remove the columns that had been placed on eastern side of the island. It is estimated that this component will generate, 375 m3 of waste.

3.11.6.1.3 Reusing coral from demolition waste

Twenty years ago, the most common material for the construction of the resorts was corals. These were mined from reefs with a permit when the island was developed. As such, kudathithi was also built with legally obtained corals. Hence the demolition of old buildings would generate corals in the demolition waste stream. It is estimated that 99.15 m3 of corals would be recovered from the demolition waste stream.

The concept of redevelopment is to capture the architectural signature that was originally created at the island. Hence, with this intention, the new buildings which would be constructed would be decorated with a layer of corals that would be been recovered in the construction waste stream. Also, since one of the principles of waste management is to recover what is usable and valuable in the waste stream, it would be a waste to dispose the corals which have been recovered and separated from the demolition waste stream. Hence it is proposed to reuse the recovered corals in the waste stream.

3.12 Redevelopment Component

3.12.1.1 Main Residence

The proposed redevelopment includes the construction of the Main Residence on land. The proposed area for the Main Residence structures is 364 m².

3.12.1.2 Support Bungalows

The proposed redevelopment includes the construction of the two support bungalows on land. The proposed area for the bungalow structures is 73.51 m².

3.13 Construction schedule, process and methodology

As soon as the EIA is approved and a decision note is issued, the redevelopment project will begin at Kudahithi. Mobilization will start as the first activity of the project. The construction will be undertaken in the planned time period to reduce cost and also reduce the environmental damage.

Time Frame : Months after Grant of Approval for Construction (Preliminary)

Activity	1				2				3				4				5				6				7				8			
	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4	w1	w2	w3	w4
Demolition & Site Clearance																																
Service Complex																																
Recycle house																																
Fuel Farm																																
Recycle house																																
Fuel Farm																																
Island suite																																
Water Residence																																
Reception Lobby																																
Event Resturant																																
Staff Centre																																
Mosque																																
External Landscaping																																
Renovation of Jettys																																
Commissioning of Full Service Facilities																																
Removal of Construction Equipment																																
Completion of Construction																																

3.13.1 Work methods for new structures

Main Residence, Support Bungalows, Main Pavilion, staff centre and service centre will be developing on land. The method of construction would start as soon as the existing structures on the land are demolished and cleared. Then sites would be excavated to lay the foundation of the buildings. Then concrete columns and beams will be casted. Then walls will be constructed following plastering. Afterwards, plumbing, electrical and fire networking lines will be laid.

3.13.2 Demolition strategy

All demolition work will be undertaken manually except where machinery is required. The use of machinery will be limited for demolition.

3.13.3 Management of waste

The executive arrangement in place for managing construction stage waste is simply by stockpiling the waste for the shortest duration possible, in the island. The combustible waste will be incinerated or burnt on the island. The residual waste then transport immediately to facility or place identified by the Ministry of Housing, Transport and Environment and communicated to the developer through the Decision statement issued for this EIA. This operation is not expected to be disrupted and the management of the waste will not be a significant issue as already regular transfers are made to Thilafushi.

3.13.4 Montreal Protocol

The redevelopment considers the Maldives commitments to the implementation of the Montreal Protocol on Substances that depletes the Ozone Layers. The accelerated HCFC phase-out schedule for Maldives for consumption and production of HCFC as agreed Montreal Protocol is presented in table below. Hence the new infrastructure that would be added for the development in the area of cooling and refrigeration systems would comply

with the national requirements that had been outlined and communicated by the Ministry of Tourism.

Control measure	Schedule
Baseline	Average of 2009 & 2010
Freeze	2013
90% (10% reduction)	2015
65% (35% reduction)	2020
32.5% (67.5% reduction)	2025
0% (100% reduction in manufacturing)	2030
Annual average consumption of 2.5% (for servicing)	2030 to 2040

3.14 Carbon Emission

The upgrade and redevelopment will demand, daily additional 100 L of diesel to generate power for the island. It is estimated, using reference approach as outlined by IPCC, that additional 307.2 Gg of carbon dioxide will be emitted from the proposed redevelopment. The actual carbon emission from the energy sector from the increasing in demand would be 83.7 Gg.

3.15 Expected environmental conditions

Since the project will take place in south-west monsoon, environmental conditions can at times influence the work. But June and July, being the worst period of south-west monsoon, working conditions is not expected to be of any significance as the coastal protection and beach replenishment component of the construction will most likely take place in August.

3.16 Risks associated with the project

There are few risk factors associated with this project that could possibly have financial and environmental implications. First, there is the risk of project delays caused by bad weather as the construction period falls within the south-west monsoon. This risk can be minimized if the refurbishment of the arrival and service jetty footings and removal of the existing columns of the water villa jetty could be completed within the minimum period. This risk will also be minimized by awarding the contract to only experienced contractors with experience in working in similar situations. Therefore, work delays will be least impacted.

3.17 Project Inputs and Outputs

3.17.1 Project Inputs

The types of resources that will go into the project and from where and how these will be obtained are given in table 1 & 2.

Table 1: Matrix of major inputs during construction period

INPUT RESOURCE(S)	SOURCE/TYPE/QUANTITY	HOW TO OBTAIN RESOURCES
Workers (100)	Maldivians and foreigners	contractor
Water supply (construction period)	Existing Desalination plant in the island for construction period	20 m3/day desalination plant
Electricity/Energy (construction period)	Existing Diesel generators in the island for construction period	400kva, generator
Construction machinery	Concrete Mixer, barge, excavators, and general construction tool	contractor
Telecommunications	Island's Phone Systems, Fax Machines, E-mail and internet facilities	Already this services is available in the island
Transport (sea)	Sea transport by dhoni and speed boats. Materials to be transported in cargo	Setup already established.

INPUT RESOURCE(S)	SOURCE/TYPE/QUANTITY	HOW TO OBTAIN RESOURCES
	vessels/dhoni or large barges. All construction debris will be transported to a facility identified and communicated by Ministry of Environment via cargo vessels/dhoni	
Food and Beverage during construction period	Mainly imported sources except a few locally available.	Already setup available
Fuel, Kerosene and LPG	Light Diesel, LPG Gas, Petrol, Lubricants	Already setup available

Project Outputs

The type of outputs (products and waste streams) and what is expected to happen to the outputs are given in the next table.

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

PRODUCTS AND WASTE MATERIALS	ANTICIPATED QUANTITIES	METHOD OF DISPOSAL / CONTROL
Sewage and wastewater Grey water/laundry wastewater	Estimated to be at 100 litres/person/day	Utilize the existing disposal system in the resort.
Construction waste from construction activities, mainly timber and other building materials.	75 to 100 cubic meters of debris in total and general construction waste. This includes, timber, empty cement bags, aggregate, steel bars etc.	Debris sent to waste management facility identified by Ministry of Environment and communicated through the Decision Statement
Demolition waste	It is estimated that 496.30 m3 of demolition waste would be generated. Out of which 99.15 m3 of corals could be recovered	Demolition waste would be treated with the guidance received from EPA through the EIA Decision statement.
Waste oil and grease	5 to 10 L as only small excavators will be used to place the villa footings.	waste management facility identified by Ministry of Environment
Noise	Localised to the island environment	No controls are need as the level of noise would not be significant. Only localised to the island environment only.
Air pollution	Limited quantities of dust .	Mainly arising as a result of dust emission from the construction work such as cement mixing, and other processes. Only localised to the island environment only.

4 Methodology

The section covers methodologies used to collect data on the existing environment. The key environmental components of the project under consideration are coral reef areas, the marine environment and the coastal environment. The following data collection methodologies were used during the field visit undertaken in June 2010.

4.1 General Methodologies of data collection

Conditions of the existing environment were analyzed by using appropriate scientific methods. The environmental components of the study area were focused for marine and coastal environment. The marine environment of the island covered the coral reef and the lagoon. Coastal environmental data collection involved taking beach profiles from selected locations and assessing the coastal environment.

4.2 Mapping and Location identification

The island, including shore line including the low tide line, mid tide line and high tide line, vegetation lines and coastal protection structures on the beach were mapped for the assessment. Mapping was undertaken using hand held differential GPS and available satellite photos. The location of data collection sites were marked using handheld GPS. These data collection points include marine water sampling locations, marine survey locations and beach profile locations.

4.3 Marine Water Quality

Water quality was assessed during the field trip in June 2010 by collecting samples and testing them at National Health Laboratory. Water quality was assessed from two locations. (see Figure 1) The locations, frequency and parameters to be monitored are given in the monitoring programme outlined later in the EIA report.

4.4 Marine Environment surveys

The purpose of the marine survey is to define and establish marine environmental baseline conditions for the evaluation of success or failure of the coral enhancement project. Surveys are based on standard marine environmental surveys so that they can be repeatedly carried out to monitor and record changes and assess possible impacts on the marine environment from the proposed work activities. They include quantitative and qualitative methods. In addition, a series of photo images using an underwater digital camera was taken to support a qualitative survey for benthic assessment studies.

Four methods were primarily used to collect data, namely: (1) Photo frame survey, (2) Detailed LIT at the northern jetty of the island for sessile benthic community estimation, complimented by photo documentation, (3) Fish census at all sites and (4) Qualitative surveys through visual observations, particularly in areas close to survey sites

4.5 Photo frame Survey

Surveys were conducted in the shallow lagoon using a standard random photo-frame method. At 1-1.5m depth, PVC squares of 60x60cm were placed randomly on the intertidal reef and 4 sectors were photographed separately. 5 frames were placed at Site I and 10 quadrats were placed each at Site. The benthic community was counted on the digital pictures of the photo-frames applying 100 randomly distributed points per quadrat (or: 25 points per sector) using CPCe 3.6 software (Kohler and Gill 2006). Substrate categories such as live corals and other living or non-living substratum are listed in Table 3.

Code	Category	Subcategories	Details
CR/RU	Coral Rock or Rubble	Coral Rock (CR), Coral Rubble (RU)	Biogene coral rock. Rubble: Structure of the coral may not be made out, up to 15cm in diameter
LC	Live Coral	*Acropora sp. (AC), Pocillopora sp. (POC),*	Healthy live reef-building corals (includes all hard corals, *Millepora sp*., *Heliopora sp*. and

Code	Category	Subcategories	Details
		Porites sp. (POR), Faviidae (FAV), Other live corals (OL)	*Tubipora musica*).
BL	Bleached Coral	Fully bleached coral or bleached spots on coral	Fully or spotted bleached coral, not overgrown by algae
DC	Dead or broken Coral	Dead Coral Damaged (DCD), Dead Coral General (DCG), Dead Coral Recent (DCR), Dead Coral with Nutrient Indicator Algae (NIA)	Dead reef-building coral, recent or very recent, but not bleached. Coral structure can still be made out. NIA: Blooms of fleshy algae that indicate nutrient pollution (therefore, *Halimeda sp.*, *Sargassum sp.*, *Turbinaria sp.*, coralline algae and turf algae are not counted); algae that cover coral after a bleaching event are included here.
SA/SI	Sand or Silt	Sand (SA), Silt (SI)	Coral sand or silt, indicates sedimentation pressure on reefs
OT	Others	Coralline algae, Macro algae which are no indicator of pollution or stress on corals, Sponges, Alcyonarians, Clams (*Tridacna sp.*), Ascidians and other life forms	Includes other living or non-living substratum

Table 3 Substrate categories and subcategories used for benthic survey

4.6 Line Intercept Transects (LITs)

Line Intercept Transect (LIT) surveys were carried out to assess the benthic types and species at the surveyed sites. This method uses life form categories to assess the benthic sessile community of reefs and it is possible to incorporate taxonomic data as well. LIT surveys can be used to evaluate the community structure of corals in terms of species composition and diversity patterns in different zones on a reef. LIT method also provides a rapid estimate of percent cover of corals, algal cover, and cases of other prominent organisms as well as bare substratum.

Quantitative percent cover of the reef community can be obtained using this method and it can be repeated to obtain changes over a period of time. Disadvantages of this method include difficulty in standardizing the life form categories and the limitation of the data collected, to information on percent cover and relative abundance (English et al. 1997). LIT surveys produce valuable data even though they are time consuming and require considerable effort and skills to record notes underwater (Segal & Castro 2001).

To demonstrate the existing situation of the shallow benthic community next to the northern and southern jetty, which are proposed to be renovated, a transect line of 20m length was placed about 1 meter west of the northern jetty in order to evaluate coral communities. No transect was placed at the southern jetty since its surrounding is free of live corals (visual observation).

39 data samples were obtained from the transect by recording the substrate every 50cm under the measuring tape. The transect started from the end of the jetty 20 meters towards the island.

4.7 Reef fish Visual Census

Under water counts of reef fishes or underwater visual census (UVC) method was used to assess the fish population at the surveyed sites. Visual counts appear to give reasonably reliable results provided that they are applied to fish that are noncryptic and either diurnally active or at least evident by day. In this method, the surveyor swims along the transect paths above the reef, counting fish that were observed within 1.5m either side of the transect and above up to the water column. The same transects line as for the LIT at the northern jetty was

utilized to carry out the fish census. Fish were counted along the 20 m transect path (that is in a belt of 5 m on either side and up to the water surface). To count the fish, the surveyor swam slowly along, counting fishes that were seen within the defined band transect, 20m long by 3m wide (i.e. one with a total area of 60m²). All fish encountered were recorded at least up to family level, some up to genus and species level, noted on the underwater slate immediately after they were seen. Counting any fish more than once was avoided by training and experience. Speed at which the path was swum was controlled so as to standardize the efficiency of search. If the surveyor swims too fast it is easy to miss fish, especially of smaller species, that may be temporarily obscured by corals or rock or be taking shelter. Experience shows that the slower the surveyor swims, more fish that is recorded up to a point. However, the highest number recorded by moving along very slowly may actually be an over estimate of fish density. Hence it is necessary to standardize swimming speed to a slow but not too slow pace. The standard speed of swimming practiced was at a mean rate of 8m a minute. For results, fish families representing one of the following functional groups were taken into account: herbivores (Acanthuridae, Scaridae), omnivores (selected Labridae), corallivores (Chaetodontidae) as well as habitat specialists (Pomacentridae).

Fish census at Sites I, II and III, as well as at Jetty South was carried out in a different way, since live coral cover was recorded there using photo frames (Sites I – III). At Sites I (5m2 patch) and II (10m2 patch), a detailed fish census was performed for 3 minutes. At Site III (10m2) and at Jetty South, fish were recorded using a rating system starting from low abundance (*, 1-4 individuals), low+ (**, 5-9 individuals), medium (***, 10-30 individuals), high (****, 31-100 individuals) to very high abundance (*****, more than 100 individuals).

4.8 Coastal environment

Data collected on coastal environment included beach profiles, existing coastal defense structures, beach width, shore line and vegetation line. All beach profile locations were marked on GPS maps and their geographical coordinates were marked on a map. Beach profiles were taken as baseline data to make comparisons during monitoring programme so that any changes resulting from proposed project can be assessed accurately. Beach profiles were measured using Auto levels and a staff.

4.9 Bathymetry

A detailed bathymetric survey was undertaken in the lagoon using Echosounder attached to a boat. The levels were then corrected for mean sea level and represented in a map. Bathymetric map is attached as an annex.

4.10 Aerial photos

Recent satellite photos acquired in January 2009 were used in the assessment. Aerials photos provide useful information such as assisting the analysis of marine environment, identifying wave patterns and changes to shoreline and also vulnerable areas of the island. Satellite aerial photos were purchased from DigitalGlobe. This has been used extensively in this EIA and has been presented in different sections of the report.

4.11 Available long term weather data

Long term available weather data was obtained from the nearest weather station to Kudahithi, which is based in Hulhule. These data sets were used to develop a regional model in ArcGIS to assess the vulnerable areas of the island during both monsoons, thus helping the EIA team to assess the vulnerable areas of the island for erosion.

5 Existing Environment

The existing environment of the island has been studied by the consultants during a field visit undertaken on June 2010. A photographic summary of the existing environmental conditions is provided in Figure 9.

5.1 Physical environment

Male' Atoll is located roughly in the centre of the chain of atolls islands that stretch from north to south across the equator to form the Maldives. Most of the islands are formed on the atoll rim reef systems where the islands are exposed to the Open Ocean and tidal currents. Male' atoll is characterized by a mixture of resorts and inhabited islands on both east and west cost and within the atoll itself. Coastal dynamic around these islands are more profound than islands inside the atoll. Several islands of varying size are formed inside the atoll lagoon. These islands are the most appropriate for type tourist resort development in the country for number of reasons. They are separated and away from the inhabited islands thus any resource use conflicts between tourism and other economic activities will be minimal as well as environmental management of the island will be much easier.

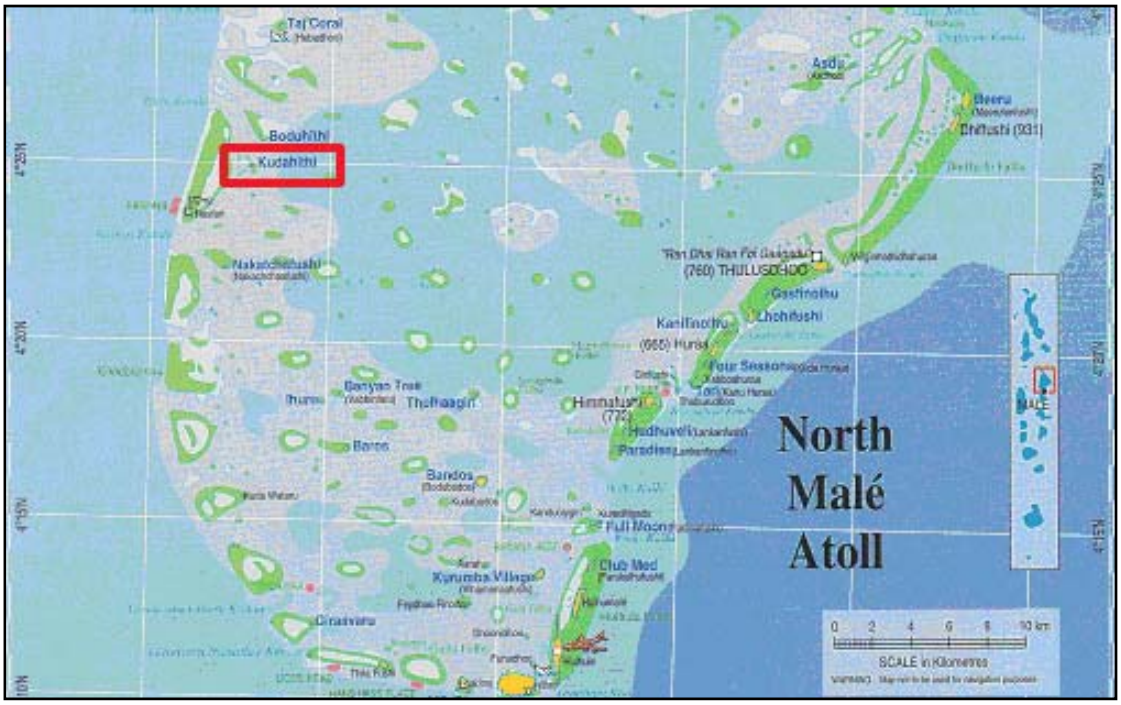


Figure 2: Male' Atoll and the location of Kudahithi

5.2 Marine Environment

5.2.1 Description of Marine Environment

Marine environment of Kudahithi can be categorized into two main components. They are the island lagoon system and the coral reef system or the island's house reef. The whole system of Kudahithi is situated approximately 1km west on the lee of Rasfari faru and approximately 2km south of Boduhithi faru therefore, very sheltered. However, strong south-easterly currents flowing into the atoll through Hithi Kandu during southeast monsoon is felt along Kudahithi reef system. This geomorphologic setting had shaped and oriented Kudahithi reef system north-east and south-west direction.

There are no islands in the vicinity of Kudahithi other than Boduhithi and Rasfari. The next closest island to Kudahithi is Nakatchafushi approximately 6km SSW of Kudahithi. There is no other significant reef system close to Kudahithi reef system.

5.2.2 The lagoon system

The island lagoon system is very shallow having about 1.5m depth at most of the areas during mean sea level. The lagoon bottom consisted of mainly fine sand, unconsolidated rubbles in some areas and patch reef on eastern side of the island. The lagoon area of Kudahithi island system is approximately 5.3 hectares. Lagoon on eastern and western side of the island is approximately 90m and 64m wide respectively. The largest lagoon area exists in south-east of the island where the water villas were proposed to be constructed. Lagoon length of approximately 135m is found in south of the island.

5.2.3 The reef system

Reef system of Kudahithi is oriented in northeast and southwest direction influenced by monsoon currents and waves. Approximately 450m long and 77m wide section of the reef is extended towards northeast from the main reef system. This section of the reef is deeper than the rest of the reef system. A large section of the reef is also protruded from southwest of the main reef system. This section of the reef measures an area of approximately 2.7 hectare.

The reef slope on eastern side of the island is steeper than western side as a result stronger current flow on eastern side. The reef-flat on south of the island is widest having approximately 50m in average whereas reef-flat in other areas have an average width of approximately 20m.

The reef system of Kudahithi is very small having a length and width of approximately 880m and 260m respectively and a total area of approximately 12.4 hectares and an outer perimeter of 2.8km. Most other reef system in the vicinity is several time larger, than Kudahithi reef system, for instant Rafari reef system has a length of 7km.

5.2.4 Assessment of coral and fish community at Site I

Entering the water from the existing seawall on the western site of the island, one will find the beach sloping down into a sandy lagoon. Sand and coral rubble dominate the first 30m until coral patches, scattered across the lagoon, start appearing. These patches seem to have been established on a coral rubble field (Figure 3) and are distanced from each other by several (10+) meters. A coastal protection structure is expected to be built either on sand, or in an area of such coral patches; therefore, a reef survey has been undertaken on such coral patches.

It is known that coral bleaching has taken place in the Maldives in April/May 2010 (personal observations and communication with the MRC Male'). At the time of the survey, such a patch was overgrown by 39% with algae. It is dominated by dead coral (which includes dead corals overgrown by algae) with 45.9 % and coral rock and rubble (36.4%). Only 5.78% live corals were present. This pattern is similar to other patches at this Site which were observed up to the jetty on the northern side of the island (parallel to the beach) and towards the reef crest (perpendicular to the beach), where the reef becomes denser. Whole coral colonies were bleached or already overgrown with algae as shown in Figure 4.

Figure 3: Coral colonies established on rubble lying on the seafloor. While some colonies are still alive (see Acropora right bottom corner), others have died and are overgrown with algae (photo center).

Figure 4 Coral patch, view towards reef crest. Corals are either bleached (pale, white) or already overgrown by algae (briwn/green colour). Such patches are separated from each other by sand and coral rubble.

Such a coral patch at Site I is dominated by Pomacentridae (mainly juvenile and adult *Dascyllus aruanus* that seek refuge in *Acropora* branches, and *Chromis* sp.), followed by various Labridae. During the time of the survey, no Acanthuridae, Scaridae or Chaetodontidae were observed. Site I appears to be dominated by habitat specialists.

5.2.5 Assessment of coral and fish community at Site II

Site 2 was surveyed 30 meters away from a damaged sea wall lining the beach. As in Site I, the existing coastal protection structures are expected to be refurbished in this area. The first 30m consist mainly of dead corals, coral rubble and sand, and are then followed by a scattered

inshore reef consisting of low live coral cover (3.6%). This results from coral patches being scattered across the lagoon, separated several ways from each other by rubble and sand, and from a high amount of dead corals covered in algae (21%). 7.9% of corals were bleached at this site.

Pomacentridae (*Dascyllus aruanus* and adult *Pomacentrus indicus*) dominated this site, followed by Scaridae, which were absent towards the jetty and at Site I, and Acanthuridae (e.g. *Ctenochaetus striatus, Zebrasoma sscopas*).

5.2.6 Assessment of coral and fish community at Site III

Site III in front of the seawall and groyne at the eastern side of the jetty begins with a sandy seafloor being scattered with coral patches after the first 30 meters. Patches here are covered to 23% in algae and consist of only very low coral cover (1%), resulting from sand floor separating patches (30%) and a high amount of dead coral (includes algae covered corals) and rubble, together amounting for 61% of the benthic substrate. Pomacentridae (****) was the most dominant fish family encountered at this site, followed by Acanthuridae (**), Scaridae (**) and Labridae (*).

5.2.7 Assessment of coral and fish community at the northern jetty

The first 30 meters along the northern jetty is free of live corals. The transect started from the end of the jetty 20m beachwards and revealed that 35.9% of the reef that could be affected by renovation works is still covered with live corals. 33.3% of the reef consisted of dead or broken corals, of which many were covered in algae. 12.8% of this site consists of recently bleached corals, which were not overgrown by algae at the time of the survey.

Pomacentridae (juvenile and adult *Dascyllus aruanus, Chromis sp.* and juvenile *Pomacentrus indicus*) dominated the transect, followed by Acanthuridae, Labridae and various species of Chaetodontidae.

This site appears to have had an extensive reef flat (up to 100% live coral cover) prior to the bleaching event (personal impression, confirmed by communication with island management) and seems to have been impacted only recently, as living, dead and dying coral colonies suggest (Figure 5).

Figure 5 Reef flat on the western side of the northern access jetty. It appears to have been a healthy reef flat, but was heavily impacted by coral bleaching, as results suggest.

Figure 6 Southern jetty situated in the lagoon, surrounded by sand and rubble

5.2.8 Assessment of coral and fish community at the southern jetty

The area around the southern jetty is mainly free of live corals and consists to a great extent of sand and coral rubble only (Figure 6), except for a few colonies that have established themselves on the sandfloor. Most of these colonies have, however, died during the recent bleaching event, as bleached corals and corals covered in algae, similar to other parts of the lagoon, suggest. It can be clearly seen that the columns, on which the jetty was built, offered hard substrate for *Acropora* sp. and *Stylophora* sp. to settle and grow, even though most colonies (especially *Stylophora* sp.) are already pale and are expected to have died a few days after the survey. The few remaining branching *Acropora* and demolition waste lying around attract a number of Pomacentridae (***, mainly *Dascyllus aruanus*, *Chromis* sp. and *Abudefduf vaigiensis*), as well as Acanthuridae (***e.g. *Ctenochaetus striatus*), Scaridae (**), Chaetodontidae (**, *Chaetodon decussatus*, *C. trifasciatus*, *C. auriga*), Labridae (*), Nemipteridae (*), and Mullidae (*). One juvenile *Plectorhinchus vittatus* was observed under the jetty, as well as both a large school of juvenile Bigeye Jacks (****, *Caranx sexfasciatus*) and a group of Needlefish (*Tylosaurus crocodilus)* just below the surface. The contents of a fish cage on the western side of the jetty could not be seen through the narrowly-spaced mesh.

5.3 Existing Coastal environment

5.3.1 Geological Setting and Island Formation

Kudahithi island is located close to the western rim of North Male' Atoll approximately 31km from Male'. Longitude and latitude of Kudahithi are approximately 4°26´N and 73°23´E respectively. The closest island to Kudahithi is Boduhithi located approximately 1.3km NW of Kudahithi. Rasfari is located approximately 5km SW and Henbadhoo (Taj Coral) is located approximately 6km north of Kudahithi. Other islands within the locality are beyond a 6km radius of Kudahithi.

At present (June 2010) , the perimeter of the island measures 523.8 m along the shore line and the total area of the island is about 9,279.5 m^2 inside the vegetation line and 10,980 m^2 inside the high tide line. The registered land area at Ministry of Tourism for Kudahithi is 13,995 m^2.

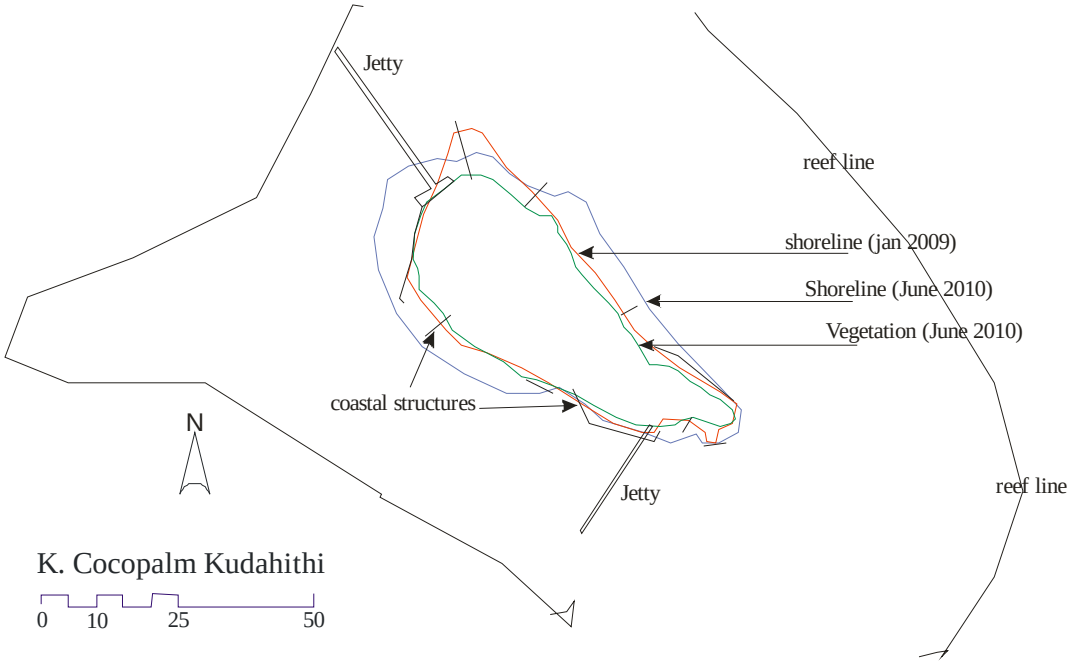


Figure 7: Comparison of islands vegetation and beach lines in 2009 & 2010

There have been dynamic changes to the shorelines of Kudahithi over the past years. These changes are mainly due to natural evolution of the island but have also been affected to a great extent by the different changes that have been made in the name of coastal protection in the past. Based on the survey of June 2010, it is found that the island has lost 3,015 m^2 of its beach compare to that of the registered land area.

Figure 8: Satellite photo (January 2009) from Digital Globe

From Figure 7 as well as the aerial photo shown in Figure 8 it can depicted that the island the island beach has lost sand due to erosion. This is mostly visible on south eastern and north eastern side of the island.

5.3.2 Climatic Conditions

General studies on the climatic conditions of the country were taken into consideration since there is very little variation in the climate of the country. Figure 4 shows the general trends in climatic variations and geomorphologic features across the Maldivian Archipelago.

The prevailing weather conditions for the Atoll is very similar to other parts of the country However, the rain fall is greater in the southern atoll but the showers are not as heavy as in the north. Greater extremes of temperature were also recoded in the northern atoll than in the southern atoll. Otherwise very similar two monsoonal climatic conditions are experienced in the country.

The southwest monsoon is the rainy season, cloudy skies, moderate to rough seas are common. Frequent gale force winds with speeds of 11 mph occur and wind gusts of 35 mph have been recorded occasionally. In September and October conditions are calmer. November is usually transitional period for the monsoon system to change from southwest to north-east monsoon.

The northeast monsoon is usually from December to mid April. Calm seas, hot and dry days, cooler nights are more commonly experienced during this period in the atoll as for the whole country. Frequent light winds usually from northeast and variable sea breezes with an average speed of 9 km/h are felt. Transitional period from northeast to southwest monsoon begins in April with calm, windless days which are more common than any other period as experienced during the site surveys. Onset of start of monsoon can be delayed or start a month or so early than usual, otherwise climatic conditions are predictable from year to year.

Average daily temperature variations are from 31 ^{o}C in the day times and 24.7 ^{o}C in the night times and the average yearly temperature remains very constant throughout the year with variation of maximum 31^{o}C (in around April - May) to 30.4^{o}C (in around November - December).

Monthly average wind speed was recorded as 8.1 mph and varies from 6 mph (around March) to 11 mph (around October). Heavy windy conditions occur during south-west monsoons. Wind gusts of 35 mph to 45 mph can be were occasionally recorded when effects cyclones from Arabian sea can be felt in the country. Direction of wind changes predominantly from north-east in the north-east monsoon to west and south-west in the south-west monsoon and variable direction of wind are experienced in the monsoon transition periods.

5.3.3 Currents

Generally current flow through the Maldives is driven by the dominating two-monsoon season winds. Westward flowing currents are dominated from January to March and eastwardly from May to November. The change in current flow patterns occurs in April and December. In April the westward currents are weak and eastward currents flow will slowly take place. Similarly in December eastward currents are weak and westward currents will take over slowly.

Studies on current flow process within a coral atoll have shown that waves and tides generate currents across the reef platforms, which are capable of transporting sediments on them. Currents, like waves are also modified by reef morphology. Under low-input wave conditions (0.5m heights) strong lagoonward surge currents (>60cm/sec) are created by waves breaking at the crest. Studies on current flow across reef platforms have shown that long-period oscillations in water level cause transportation of fine-grained sediments out of the reef-lagoon system, while strong, short duration surge currents (<5sec.) transport coarse sediments from the breaker zone to seaward margin of the backreef lagoon. Always sediment accumulates at the lee of high-speed current zones. Generally zones of high current speed (jets or rips, 50-80cm/sec) are systematically located around islands.

Figure 9: Photographic summary of the environmental conditions at Kudahithi island resort.

With the dynamic nature of oceanographic conditions around the islands of the Maldives, general current flow patterns were not based only on field measurements but on local knowledge and experience of the consultants.

Tidal currents as well as oceanic currents are felt in the atoll. The exposure of the Atoll to the vast ocean ensures that an immense body of water is constantly flowing across the atoll. The currents can be extremely strong in the channels between the reef systems around the atoll especially during ebb and flow into the atoll. Current speeds of four knots or more have been recorded in the atoll channels in the country. Oceanic currents are largely influenced by the direction of trade winds and can be of great strengths. Tidal currents which flow according to the height of the tide and the direction of prevailing winds, are much weaker than oceanic currents.

5.3.4 Tidal variations

Tides affect wave conditions and wave-generated and other reef-top currents. Tide levels are believed to be significant in controlling amount of wave energy reaching an island, as no wave energy crosses the edge of the reef at low tide under normal conditions. In the Maldives, where the tidal range is small (1m), tides may have significant influence on the formation, development and sediment processes around the island. Tides also may play an important role in lagoon flushing, water circulation within the reef and water residence time within an enclosed reef highly dependent on tidal fluctuations.

Like most of the places semidiurnal tides are experienced in the atoll, that is two high tides and two low tides a day. The tide varies from place to place, depending on the location and on the shape and depth of the basin, channels and reefs and also time of the year.

5.3.5 Waves

Studies by Lanka Hydraulics (1988a & 1998b) on Malé reef indicated that there are two major types of waves on the coasts of the Maldives: wave generated by local wind with a period of 3-8 seconds and swells generated by distance storms with a period of 14-20 seconds. Wave energy is important for sediment movement and settlement, and it is also a crucial factor controlling coral growth and reef development. Waves have been attributed to the diversity and the abundance of coral and algal species. These aspects have implications for the type and perhaps the supply of sediments into the island.

5.3.6 Wind

Wind has been shown to be an important indirect process affecting formation, development and seasonal dynamics of the islands in the Maldives. Winds often help to regenerate waves that have been weakened by travelling across the reef and they also cause locally generated waves in lagoons. Therefore winds have a dominant influence on the sediment transportation process (waves and currents). With the reversal of winds in the Maldives, NE monsoon period from December to March and a SW monsoon from April to November, over the year, the accompanying wave and current processes respond accordingly too. These aspects have ramification on the seasonal sediment movement pattern on the islands and also the delivery/removal of sediments from the reef platform/island.

Analysis of 18 years of wind data for Malé indicated that the highest frequency of wind occurs from the west followed by WNW, NW and WSW during the south-western monsoon and from ENE and NE during the north-eastern monsoon. Results also show that the westerly component dominates over the easterly. Comparison of wind frequency of the transition period between the easterly monsoon and the westerly shows that the transition takes over between March and April and the Western monsoon reaches its peak by June.

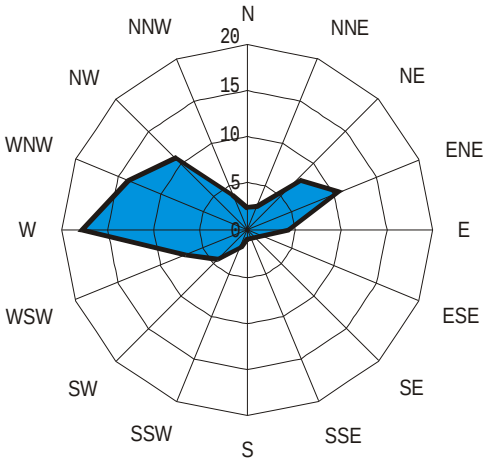


Figure 10: Wind rose diagram for Malé International Airport (1980-1999)

5.3.7 Coastal and Marine Water Quality

Qualitative and quantitative assessments were made on sea water to assess the sea water quality. Hence, physical inspection of the seawater from the immediate lagoon revealed no sign of contamination or pollution. The sea water is clean and clear, with the exception of occasional sedimentation caused by the changing tide. To confirm this, water quality tests were done at the Public Health laboratory. Seawater quality results are shown in Table 4. The results tend to indicate that the water around Kudahithi is reasonably pollution free.

Table 4: Results for water quality testing for sea water.

Parameter tested	SW1	SW2
Physical appearance	Clear	clear
Temp (°C)	28.20	29.10
pH	8.5	8.5
Salinity (mg/L)	32.00	32.80
PO_4^{-3}	0.02	0.02
Nitrate (mg/l)	0.00	0.00

5.4 Terrestrial Environment

The terrestrial environment of Kudahithi was appraised by visual analysis and floral and faunal surveys carried out during a field trip to the island on June 2010. Vegetation survey was carried out as line transects along the coastal vegetation line and across the island in two locations. These findings are discussed in detail in the sections below.

Soil conditions and groundwater conditions were appraised through qualitative analyses and also obtaining water samples for analysis. Water samples were taken from one location within the island. Water samples were collected into pre-sterilised bottles and empty PET bottle of appropriate sizes..

Photographic surveys were carried out in the transect areas and at random points throughout the island.

Noise and air quality was not considered crucial for Kudahithi environment as the island has retained its untouched natural conditions for long time and there were no unnatural sounds which may be considered noise.

5.4.1 Floral Landscape

The landscape of Kudahithi cannot be considered unique but representative of many other uninhabited small islands of Maldives. There are no terrestrial landscapes of significance. The landscape could be described as having two major types of vegetation: well established vegetation on the inside of the island and relatively young vegetation around the island.

There are no major vegetation clearings in the island. The islands vegetation have grown covering most of the existing infrastructure in the island. Once inside of the island, it is not possible to se the sky as the tree canopy has entirely spread over blanketing and covering the island. Inside the islands, vegetation is characterised mainly by mature Dhiggaa, Uni and coconut palms. Except for the foot paths, the rest of the island is vegetated. Due to the small size of the island, this pattern of inner vegetation prevails throughout.

5.4.2 Terrestrial Flora

Kudahithi's flora was assessed using line transects along the coastal vegetation line and across the island at two locations. The findings of these line transects are summarized later in this section. No rare or endangered or endemic terrestrial plant species were observed during the site visits. Over nine plant species were observed, predominantly on the sandy shoreline (vegetation line) and six species from inside the island.

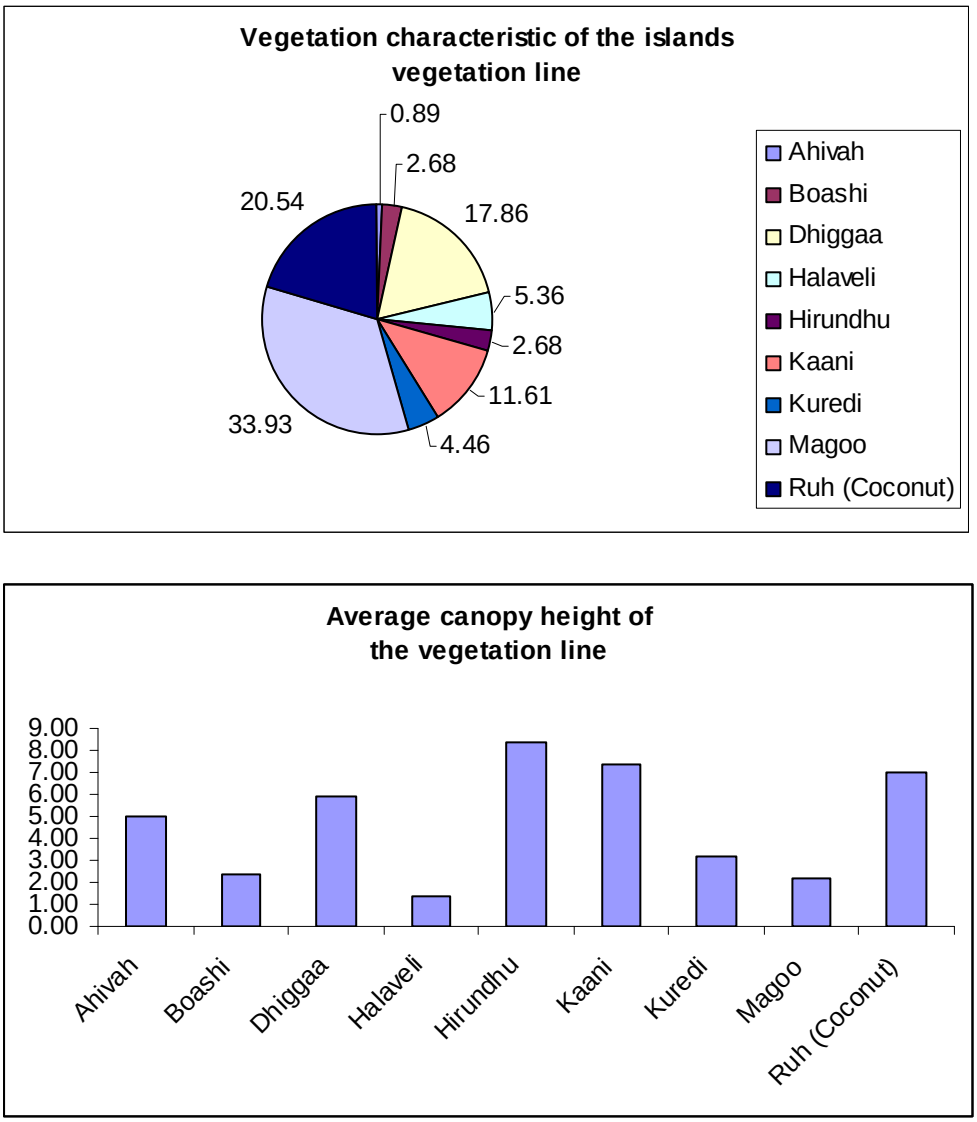
5.4.2.1 Line Transect 1 (along the vegetation line)

The coastline or the vegetation of the island was assessed by walking along the vegetation line to assess the vegetation and their abundance. Two more line transects were done across the island to assess the inner vegetation of the island at selected zones. Each plant species encountered along the walk through was identified and recorded on paper. The physical and biotic environments were also recorded.

The vegetation along the vegetation line was well defined, throughout the islands perimeter with a mixture of mature and young pants. Most of the mature plants were observed to be Kaani and Coconut *Cocos Nucifera*, while young plants observed were mainly Magoo and Kuredhi. The island has been protected by a sea wall on the northern side which has protected the beach from erosion. In comparison to the size of the island with other islands, the vegetation found along the perimeter of the island was observed to be mature and distinct. A total of nine plant species were recorded along the vegetation line.

The dominant species observed in this region was mainly *Scaevola taccada* (Magoo), *Cocos Nucifera* (Coconut), *Hibiscus tiliaceus* (Dhigga) and *kaani*. There were a total of nine plant species observed along this region. The average canopy height of this zone varied between 2 to 8 meters. Hirundhu was the tallest, which averaged to 8 meters.

Figure 11: The summary of the vegetation survey conducted along the vegetation line of Kudahithi



Line Transect 2: Across the island

This transect showed contrast with that found around the vegetation line of the island. In fact this was an average of two transects taken across the island. The vegetation characteristic of transect two and the average canopy height for different species and their frequency are illustrated in Table 3. The plant community here comprised of thinly spread bushy grass except on the cleared foot path and mostly mature Dhigaa. In addition, young and mature *Cocos Nucifera* (Cocounut tree) was observed. Average tree canopy height ranged between 2-8 m with the exception of busy and young trees.

Table 5: Results of vegetation survey for transect two

Name	Percent	Average canopy height
Ahivah	0.89	5.00
Boashi	2.68	2.33
Dhiggaa	17.86	5.90
Halaveli	5.36	1.33
Hirundhu	2.68	8.33
Kaani	11.61	7.38
Kuredi	4.46	3.20
Magoo	33.93	2.19
Ruh (Coconut)	20.54	7.01

Figure 12: Photographic illustration of the islands inner vegetation pattern

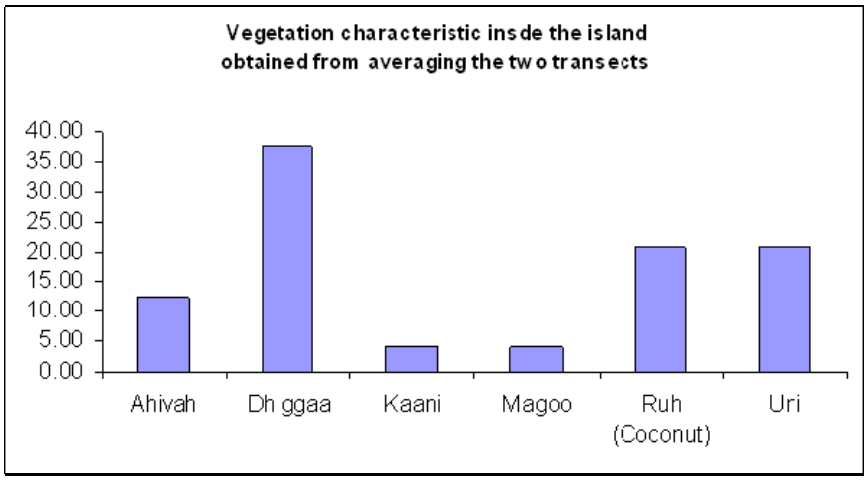
Vegetation inside the island is mainly mature with few exceptionally grassy species and young vegetation.

An existing garden surrounded by palm and other young vegetation.

5.4.2.2 Terrestrial Fauna

Only few bird species were heard and observed during the survey. These include *Kirudhooni* (Black-naped tern) and *Maakanaa* (eastern grey heron). No attempts were made to do a detailed survey of their habitat. No turtle nests were observed in the island during the survey. Some species of Kakuni and lizards were also observed from the centre of the island.

Figure 13: Graphical representation of the results for transect two.



5.4.2.3 Soil and Groundwater

Soil conditions in Kudahithi are expected to be moderately fertile. Visual surveys done near the centre of the island show a considerable layer of dark humus soil. An existing well, was used for sampling groundwater to assess the quality. Below is a discussion on the finding of these analyses.

Groundwater assessment was conducted to assess the ambient conditions of groundwater. The water table stands at 1.2 meter below ground. Groundwater samples were taken for testing using standard methods for water quality and investigation were done at Public health laboratory. Groundwater of the island was tested for nitrates, phosphates, TDS and salinity. These investigations of groundwater revealed that the groundwater of the island is very fresh. Conductivity was at 1895 us/cm which classify as freshwater. Conductivity readings of 2500 us/cm is the cut off limit for freshwater. The results of the water quality tests are illustrated in Table 4.

Parameter tested	Ground water
E-Conductivity	1895 us/cm
TDS	964 mg/l

Table 6: Results for water quality testing for ground water

6 Environmental Impacts

6.1 Introduction

6.1.1 Impact Identification

Impact identification has been undertaken by considering the proposed activities and examining the level of impact the new construction will have on the environment. Each activity was then examined in detail to identify the construction methods, technology and other factors that would determine the potential impact of the various activities.

6.1.2 Assessing Impacts of significance

Environmental impacts of the proposed redevelopment work have been examined through a number of processes. These include consultations with the stakeholders, field surveys, observations and assessment, and field experience gained from similar development projects implemented throughout the country.

6.1.3 Characterizing impacts which were identified

The significance of the identified impact was characterized using following parameters; Nature (positive/negative, direct/indirect), Magnitude (severe, moderate, low), Extent/location (area/volume covered, distribution), Timing (during construction, operation etc, immediate, delayed), Duration (short term/long term, intermittent/continuous), Reversibility/irreversibility, Likelihood (probability, uncertainty), Geographical significance (local, regional, global). Then, these has been presented as summary table.

6.1.4 Evaluation of the impacts identified

The impacts were then evaluated using following principles;

- Environmental loss and deterioration
- Social impacts resulting from environmental change
- non-conformity with environmental standards
- Probability and acceptability of risk

6.1.5 Uncertainties in impact prediction

The uncertainty of the impact prediction is mostly related to the data uncertainty. This is mainly lack of adequate data and information to make an informed impact prediction based on scientific evidence. There is also limited data and information regarding the particular site under consideration, which makes it difficult to predict impacts.

6.2 Constructional Impacts

Construction phase will have the major direct shot-term impacts and some secondary long-term impacts on the environment. The construction and development of the island is expected to have some impact on the terrestrial and marine environment.

Potential negative impacts on the environment, especially on the reef system from the proposed works are limited to a relatively small number of activities which include:

- Potential changes to the longshore transport and littoral regime of the island due to the erection of coastal structures such as jetties (considered as a minor adverse impact given precautions were taken)
- Possible siltation and excessive sedimentation (considered as a moderate adverse impact) on coral reef and the lagoon bottom from (i) coastal modification (ii) beach alteration (iii) by the removal of the existing water bungalows jettiey as these may alter the hydrodynamics within the system resulting in siltation and increased water turbidity.
- Littering of construction waste and accidental spillage to the marine environment (considered as a negligible impact given precautions were taken)
- Physical damage to the reef from equipment mobilization (considered as a minor adverse impact)
- Direct alteration of the lagoon bottom by facilitating mooring and harbour areas. (considered as a minor adverse impact given precautions were taken)

6.2.1 Coastal Structures

Structures such as jetties and coastal defense structure can involve coastal modification leading to alteration of current regime that may facilitate increased siltation that would have a negative impact on the reef system.

Siltation on coral reefs have been found to have detrimental chronic and acute impacts on coral reef system depending on various factors such as present status, geomorphological characteristics, climatic and weather conditions, magnitude of the work and precautionary measures taken.

Siltation and excessive sedimentation can smother and kill corals and reduce coral recruitment by reducing suitable substrate area of the reef for coral recruitment. Intense siltation can cut down light availability to benthic organisms including corals which require light for growth.

6.2.2 Construction materials and waste

Transportation of construction materials such as cement, aggregate and sand to the site has the potential to aesthetically damage the marine environment especially the lagoon areas due to accidental spillage. Accidental disposal of construction wastes have too often occurred especially during transportation and transfer work. Quite often construction wastes get their way into the marine environment during the course of their disposal unless necessary measures taken to avoid this happening. Pollution of the sea can be caused by water borne and windblown debris escaping from construction site.

Wastes and residue arising from construction activities such as oil spills and other wastes may effect the terrestrial environment. Dumping of construction debris or remains of earth works or temporary waste mounds on or nears scrubby vegetation could destroy them easily. Hence, strict measures need to be considered on deposition and monitoring of the refuse as well as other materials produced during the construction phase. Haphazard deposition of waste could destroy several habitats and microhabitats that are crucial for the dynamic island environment.

6.2.3 Mobilization of Equipment and Labour

Mobilization of heavy equipment such as barges to the site has the potential to physically damage some areas of the reef. Increased activities of larger vessels to supply the construction

materials will also have direct and indirect damage to the reef through anchoring, waste from these vessels as well as accidental oil spills in some instances.

Influx of workers to the island would inevitably have negative impacts on the terrestrial environment. Lack of awareness or concern to preserve the environment may lead to deliberate or inadvertent damages to the trees in order speed up their work. Disposal of hazardous waste and sewage may be a concern if not appropriately dealt with. If proper attention is not paid such a large number of workers in the island could easily disturb the island fauna.

6.2.4 Impacts on Terrestrial Fauna

In the absence of adequate data on the faunal species of Kudahithi it would not be appropriate to draw conclusions on detailed impacts on the fauna. However, general impacts could be identified through experience in such activities. Generally, any clearing of vegetation will either displace or eliminate certain animals since their habitats are destroyed. Amongst the most effected would be bird species using the island. The clearings combined with heavy machinery operation may temporarily force them to look for alternative sites.

6.2.5 Effects on Groundwater Quality

The construction and development of the island is not expected to have major impact on the groundwater. However, pollution of groundwater aquifer needs to be seriously considered. During the constructional phase oil, paint or other chemicals will need to be handled properly. Mishandling of fuel has led to serious pollution of groundwater aquifer in Malé. There have also been reports of spilled oil near temporary generator sets setup during other resort construction projects. This sort of pollution may sometimes have long-term irreversible effects since such contamination does not degrade itself and is expensive to clean up.

Impacts to groundwater during the construction phase include extraction of ground water, storage, use and transport of oil for development activities and excavation works that require dewatering. Excavation can also expose ground water and the deeper sections of the soil to more harmful contaminants such as oils and hydrocarbons that may contaminate the land from vehicles and other machineries used during the construction. Therefore, in this regard, groundwater is likely to be affected in the following manner.

- Use of machinery and equipments has the potential to contaminate the land.
- Excavation and withdrawal of ground water especially around the periphery of the island will increase the likelihood of “up-coning” of the water lens below any given point, thereby allowing salt water intrusion.

Groundwater pollution can also occur as a result of poorly designed and poorly addressed wastewater treatment systems. Leaking systems such as septic tanks will create accumulative pollution of the soil, enabling sewage to go septic in time.

6.3 Operational Impacts

Possible environmental impacts from the operational phase of the proposed development are limited to a relatively few activities, however, would be long-term impacts as experienced in most other similar resort islands which include:

- Beach nourishment and other coastal improvements (minor adverse if appropriate design criteria were met)
- Sewage and wastewater disposal (considered as a minor adverse impact given proposed mitigation measures are taken)
- Solid wastes generated from the resort operation (considered as a minor adverse impact given proposed mitigation measures were taken)
- Hypersaline brine disposal from desalination plant (considered as a negligible impact).

- Wastes from supply boats and transfer vessels and boat-induced damage (considered as a minor adverse impact given proposed mitigation measures were taken)
- Recreational diver and snorkeller impacts on the reef system (considered as a negligible impact if appropriate measures were in place)
- Recreational reef fishing (considered as a minor adverse impact given mitigation measures were taken)

6.3.1 Sewage and Wastewater Disposal

Impacts of sewage and waste water pollution depend on amount discharged, level of treatment before discharging, the degree of natural flushing by currents and point of discharge. Presently septic tanks system is used on the island. It is proposed that an outfall will be developed as part of the redevelopment.

Groundwater pollution due to improper disposal of sewage has been observed in islands across the Maldives. It can also occur as a result of poorly designed and poorly constructed sewerage systems. Leaking sewerage lines and septic tanks will create accumulative pollution of the soil, enabling sewage to go septic in time. This in turn will lead to the formation and accumulation in the aquifer of hazardous gases such as hydrogen sulphide (commonly known as sewer gas). Therefore, proper design and maintenance of the sewerage system that will be installed in Kudahithi is essential to reduce or minimize severe environmental health impacts.

6.3.2 Waste Disposal

Kudahithi will have a Solid Waste Management Plan. As solid wastes will be incinerated on site and the rest of non-combustible matter taken away from the island to Thilafushi island for disposal, they will not have a significant impact on the immediate environment of the island.

Tourists resorts normally tend produce a lot of waste. This is probably due to luxurious nature of its operations. If mismanaged, this issue has the potential to create a number of various environmental issues. Hence Kudahithi plans to reduce the impact of solid waste management to a minimal.

6.3.3 Energy Generation

Kudahithi will generate electricity at 400 volt, 3-phase, 50 Hz via 2 x 40KVA 1 x 50 KVA. The 400-volt supply will be distributed throughout the island install. A small-scale installation such as this would meet all international emission standards since larger scale installations such as that in Malé meet appropriate emission standards.

Poor handling and management of diesel and other fuel has, in many resorts, often lead to contamination of the aquifer. This is of serious concern and must be emphasized in the developmental process. Moreover, improper handling of fuel could result in accidents and mishaps such as fires, which had caused major damages in the past.

6.3.4 Water Consumption

Desalination will be the major source of fresh water for the resort. Kudahithi will install a reverse osmosis desalination plant to cater for the water needs of the resort. Operation of the desalination plant will result in generation of brine as waste. In general, salt concentrations above those of receiving waters can impact the receiving body under different circumstance (seawater salt concentration is about 35,000 ppm; desalination plants discharge brine with 46,000 to 80,000 ppm). However, brine discharge will take place to a large water body (sea), a lot of dilution will take place and the impact of brine will be nearly negligible. Environmental impacts of brine discharge are therefore very little and pose negligible risk due to long distance between outfall and reef and the relatively limited quantities of brine in comparison to the volume of the receiving water. The location of discharge will be in such to allow maximum dilution to take place.

6.3.5 Replenishment of the eroded beach

The replenishment of the eroded beach will undertake by using sand pumped from the lagoon eastern side of the island. Beach erosion is a major environmental issue facing the island. Even at present, several large trees have been lost due to erosion.

Beach replenishment will be undertaken on eastern and western side of the island. Therefore the lagoon in this area will be directly impacted due to complete alteration of the lagoon bottom and spreading of sediment plumes from the filling material. Approximately 600m² of the lagoon will be directly impacted during filling period.

With this, there is the possibility of increased sedimentation in the lagoon. If the work is carried out in south west monsoon, then the impact of sedimentation will be felt mostly on the western side of the island reducing the chance of impacting on the coral reef which is located on northern side of the island.

Beach replenishment and filling is usually associated with the direct and permanent alteration of the fill area and indirect impacts resulting due to sedimentation. Turbidity increase is almost an unavoidable consequence but can be minimized. In general, the following impacts will be felt.

- Turbidity increase in the water column from spreading of silt plumes. When lagoon floor is disturbed by filling, fine sediment and silt may be released into the water column.
- Lagoon sediments consisting of varying sizes of particles may be suspended for hours in the water column cutting down light to photosynthetic reef benthos. The magnitude of this impact will depend on various factors such as size of particles; hydrodynamic conditions; and reef and lagoon topography. In addition to this many infauna and their habitats will be lost.
- Possible siltation and excessive sedimentation in the lagoon system
- Excessive sedimentation and siltation on coral reefs is detrimental to corals and other reef benthic organisms as it cuts down necessary light and physically smothers corals. It is not expected that the beach replenishment will have an impact on the coral reef system of the island

Long-term ecological impact arising from the proposed work activities is not predicted to be significant as the proposed work is limited and localized in a small part of the island system. However, long-term monitoring is required to identify ecological impacts more completely and thoroughly.

6.4 Summary matrix of the impacts, their significance and characterization

Impact indicator	Impact type (NEG or POS) +	Significant (H/M/L)*	Direct	Indirect	Magnitude # (N/M/MA/MoA/MaA)	Short term	Long term	Unavoidable	Reversible	Irreversible	Cumulative	Mitigation Required
Demolition of existing buildings and removal of the concreter columns	Neg	M	X	X	M	X			X			X
Coastal structures (refurbishment of jetties)	POS	M	X	X	M	X	X	X		X		X
Construction materials and waste	Neg	L	x		N	X		X	X	-	-	X
Undertake beach replenishment	POS	M	X	X	M	X	X	X	X			X
Refurbishment of the groyns and sea walls	POS	M	X	X	M	X	X	X		X		X
Mobilization of equipment and labour	Neg	L	X	X	M	x		x	x			x
Impacts on terrestrial fauna	Neg	L	x	x	M	x		x	x			x
Groundwater quality	Neg	L	X	x	M	x	X	x	X		X	X
Sewage and waste water disposal	Neg	M	X	x	N	x	X		X		X	X
Energy generation	Neg	L	X	x	M	x	X	x	X		X	X
Water consumption	Neg	L		x	N	x			X			X

+ POS = positive impacts,
NEG= negative impacts

* H=high, M=Moderate,
L=Low

N=Negligible, M=Minor, MA=Minor Adverse; MoA= Moderate adverse; MaA=Major Adverse

7 Mitigation Plan

If identified impacts are significant and/or important, it is necessary to identify and implement mitigation measures. Mitigation measures are selected to reduce or eliminate the severity of any predicted adverse environmental effects and improve the overall environmental performance and acceptability of the project. Where mitigation is deemed appropriate, the proponent should strive to act upon effects, in the following order of priority, to:

- Eliminate or avoid adverse effects, where reasonably achievable.
- Reduce adverse effects to the lowest reasonably achievable level.
- Regulate adverse effects to an acceptable level, or to an acceptable time period.
- Create other beneficial effects to partially or fully substitute for, or counter-balance, adverse effects.

7.1 Mitigation Options

Possible mitigation options include:

- Design alterations (e.g., different locations for sewage outfalls, jetties, etc.)
- Work method alterations (e.g. changes in construction scheduling to reduce sedimentation)
- Provision of environmental protection and health and safety equipment (e.g., noise mufflers, pollution abatement equipment)
- Changes in management practices (e.g., staff training, recycling waste by-products instead of landfilling, public awareness)
- Changes in operation (e.g. organized group excursions, specific times for meals, buffets).

7.2 Mitigating Constructional Impacts

7.2.1 Pre-planning

Early planning is one of the most important steps in reducing and eliminating any adverse impact on the environment from the proposed project. Environmental concerns should be considered concurrently with technical and economic planning of the development and precautions should be applied from the outset of the planning process through all phases of development of the proposed project.

An environmental firm that has experienced in same or similar work in the local environment should be consulted and allowed to inspect and monitor the development work activities throughout the whole construction as well as the operation phases. Coordination and communication among the environmental firm, the contractor and the client is vital to minimize adverse impacts on the environment from construction phase.

Sedimentation and siltation resulting from the proposed work activity should be minimized by using appropriate techniques such as use of silt screens and other appropriate retention features to reduce spreading of sediment and silt plumes to the lagoon floor and the reef system.

Jetties should be located and oriented such that hydrodynamics of the system is least altered to minimize any possible siltation and turbidity problems resulting from alteration of local hydrodynamics.

Outfalls such as outlet of desalination plant, waste water from kitchen, and sewage, should be located furthest from the sea bathing areas and oriented such that natural dilution by currents will be maximum. These outfalls should be taken over the reef edge out of the lagoon area into the open water. The opening of these outfalls should be at a depth not less than 5m below the surface during lowest tide. It is most appropriate to conceal and firmly fix these pipelines in the lagoon floor so that rupture and leakage is avoided. It has been found that in many resorts these pipelines were damaged and effluent leaking in the shallow lagoon areas.

Septic tanks and initial filtration tanks should be located furthest from freshwater wells. During pipe laying, waste water from restaurant, kitchen, shower water from bathrooms and effluent from laundries should be led to a separate storage tank to reduce overall water volume to septic system to prevent overload.

Littering, accidental disposal and spillage of any construction wastes should be avoided by pre-planning ways of their transportation and unloading to the island. Careful planning of the work activities can also reduce the amount of waste generated.

In case heavy equipment and vessels such as barges and cranes are to be mobilized closer to the reef, care should be taken to avoid accidents and damage to the reef.

Awareness raising of project managers and labourers on environmental friendly practices in all the work activities should be encouraged to minimize any possible negative impact on the environment.

Construction work activities should be completed within as short period as possible to avoid chronic impacts on the marine environment from construction work activities such as mobilization of heavy equipment and activities that involve disturbing the lagoon floor.

7.2.2 Island Fauna and Flora

The resort management is determined to redevelop Kudahithi as an environment friendly resort along the lines of eco-tourism. Hence a number of measures are in place to preserve the island flora as much as possible during the construction phase and to improve on it by planting new trees during the operational phase. Following are measures already devised by the developer to minimize the impact on the flora of Kudahithi.

- Felling of trees will be kept to an absolute minimum. Larger trees will be preserved unless absolutely necessary to be felled. The island is redeveloped with only very minimal guest room in the island. Most of the guest rooms are located on the lagoon as luxury exclusive water villas. Therefore the erection of rooms will not hinder the terrestrial ecosystem in anyway.
- Only the sites of building and footpaths will be cleared for construction purposes and removal of scrubs and shrubs will be limited to the minimum extent required. The existing clearing inside the island will remain.
- No soil, fertilizers or plants will be imported in order to protect the local vegetation from the introduction of diseases.
- Plants and trees that have to be removed form construction sites will be used for landscaping and filling other areas of the island.
- Use of pesticides and herbicides will be avoided as much as possible. If absolutely necessary it would be used in consultation with Ministry of Fisheries, Agriculture and Marine Resources.
- Footpaths created would avoid felling trees and will be kept narrow to avoid clearing vegetation.
- A comprehensive plan is in place for landscaping and to maintain the existing flora during the operation phase.

7.2.3 Temporary Workforce

Temporary workstations, workforce and initial construction activities can generate considerable amounts of environmental impacts. As workforce and their activities generate the initial effects on the terrestrial environment, their activities require appropriate supervision and proper management. Most of the initial environmental impacts must be appropriately handled, as such impacts can become serious in the future. Therefore, every effort shall be made to ensure that technically competent personnel supervise activities of workforce throughout the construction.

One of the most important aspects as outlined in the environmental impacts that may seriously generate from the workforce is sewage disposal mechanism. It will be very important to ensure that coastal waters and ground water must not get contaminated with raw sewage. An effective mechanism of appropriately disposing sewage will be laid by sanitary toilet systems with septic tanks prior to initiation of all mass construction activities. Also, possibilities of installing a sewage treatment plant at the outset of the project shall be looked into in order to avoid problems related with sewage from workforce during the construction phase.

No waste of any kind to the slightest possibility will be either disposed or dumped into the marine environment; rather, all the waste generated from constructions will be categorically stored and transported to Thilafushi Island. Reusable waste from several construction activities will be effectively reused in order to reduce and minimise waste content. Domestic waste such as food items together with leaf litter and other organic materials will be collected and disposed to Thilafushi as well.

Supervisions must be carried out during land clearings as no area shall be cleared if it is not absolutely necessary for the constructional purposes.

Oil handling and management procedures will be made known to all relevant staff and mismanagement will be fined. Regular monitoring of the groundwater aquifer will ensure that the aquifer is protected from spills.

Extra care should be taken to prevent spillage and dumping of oil on the ground.

Appropriate waste disposal and sewage treatments should be installed before the workforce arrive on the island. A waste collection site needs to be established in order to contain the waste generated by the workforce.

In order to minimize any such impacts on the environment strict supervision of work is essential.

7.2.4 Beach Nourishment

The most important mitigation measure is to control sedimentation as it is the main factor that can cause the greatest impact on the coral reef. Hence, most of the mitigation measures proposed are centered around reducing sedimentation. More specifically the following measures will help to reduce the impacts.

- Working during low tide hours.
- Creating a bund wall around the fill area initially and then filling inside this bund using excavated material. The existing sand cement bags could be used as this bund wall. The bund will be removed after the beach replenishment work.
- Completing the filling works in the shortest possible time period.
- Only replenish the required area of the beach
- Using coarse dredge material to make the bund rather than fines.

7.3 Mitigating Operational Impacts

7.3.1 Coastal structures

The Ministry of Tourism does not encourage hard engineering solutions such as heavy breakwater structures, groynes, solid jetties, seawalls and revetments on tourist resorts of the Maldives for the genuine reason that the geographical attributes, which makes the islands of the Maldives a special place for tourists, are protected and preserved. Therefore, soft engineering solutions must be sought wherever possible. Existing jetties will be used during the construction stage, which will avoid construction of temporary jetties and other solid structures.

7.3.2 Waste Management

The following waste management procedures are proposed by the developer to ensure minimum environmental impact from solid wastes in Kudahithi.

- An incinerator will be installed on the island.
- Packaging of all imported supplies and materials will be controlled to ensure that the majority of items will be either organically degradable or recycled through the plant. Other materials would be incinerated or shipped to the waste management site in Thilafushi regularly.
- Organic waste from kitchen and toilets will be processed by means of anaerobic digestion, which will ensure that the process is odourless and that the resultant sludge can be used (odourless) for improving the quality of the soil on the island.

Waste management system would be established to handle wastes generated from the resort. Awareness programme should be conducted for managers, staff and the guests about various problems of wastes and how to reduce them. Wastes taken out from the resort for disposal in the designated areas should be monitored to make sure that they reach the designated site of disposal. Wastes should be handled with care during loading, unloading and transportation to make sure that, no wastes enter the marine environment.

7.3.3 Energy Generation

Impact of energy generation in Kudahithi is planned to be reduced through the following measures.

- Use of natural lighting and ventilation by new and improved design.
- Provision of space cooling will be minimized by architectural design providing wherever possible public spaces with cross ventilation and the use of terrace spaces will be maximized.
- All external terrace, road and pathway lights will be photovoltaic, self-contained fittings, which charge an internal battery during daylight hours to then power the light fitting overnight.
- Hot water will be produced using solar water heaters. Solar water heating may also be supplemented, if needed, by heat recovery from the generator sets.
- The power plant is proposed to be built in the utilities area in order to reduce noise nuisance to guests. The plant will also be built with noise insulation baffle walls and gensets will be placed on anti-vibration mounts. Hearing protection gear will be provided to those working in high noise environments.
- Energy conservation awareness messages and notices will be placed at strategic points
- Staff at the power house and other fuel handling areas will be made aware of the need to observe care in handling diesel and waste lube oil or similar products.
- All fuel handling areas will be covered with protective flooring to protect waste and leaking oil from seeping into the ground.
- Diesel fuel will be stored in a fuel storage tank located near the generators
- Main fuel tank will be well constructed and bunded.
- Staff training and continued motivation will be provided for efficient utility use.

7.3.4 Other energy conservation measures include:

- implementing devices to reduce street light energy consumption late at night;
- using energy saving lights throughout the resort;
- using a master switch near the door to allow lighting to be turned off if no one is in the room.
- installing meters to monitor fuel consumption, thereby allowing for the analysis of effectiveness
- ensuring good practices such as operating washing machines and dishwashers at full load, guests and staff awareness on conservation and waste minimization.
- using efficient and well maintained boats and vessels for transportation
- planning transportation to avoid vessels to have to travel ‘empty’, conserving fuel and energy

7.3.5 Mitigating the impacts on groundwater

Current tourism regulations require resorts to protect and conserve their groundwater. Groundwater has only recently been regarded as a potential environmental feature that needs to be carefully managed. Following are some measures that will be undertaken to protect the groundwater

- Groundwater extraction will be limited and carefully planned to ensure that contamination do not occur.
- Water for laundry and cleaning will be desalinated water produced within the resort.
- Use of desalination to relieve the burden on groundwater.
- Oils spills and leaks from chemicals will contaminate the ground water. Therefore special emphasis will be given to store, handle and transport chemicals and oils in the resort to avoid contamination of the soil and hence the groundwater.
- Solid waste management practices can also influence the groundwater which is why solid waste management will be a key environmental aspect which the resort operations will consider. Waste management will be done using a combination of methods such as incineration, recycling, deep sea dumping and off site disposal.

7.3.6 Water Production and Consumption

Water production will ensure cost-effectiveness and environment friendliness. The following measures are planned to mitigate the negative impact of water production, its use and other related impacts.

- Desalinated water will be used to supply most of the water requirements of Kudahithi. Brine or waste water from the plant will be disposed into the sea, away from coral reef.
- Use of mechanical taps throughout the resort
- Low flush shower heads shall be used
- Water efficient machinery shall be used in the laundry and kitchen
- Awareness programmes for staff and guests on conservation of water.
- Biodegradable detergents and agents will be used for all cleaning purposes (sanitary installments, bungalows, kitchen, laundry etc.) in order to facilitate wastewater treatment and minimize the impact of such agents on the environment.

7.3.7 Mitigation of impacts on marine environment

Early planning is the key to minimize the impacts on the marine and coastal environment from the proposed redevelopment at Kudahithi. If environmental concerns are considered concurrently with technical and logistical planning of the proposed work and precautions are applied from the outset of the planning process it will not be difficult to mitigate and minimize any adverse impact on the environment.

In all development projects, it is essential to identify possible impacts to the natural environment and suggest best possible ways of minimising or overcoming those impacts. In this regard, there are a number of mitigation measures that can be taken to minimise the impacts on the marine environment identified in the previous section of this report. Therefore, it is important to take the following mitigation measures to minimize the impacts form the proposed redevelopment at Kudahithi.

They are:

1. The proposed redevelopment should be completed in as short period as possible and the work should be carried out during outward drift of current so that sediment settling on the reef would be minimised. Therefore, it is important to carryout the work during southwest monsoon It is best to carry out the work during low tide and in calm whether conditions to minimise spread of sediment plume.

2. Vessels and equipment used for the work should be properly maintained at all times during the operation.

3. The project manager, and the work force involved during the operation of the work should be briefed of environment friendly practices.

4. The work should be properly supervised and monitored to minimise any adverse effect on the environment.

5. Sedimentation and siltation resulting from the proposed work activity should be minimised by using appropriate techniques such as enclosed sand bags and other appropriate retention features to reduce spreading of sediment and silt plumes to the lagoon floor and the reef system.

6. The marine environment should be monitored for sedimentation stress and possible impacts on the biological aspects such as bottom benthos.

7. Littering and accidental disposal of any construction wastes can be avoided by pre-planning modalities for waste disposal or re-use wherever possible. Careful planning of the work activities can also reduce the amount of waste generated.

8. In case heavy equipment and vessels are to be mobilized closer to the reef care should be taken to avoid accidents and damage to the reef.

8 Alternatives

EIA Regulation requires two alternatives to be suggested for such developments and therefore two alternatives have been suggested in addition to the no project alternative. These alternatives are discussed below:

No Project Option

The no project option takes the following into account.

- The resort will be operated with its existing infrastructure.
- No additional infrastructures/services are introduced, therefore, price cannot change and profit margin will decrease year by year

The main advantages and disadvantages of these are given in Table 7.

Table 7: Advantages and disadvantages of the no project option

Strategy	Advantages	Disadvantages
Allow the resort to be operated with the present infrastructure	Environmental problems related to additional development can be avoided No upgrading costs to the Proponent, short term benefit	With the existing infrastructure, the resort can only be marketed to certain markets. Target clientele cannot be diversified.
Existing guest rooms would be left as it is.	Environmental problems related construction of new water villas can be avoided No upgrading costs to the Proponent, short term benefit	Profit cannot be increased. Modifying the existing water villas would be more costly, as most of them are not specially designed to suit the current market.

8.1 Design Alternatives

During the EIA process, few alternatives were considered, mainly for the refurbishment of the existing jetties and undertaking beach nourishment.

8.1.1 Alternative methods to protect the beach

There are a number of options for shore protection on the western and eastern side of the island. The suitable options are emerged breakwater and artificial reef

8.1.1.1 Emerged breakwater

The emerged breakwaters were popular coastal protection features in the resorts. However, the emerged breakwater has an aesthetic impact that had become unpopular in the resorts. The emerged breakwater functions like a submerged breakwater but these are designed to prevent overtopping of waves and keep the lee side of it calm.

8.1.1.2 Artificial reef

Artificial reefs on the western, northern and eastern side would be similar to submerged breakwater in terms of design but with a greater base and lower crest. Since the western side is the sandy lagoon area, creating an artificial reef using submerged structures similar to “reef balls” or similar substrate may be useful.

8.1.1.3 Continuous Re-nourishment of the beach

Re-nourishment would be an ongoing process, but the proposed coastal protection measures such as the groyne field and the breakwaters would help to minimize the frequency of re-nourishment. It is estimated that re-nourishment may be required every three to five years.

8.2 Corals recovered from demolition waste

An alternative to reusing the coral rubble that would be recovered from the waste stream is to destroy the corals completely so that it cannot be further reused or transport it to the landfill at Thilafushi.

Destroying the coral rubble that had already been collected from the demolition waste stream can be done in several ways, all of which would not be of any particular benefit to the environment.

It is not guaranteed that even if recovered corals are transported to Thilafushi that it would be destroyed. It is most likely that these corals will be picked by an scavenger at Thilafushi and sold in the market.

9 Stakeholder Consultations

For the purpose of this project, statkeholder consultations were limited to relevant government agencies, the proponent and the designer / Architects. As the project is a redevelopment of an existing resort, these key stake holders were identified relevant to undertake public consultations. Methodology for undertaking these discussions was through interviews and discussions.

9.1 Consultation with the proponent

In general, discussions were held with the proponent to obtain information about the need for this redevelopment and to justify the project. The major outcome of these consultations is outlined below.

- Though the island can be developed as a 7 room resort, the developer wishes to develop one bungalow.
- The development on the island has been planed as to bring a very premium product into the Coco Collection resort brand
- The develop is interested to develop the island by blending into the natural environment of the island

9.2 Consultation with long term staff

Long term staff working in the resort was also consulted to obtain their views on the development. The following are the main outcomes

- The island faces erosion on western side of the island. Existing coastal defense structures are functioning well. The sand pit on western side of the island shifts in two monsoon
- Upgrading will definitely be good for the resort as the market segment is changing rapidly.

9.3 Consultations with the Ministry of Tourism, Arts and Culture

Consultations were held with official of Ministry of Tourism, Arts and Culture. Following are the main outcome.

- This project has been approved by the ministry including all the concepts.
- The Ministry is generally very positive about introducing very premium products.

9.4 Consultations with Ministry of Housing, Transport and Environment

Consultations were held with Mr. Mohamed Zahir, Director General at the Ministry. Following are the main outcome.

- All the development in the tourism industry would have to do EIA before the project is given approval.
- EPA is the main institution which overseas the EIA work under the Ministry
- The redevelopment shall refrain from the removal of any trees and importation of trees from other island shall be undertaken accordance with the regulation under the Ministry.
- Environment Ministry's interest lies in protection of the environment at the same time allowing development to take place. This means, that developer should implement all mitigation measures and also undertake regular monitoring.
- New developments need to take into consideration the goals outlined in the new Third National Environment Action Plan and the National Sustainable Development Strategy. The development shall try to aim to reduce the carbon emission. Reduction of carbon emission from private sector would help to achieve the carbon neutral policy of the government.

9.5 Consultations with project team

Consultations were held with Mr. Adam Nasser. Following are the main outcome.

- The new concept for the development taking into consideration the development, only on land.
- The island has lost a considerable amount of beach on western side and eastern side of the island. Bringing back the beach shall be an aim of the redevelopment as the beach is the main theme of Maldivian resorts.
- There is a great need to complete the resort at the earliest in order to make this property a profitable one. The project is planned as to open the resort for business by next winter season.
- Feels that this development is considerably small as most of the infrastructure has already been constructed.

9.6 Consultation with the Marine Biologist

Consultations were held with Ms. Verena Wiesbauer. Following are the main outcome.

- Attention shall be given to the protection of the marine environment during the construction stage of the development. Marine environment could be impacted, during the construction phase, when workers are not properly educated. hence, creating awareness to the workers, through an orientation, could help to minimise the impact on the marine environment
- Marine environment would be protected, if proper attention is given. Creating a post for resident marine biologist would help to create awareness of the staff and guest, during the operation stage, on protecting the marine environment.

List of persons consulted

Following are the names and designation of persons consulted.

Name	Designation	Office
Mr. Mohamed Adhlee	Assistant Director	Ministry of Tourism, Arts and Culture
Mr. Mohamed Zahir	Director-General	Ministry of Housing, Transport and Environment
Mr. Ibrahim Naeem	Director	Environmental Protection Agency
Shah	Caretaker	Kudahithi
Mr. Shaugee	Assitant Resident Manageer	Boduhithi
Ms. Verena Wiesbauer	Marine Biologist	Water Solutions
Mr. Adam Naseer	Project Manager	Sunland
Mr. Hussain Hilmy	Director	Sunland Hotels

10 Environmental Management and Monitoring

10.1 Introduction

Environmental monitoring is essential to ensure that potential impacts are minimized and to mitigate unanticipated impacts. Monitoring will be carried out as part of the environmental impact assessment and monitoring requirements addressed in this EIA report.

10.2 Cost of Monitoring

The proponent has committed fully for the monitoring programme outlined in this report. The cost indicated below is for monitoring the project during the construction stage and for an additional two years during the operational stage. Monitoring will be undertaken by subcontracting the work to an independent consultant or a consulting firm.

10.3 Aspects of monitoring

Monitoring will include marine aspects and coastal aspects only. Summary monitoring reports will be provided every three months and final report will be provided at the end of the construction stage and will adhere to Schedule M of the EIA Regulations, 2007.

10.4 Methods of monitoring

Environmental monitoring will be undertaken using standard methods described in the Methodology section. Monitoring is only recommended for marine and coastal environment.

Table 8: Aspects of the environmental monitoring program with cost breakdown

Monitoring Attribute	Indicator	Methodology	Monitoring Frequency	Estimated Cost (construction and operational phase for 2 years) (US$)
Marine water visibility in the lagoon	Visibility	Secchi Disc & Tow line distance	Every 3 month	No cost. Contractor to undertake this during construction period.
Coral cover at survey sites	Percentage live cover	Qualitative & Quantitative	Once during the construction stage. Once a year thereafter	3,000 per quarter
Marine water quality	suspended solids, pH, temp , COD, DO, Salinity, turbidity, nitrates, phosphates,	Onsite or Lab analysis	Twice a year	250 per quarter
Siltation	Sediment deposited on reef substrate	Qualitative & Quantitative	Every 3 month	No cost. Contractor to undertake this.
Beach profiles	Changes to the beach	Using auto level	Every 3 months after construction	750 per quarter
Currents	Changes to the current	Using drogues	Every 4 months after construction	500 per quarter

Table 9: Detail cost of monitoring during construction period and for two years.

DESCRIPTION	UNIT COST (US$)	TOTAL (US$)
Logistics		
Transport	Client to provide	
Food, accommodation and logistics	Client to provide	
Survey costs		
Cost of undertaking the environmental surveys during the project construction stage and operational stage		10,000.00
Report writing and submission to EPA		3,000.00
Sub Total		13,000.00
30 % contingency		3,900.00
Grand total for monitoring during construction stage		16,900.00

10.5 Monitoring responsibility

Monitoring responsibility will be with the client and financial provisions will be made in the project to undertake the monitoring.

10.6 Monitoring Report

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

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12 Declaration of the consultants

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

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

Name: Ahmed Jameel (EIA 07/07)

Signature:

Name: Abdul Aleem (EIA 09/07)

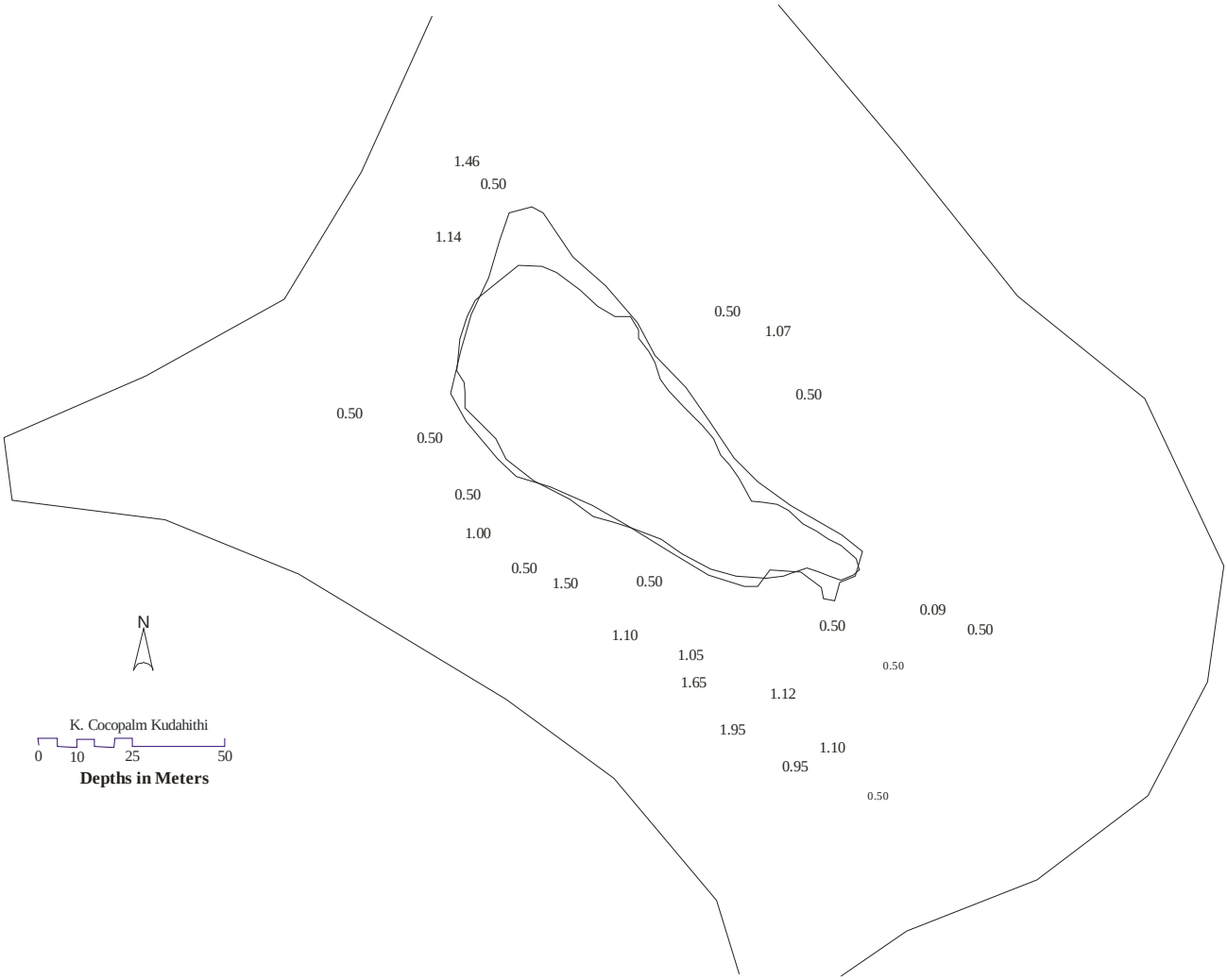
Signature:

13 Commitment from the proponent

14 Annex: Terms of reference

15 Annex: Proposed Master plane of the resort

16 Annex: Bathymetry of the lagoon



17 Annex: Beach profiles and their locations

Bench Mark	Mark Type	Coordinates
BM1	Bench Mark	4°25'.033" N 73°22.811" E
BM2	Bench Mark	4°25'.014" N 73°22.834" E
1	Beach Profile 1	4°25'.026" N 73°22.802" E
2	Beach Profile 2	4°24'.898" N 73°22.841" E
3	Beach Profile 3	4°25'.012" N 73°22.842" E
4	Beach Profile 4	4°25'.046" N 73°22.814" E
5	Beach Profile 5	4°25'.053" N 73°22.792" E

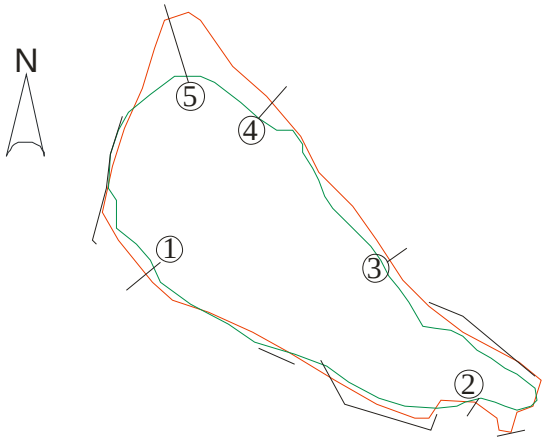
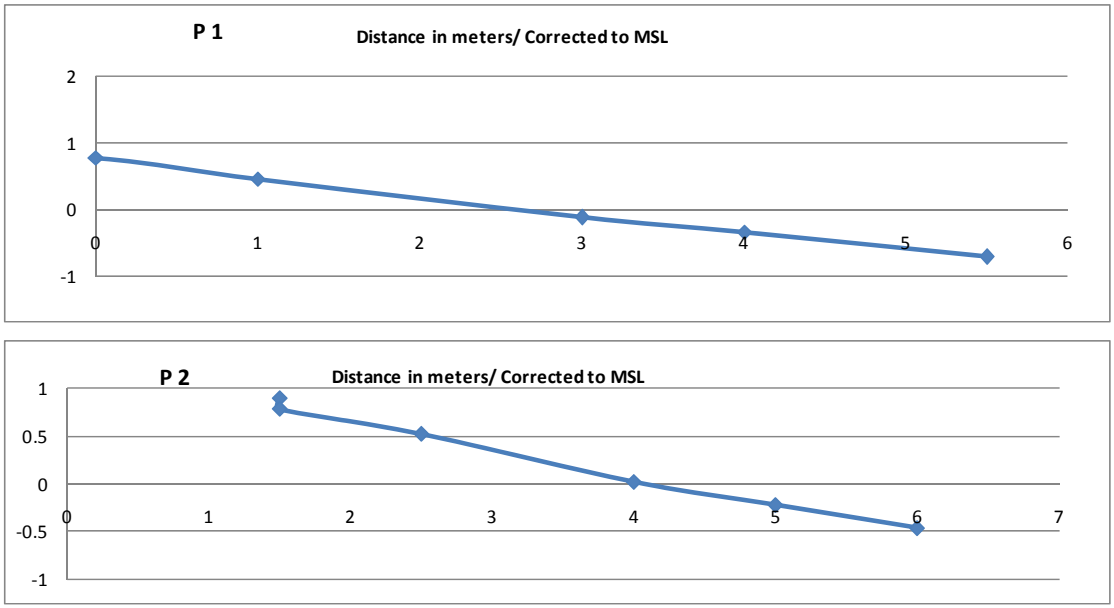
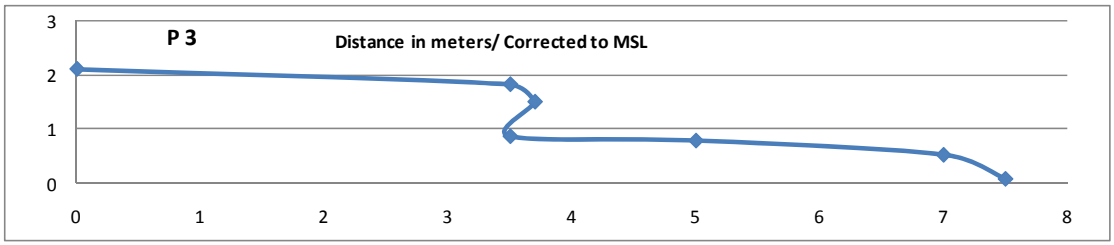
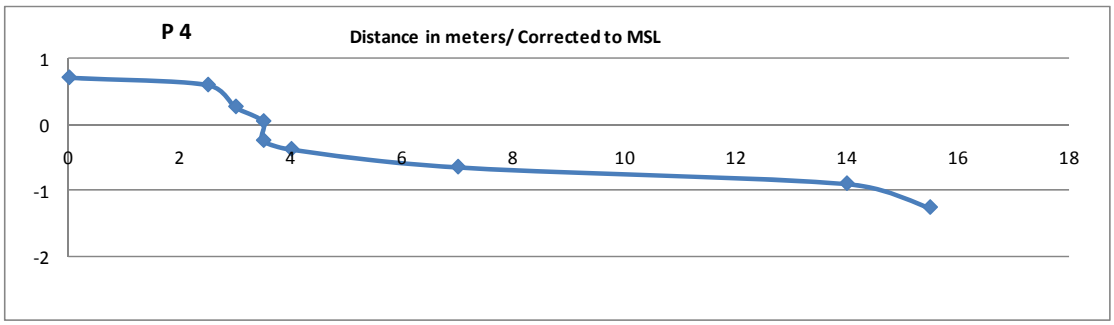


Figure 14: Beach Profiled locations




P 3
Distance in meters/ Corrected to MSL
3
2
1
0
0
1
2
3
4
5
6
7
8


P 4
Distance in meters/ Corrected to MSL
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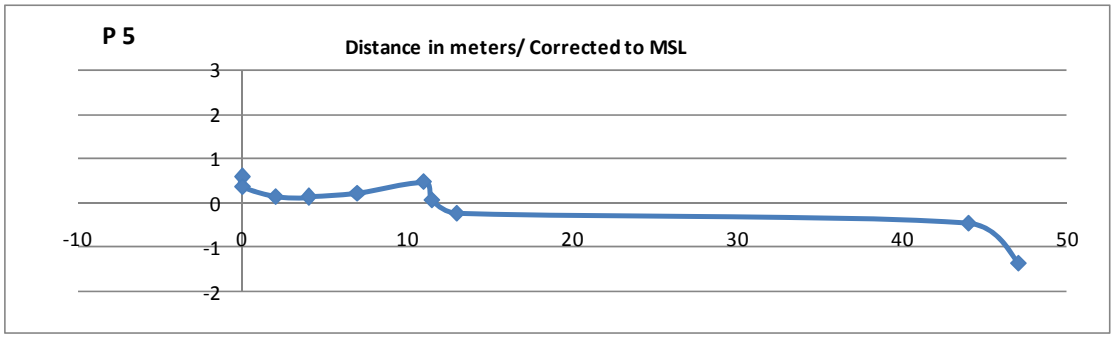
0
-1
-2
0
2
4
6
8
10
12
14
16
18


P 5
Distance in meters/ Corrected to MSL
3
2
1
0
-1
-2
-10
0
10
20
30
40
50