

# **Environmental Impact Assessment**

## **for the Proposed Development of Ekulhivaru, Noonu Atoll, as a Premium Tourist Resort**



**April 2010**

**Proponent:**

The Ritz-Carlton International  
ENA Hotel Holding Company Pvt. Ltd  
Maldives Tourism Development Cooperation



**Prepared by:**

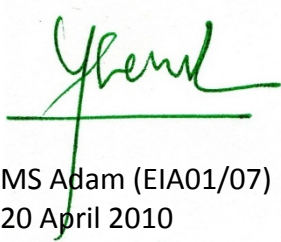
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## List of Acronyms

MoTAC	Ministry of Tourism, Arts and Culture
EPPA	Environmental Protection and Preservation Act
EPA	Environmental Protection Agency
EIA	Environmental Impact Assessment
MTDC	Maldives Tourism Development Cooperation
MHTE	Ministry Housing Transport and Environment
MoFA	Ministry of Fisheries and Agriculture
NHL	National Health Laboratory (of Maldives Food & Drug Authority)
MFDA	Maldives Food and Drug Authority
MoH	Ministry of Health
UNCLOS	United National Convention of Law of the Sea
CZMC	Coastal Zone Management Centre (of SAARC)
NCPE	National Commission for the Protection of the Environment
NDP	National Development Plan
GPS	Global Positioning System
MEMP	Maldives Environment Management Project
AECP	Atoll Ecosystem Conservation Project (GEF / WB supported)

## Declaration of the Consultant

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



MS Adam (EIA01/07)  
20 April 2010

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# 1. Non-Technical Summary

1. The purpose of this EIA is to fulfill the obligations of the proponent to undertake EIA under Clause 5 of the Environmental Protection and Preservation Act (Law # 4/93) of the Maldives and the requirements of Maldives Tourism Regulation. This EIA establishes the current state of the existing environment where the development takes place. All the activities of the development and operation are evaluated for their environmental impacts, positive or negative. Corrective and remedial measures are suggested on how to reverse or improve the predicted impacts and maintain the overall quality of the environment.
2. Ekuhivaru is located in Noonu Atoll about 10-12 km west of inhabited islands of Hembadhoo and Kendhikulhudhoo and 22 km east from Holhudhoo. Closest tourist resorts to Ekuhivaru are Dholhiyadhoo in Shaviyani Atoll, to the north and Kudafunafaru in Noonu Atoll to the south. Both are resorts in the development stage. Ekuhivaru has been leased to MTDC for developing a tourist resort. MTDC is developing the island in partnership with The Ritz Carlton and Berjaya Corporation Berhad, Malaysia.
3. The objective of the project is to develop the island of Ekuhivaru as a premier high end tourist resort – **The Ritz-Carlton Reserve**. The main features of the built environment are 55 beach villas around the periphery of the island and 35 overwater villas, built in three clusters, on the shallow sandy lagoon. In addition specialty restaurants, spa with treatment rooms and full back-of-the house facilities will be constructed on the island.
4. The construction of the resort will follow international standards with the project supervisors based at site. Sustainable 'green' building techniques and material will be applied wherever possible to limit the environmental impact of the development.
5. National and global environmental policy issues, have strong bearings on development of resorts on coral reefs in the Maldives. Legislation affecting tourism development and the institutional matters relating to tourism and environment are highlighted. The project will be developed in accordance with the guidelines and regulations relating to tourism in the Maldives. The developers will establish links to international efforts to conserve coral reef biodiversity by contributing to government efforts in environmental management.
6. The Baseline conditions of the existing environment were investigated by established scientific methods and field surveys. The components of the environment that may be affected by the project were identified and baseline assessments were made with a view to monitor these components so that potential impacts can be mitigated. Coral cover, fish fauna, terrestrial

flora and fauna, beach and nearshore marine habitats were assessed and surveyed.

7. The island of Ekuhivaru was in pristine environmental condition at the time of the survey. The vegetation of the island was thick and lush green dominated by bushy tropical plants and trees. Coconut palms grew only on the eastern half on the island and were sparse. The island has extensive sandy beaches around it with intact beach vegetation and pollution free waters. Beaches were dominant at the western periphery of the island. Extensive beach erosion was observed at the east end of the island. Coral cover on the reef slope and reef flat was moderate to low and appears to be recovering from recent disturbances. All reef habitats were abundant in young coral colonies with high diversity. Major coral types are described. Beds of the coral *Helipora sp* were found at the western shallow lagoon area. Fish life was abundant and detailed fish lists are provided. Turtles nested on the island beaches as noted by the nests and tracks observed during field assessments.
8. By carefully assessing and examining the condition of the coral reef habitats and the terrestrial environment, and after considering the project inputs and activities, environmental impacts resulting from this development was predicted and described. The most significant environmental impact resulting from the project would be the opening of a reef entrance and the deepening of the arrival jetty area lagoon to create a harbor basin. Impacts resulting from these activities are described and mitigations are proposed. Most of the impacts resulting from the construction stages and operational stages are low to medium in nature and can be mitigated with careful planning. Opening of the channel and entrance and deepening activities were found to be irreversible, but justified for a resort of this standard. Experience from other resort developments show that these impacts can be managed and an ecological balance can be achieved in time.
9. Environmental impacts that are inevitable would include loss of some bottom biota (coral and invertebrates in particular), altered bathymetry, sediment re-suspension and the potential for prolonged turbid conditions at least seasonally in the short to medium term. It is proposed to undertake practical and sensible mitigation measures to minimize those impacts. These include undertaking excavation work during maximum tidal flushing, use of bund walls and making use of a landing craft for transporting excavated material to the beach and strict supervision of the work at all times. Medium to long term impact of this change would lead to changes in bathymetry that would potentially alter the sediment dynamics in the immediate lagoon areas.
10. Mitigation measures are considered and presented for each impact causing activity of the project. Production of water, power and waste management activities will proceed in accordance with government standards and guidelines and commitments are made to achieve the highest environmental standards in the operational stages of the resort.

11. The proponent is fully committed to undertaking the mitigation measures proposed in this report and bear costs of the monitoring activities during construction and operational phase. The monitoring necessary for environmental mitigation has been laid out and their frequencies are presented. The proponent is committed to oversee and implement the monitoring programme and will allocate required finances for the activities proposed. The main monitoring activities will be those relating to coral reef health, water quality and changes in sediment dynamics and its effects on the beach profiles.

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## 2. Introduction

Ekulhivaru is a small sized island located on the south eastern section of the natural Thiladhunmathi-Miladhunmadulu Atoll. Administratively the island is assigned to Noonu Atoll and in more recent geographic demarcation in the North Province. Inhabited island of Hembadhoo and Kendhikulhudhoo lie on the east of the island at 9 and 12 km of distance respectively. Two inhabited islands, namely Holhudhoo and Velidhoo lie 21 and 31 km to the southwest respectively. The small size of the island and its shallow sandy lagoon with expansive beaches has been the attractive feature of this island in selecting for resort development. The island was leased to the Maldives Tourism Development Corporation (MTDC) in 2007. The Ritz-Carlton (incorporated in the USA) and Berjaya Berhad (incorporated in Malaysia) together with the MTDC has an arrangement for developing this tropical island for a luxury tourist resort.

This report presents the Environmental Impact Assessment (EIA) which is part of the legal requirements that need to be fulfilled for major development projects as per the 2007 EIA Regulation drawn under Environment Law (# 4/93), Environmental Protection and Preservation Act (EPAA), of the Maldives. The EIA report is based on The Project Concept developed in parallel to the environmental impact assessments and will be submitted to the Ministry of Tourism Arts and Culture (MoTAC).

The report is based on field observations on marine and terrestrial environment of the island. These assessment form the “baseline conditions” of the island on which the likely environmental change due to project development and operation will be evaluated. The assessments were also based on expert judgment of the consultants who have undertaken several EIA studies for resort development in the Maldives.

The proposed development on Ekulhivaru involves features that are common to all new resort island developments in the Maldives. The relatively large and shallow sandy lagoon around the island would be left untouched except for the developments for the entrance, a small harbor basin, service jetty and guest arrival area. Such development in the lagoon will be unavoidable in uninhabited islands like Ekulhivaru.

A main feature of the development would be 35 over-water villas in three clusters (eastern and north western section of the reef flat) and the 55 beach-villas on the perimeter of the island. The development dubbed as The Ritz-Carlton Reserve boasts ‘a luxurious tropical getaway where impeccable service and attention to detail meets barefoot luxury’<sup>1</sup>. The island is planned to be developed with minimum impacts on its environment. It is estimated that the planned developments on the island will be completed within 18 – 24 months.

This assessment reports on the environmental impacts related to the development of Ekulhivaru as a resort hotel. Impacts associated with this type of developments

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<sup>1</sup> Description provided in the Project Concept by the proponent.

are multiple and cumulative and in some cases can lead to consequent and often irreversible damage to the environment. Such impacts, however, can be mitigated by proper planning and understanding of the baseline environmental conditions of the island and its reef and aligning development with the environment. The parallel development of the concept for the island and environmental assessment is expected to achieve this desired development goal<sup>2</sup>.

The various developments that have been proposed under the Ritz-Carlton Reserve development are described in detail in the section on 'Project Description' below. Mitigation and remedial measures are proposed for potential impacts resulting from these developments for which regular monitoring programmes are proposed.

The procedures adopted for the assessment described herein was to conduct extensive field surveys of the environmental components (hydrographic conditions, marine and terrestrial ecosystems) of the whole reef of Ekulhivaru. This approach was achieved by rapid assessments of the entire perimeter of the reef complemented by detailed surveys of selected habitats where detail description of corals and fish community were given.

The methodology used for this assessment report are provided in detail in the following sections and all raw data collected for the report including marine, terrestrial and beach dynamics data are appended to the report. The report is structured as per guidelines for EIA reports set by the MHTE:

1. The introductory section describes the project, its salient features and procedures and extent of the EIA report. This information was supplied by the developers.
2. The justification of the project is given as per policies and strategies set out in Governments Strategic Action Programme (SAP)<sup>3</sup> and other relevant planning documents.
3. Policy issues and details of relevant legislation applicable to the development and current environmental policies pertaining to resort developments in the Maldives are described in Section 4.
4. The existing environment presents a comprehensive description of the baseline conditions of the natural environment of Ekulhivaru Island and reef. The descriptions are based on the field data and qualitative assessments.
5. The section on impact prediction and analysis is based on detailed studies of the project activities which may cause impacts. The likely impacts and mitigation measures are discussed. Specific activities of the project causing environmental impacts were identified and their interactions with the environmental components were evaluated.

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<sup>2</sup> Two preliminary reports were submitted to the Concept Development Team of the Ritz-Carlton Reserve. The first was submitted in April 2008 and the second one in September 2008.

<sup>3</sup> "Anehi Divehi Raajje", The Strategic Action Programme, National Framework for Development 2009-2013, The Government of Maldives, 528 pages.

6. The projects activities causing greatest impacts to the environment are identified and, alternatives are discussed.
7. Finally a monitoring plan is provided for both terrestrial and marine environmental components. Emphasis is laid on monitoring those components of the environment which would continue to have high levels of residual impacts as a direct result of project activities. It is important that all monitoring be evaluated against the base line data that have been gathered for this report.

## **2.1 Project Justification**

The development of Ekulhivaru as a tourist resort is part of a strategic planning and policy decision by the Government of Maldives through MoTAC. It represents part of an overall development plan to establish tourism in all the atolls of the Maldives and to extend the benefits of tourism to island communities in the country. In order to achieve this goal the Government formed a public limited company called the Maldives Tourism Development Corporation (MTDC) and allocated a number of uninhabited islands for tourism development. A large proportion of the share of the MTDC is owned by the public. Ekulhivaru is one of the islands selected for development by the MTDC.

Ekulhivaru was to be developed as a 90 key seven star-plus resort by Berjaya Berhad in association with The Ritz-Carlton and MTDC. The island is located in North Province under the new administrative re-organization. Although slightly isolated, resort development on Ekulhivaru will benefit the island communities in Noonu and adjacent Atolls. Two densely populated islands of Holhudhoo and Velidhoo are not far away with great potential to benefit from spin-off economic activities related to development and operation of the resort. Similarly the islands on the east, like Manadhoo and Landhoo are also dynamic communities that would benefit from development of Ekulhivaru. Employment opportunities are likely to be available and the communities will benefit directly both during the construction and operation of the Ekulhivaru Island Resort.

## **2.2 Aims and Objectives of the EIA**

The report addresses environment and development of Ekulhivaru as a tourist resort. The content and coverage of the report adheres to the officially approved terms of reference (Appendix 2) and focuses on descriptions of the existing environment and significant impacts from the development on the existing environment both during construction and operation of the resort. The impacts and the proposed mitigation measures will prevent and in most cases minimize adverse the environmental impacts and enhance the overall development of the project.

The EIA process allows environmental issues to be addressed in timely manner and in a cost-effective way during the project design, preparation and implementation.

The EIA process can also help to reduce the overall project cost, assist in completing the project on schedule and help design the project in a manner acceptable to all stakeholders. Since the project takes place on ecologically sensitive environment, this EIA will help the stakeholders to make an environmentally sound decisions and ensure less damage to the environment and minimize future costs of mitigation.

From the perspective of the proponent the main objective of the EIA is to fulfill the obligations of the proponent to undertake EIA under Clause 5 of the EPPA of the Maldives and requirements of Maldives Tourism Regulation. In doing so, the EIA establishes qualitative and quantitative values upon the existing environment with the perspective that the future generations will be benefitted from the information and that many appreciate the concerns of the existing generations of their share of the environment. Furthermore, the EIA will also emphasize the need for the present generations to be responsible for their actions and to minimize the burden they place on the environment.

## **2.2 Scope of the EIA**

The EIA covers environmental impacts arising from development and operation of the activities as described in the project activities. At the scoping meeting the activities of the project were discussed and scope of the EIA was adopted.

It was agreed that activities that need to be addressed in the report are activities that are likely to cause most significant environmental impact. These included the proposed channel opening and associated deepening of arrival jetty area and the activities during the construction phase. Most notably these are the clearing of the vegetation for the buildings, construction of the jetties (and pile system) for the over-water structures (bungalows, restaurant and spa-complex). Their impacts and mitigations are addressed in detail.

In general, the report will examine the existing environmental components of the project that would be affected from the proposed works and consider the positive and negative impacts of the proposed works and provide possible remedial measures.

Alternatives are discussed including alternatives for disposal of the dredged material, alternatives for excavation or deepening methods. A monitoring programme would be suggested, which will be subject to change at the time of submission of the complete EIA for rest of the development works. The official TOR as discussed and agreed at the scoping meeting is attached as Appendix 2

## **2.3 Methodologies**

The approach or the methodologies for undertaking environmental assessments are many and are the subject of several text books and published articles. In the Maldives, a certain short cut version has been informally adopted for tourist resort developments. Maldives does not follow proper strategic environmental

assessments for large development projects whereby, if followed, would involve stakeholder consultations, particularly the public (the communities), even at the island selection stage.

The procedure followed in this EIA has been the 'normal practice' in the Maldives for resort development projects. The methodologies rely effectively on expert opinion and judgment by the consultant and field experts. In fact most EIA methodologies, qualitative or quantitative rely on expert judgment, based on the experience of registered and licensed EIA consultants supported by field data gathered within a very short time frame (often in a single visit of 2-3 days maximum) immediately prior to the development works. EIA relating to tourism development has been the most common assessment and so a large number of reports are available in public domain.

This EIA is based on marine and terrestrial data collected during three different visits to the site, each lasting 2 days. The first trip was made in April 2008, the second during September 2008 and more recently in April 2010. During the first visit the team consisted of a coral reef expert, a marine biologist and three field assistants, and surveyors.

Conditions of the existing environment were assessed using appropriate scientific methods. The data collection methods are described in Section 5. Coastal surveys, beach profiles, and reef surveys (manta tows and photo quadrats) were undertaken. In addition data from previous EIA reports and other similar EIA were used to aid in assessing the impacts of the proposed activities. Additionally impacts were predicted based on experience gained by the consultants in similar type of projects in the Maldives.

### 3. Project Description

#### 3.1 The Proponent

The proponent of the project is The Ritz-Carlton (established in USA), Berjaya Berhad (Malaysia) and MTDC (Maldives).

The Ritz-Carlton is a world famous luxury hotel chain, now present in over 24 countries employing over 38,000 staff and has the greatest luxury hotel brand recognition in the world. The Travel + Leisure has recently included 33 Ritz-Carlton properties in their Top 500 Hotels in the world and Conde Nast listed 38 Ritz-Carlton Hotels in their 2005 Gold List. The Luxury Institute has ranked the brand at the top of the Luxury Brand Value Index and the groups such as JD Power and Consumer Reports consistently rank Ritz-Carlton as offering the highest level of customer satisfaction, value, service upkeep, and problem resolution. While Ritz-Carlton does not, itself, operate a loyalty programme Marriott International's Marriott Rewards program is one of the world's largest and this resort expects to be one the biggest beneficiaries as members seek to utilize their points.

Berjaya Land Berhad is a premier resort developer in Asia. The group has developed a number of resorts and timeshare vacation homes primarily in Malaysia and Asia Pacific. Presently the group manages over 15 Berjaya hotel properties in Asia Pacific and Europe. From the exotic island resort of Tioman, Langkawi and Redang to the cities of Kuala Lumpur and Penang to the highlands of Malaysia, Berjaya Hotels and Resort's prominence in Malaysia is further enhanced by the establishment of international hotels and resorts in Singapore, Seychelles, Sri Lanka and London.

Maldives Tourism Development Corporation PLC was established in 2006 with the objective of the distributing the tourism income to the Maldivian public at large. A large percentage of its share is owned by the public. Fifteen islands have been leased to the MTDC for development. In the first 2 years, MTDC made handsome profits and large proportion was paid out to the shareholders. The share value of MTDC rose significantly in the first few years, but dropped recently. Current value of MTDC share is about Rf 150<sup>4</sup>

#### 3.2 Project Location

Ekulhivaru is located in Noonu Atoll. Approximate geographic coordinates of the island is 5°57' N; 73°18.4'E. The closest inhabited islands are Hembadhoo and Kendhikulhu on the east. It is about 200 km north of capital Malé, some 30 minutes by the sea-plan. The island has its own 'house-reef' which is oval shape (see below). The island is located nearly centre of the reef occupying just under a third of the total reef area. There is no deep *vilu*, instead a soft sandy lagoon exist round the island with isolated patches of the coral. The demarcation between the lagoon and the reef flat is distinct. Isolated patches of corals are present both in the lagoon and

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<sup>4</sup> Information from Maldives Stock Exchange, accessed April 2010.

on reef flat area. The coral growth is well developed in the western side of the island.



Figure 1: Project location (red circle) in the North Province with inhabited islands.

### 3.3 Development Concept of the Ritz-Carlton Reserve<sup>5</sup>

The Ritz-Carlton, Maldives Reserve is a remote, secluded and intimate resort where impeccable service and attention to detail meets barefoot luxury. The aura of the resort is one of casual yet sophisticated elegance, with a crisp, contemporary feel. Here, guests are welcome to be themselves, at ease in their dress and their surroundings. The design of the resort conveys a “sense of place” through the use of indigenous building materials and techniques such as thatched roofing and the generous use of woods, creating a physical and emotional connection to the local style. All wood is teak or other species that is able to withstand high humidity such as tadi, sagwan, padauk, or balau, and is heavily hand carved in the traditional Maldivian fashion. All wood is a medium reddish-brown colour with an oiled or sealed finish. While the guest should never feel uncomfortable due to “culture shock,” they should likewise never forget that they are away from home and staying in the lush, exotic Maldives Islands.

<sup>5</sup> The Project Concept was supplied by the developer. It is incorporated as an extended version without any change or editing.

**Sustainable Design:** Sustainable or “green” building techniques and materials are employed whenever possible to limit the resort’s impact on the local ecosystem and the larger environment as a whole. While the sustainable design of the resort may be visible to the guests, in no way should it diminish the luxury experience. All guests will experience a sense that they are in a place that is sensitive to the environment and respectful of its delicate importance.

**Public Space and Arrival:** Guests arrive via sea plane at the dedicated guest arrival jetty. From the moment they arrive, guests are swept away to the casual and relaxing world that is the Ritz-Carlton, Maldives. The arrival experience has a very local feel and employs traditional Maldivian rituals and customs, while at the same time setting the stage for a luxurious stay, thus easing the guest into their authentic vacation experience. Their luggage is unloaded from the plane and delivered to the each private villa ahead of the guests. Guests are then shuttled to their villa by electric cart which will meet them at the end of the jetty.

Although guests are taken directly to their villa from the arrival jetty, they may choose to stop at the centrally located Reception Lobby. As the heart of the island, immediately upon entering the lobby, they are greeted with a spectacular and unobstructed view of the ocean beyond. The Reception Lobby and Lobby Lounge is a very open building with a thatched roof and minimal enclosed walls, thus allowing the ocean breezes and the sound of rustling palm trees to permeate through the space. Like the rest of the resort, the space is casual, with a generous use of local woods, stone and other materials. Guests may choose to lounge on the patio on Oversized indoor/outdoor couches or inside the lobby lounge on the comfortable yet sophisticated chaises arranged in multiple intimate seating groups. Guests may choose to browse in the high-end logo and sundries shop. Alternately, guests can meet with a concierge at one of the two seated reception/concierge desks. During the day, the atmosphere of the Lobby Lounge is bright, airy and fresh, with cool lighting and fabrics supporting this feel. But it is during the evening when the mood changes, allowing for both quiet, romantic rendezvous and animated, social gatherings. Music is always playing, but the volume and tempo adjusts to match the time of day and mood; at night live music may be provided to create a lively yet sophisticated “lounge” atmosphere. As always, food and drinks will available to all guests in the lobby lounge.

**Food and Beverage Outlets:** In addition to the Lobby Lounge, the island offers several food and beverage options, thus allowing for various unique dining experiences during each guest’s stay. Centrally located near the Reception Lobby is the casual three-meal restaurant with an Italian Mediterranean concept. Folding or sliding walls allow for multiple separate rooms to be partitioned off depending on the number of guests at any meal. The three-meal provides a three segment breakfast buffet, an open indoor kitchen as well as ample outdoor open and covered seating. Like the rest of the buildings on the island, the restaurant is open and airy, allowing for unobstructed views of the ocean and enjoyment of the soft ocean breezes.

The island also features two additional restaurants of a smaller capacity for lunch and dinner service only, located at more remote, secluded areas. These restaurants are destinations with specialty themes, with a design that is both respectful of the local area as well as the specific theme.

The first specialty restaurant is the Seafood Grill, located directly on the beach. It is open on all sides and surrounded by a generous wood and stone deck. There is a variety of seating options where guests can choose to sit indoors, undercover, on the deck beneath the open sky or directly on the beach. Here guests will choose their fresh seafood from a tank or bed of ice and it will be weighed and grilled in the open kitchen.

Set back deeper in the resort is the Thai Restaurant. Like the Seafood Grill, it is open and airy but with a modern and clean, yet elegant, Thai-inspired décor. Although it is set deep in the dense jungle heart of the island, the restaurant is slightly elevated to provide selective view corridors through the forest to the ocean beyond. Although more upscale than the Seafood Grill, the restaurant is elegant yet casual, with a Bistro-style atmosphere. Guests may also wish to spend the afternoon at the Viking Culinary Centre, where they can prepare and enjoy a gourmet meal with the help of an experienced chef.

During the day, guests may choose to dine at the pool bar. Although all drinks and food items are available to all guests anywhere around the pool, they may choose to sit at one of the cosy teak tables on the local, natural stone patio around the bar, where they will be protected from the sun by a simple thatched roof. Here guests are afforded beautiful views of the ocean during their casual meals. The pool bar and grill is very open, as if the guests are sitting under nothing more than a light, thatched palm roof. The pool provides a beautiful backdrop, and the light sounds of a water feature create a soothing yet lively atmosphere.

Finally, guests may chose to spend their evenings in the Ritz-Carlton Sunset bar. The Sunset bar is located in a dedicated pavilion over the water on the west side of the island. It is at the Sunset Bar that guests enjoy dramatic, unobstructed views of the sunset each evening. Here, guests may choose to sip a cocktail while watching the falling sun, enjoy light fare from the kitchen or dine on sushi from the sushi bar. The pavilion is dark and romantic, lit with low lighting and candles so as to not distract from the drama and romance of the sunset. As it is anticipated that most guests will arrive before sunset and leave after dark, the shifting of the lighting from day to night is a very important part of establishing the scene; the changing of the lighting scheme, including the lighting of candles and lanterns, may be incorporated as part of a daily performance. The pavilion is accessed by a dedicated walkway that is lit by low, dramatic lighting, reflecting off the shallow water below; the walkway appears to float over the water. Guests may also return to the Sunset Bar after dinner for star-gazing. Open terraces or areas on the beach with large double day beds with an abundance of pillows will be part of the seating. At night, the Sunset Bar transforms into a lively evening nightclub with fire pits and lounges on the beach, and ample lounge seating in the pavilion.

**Guest Amenities and Function Space:** The spa at the Ritz-Carlton, Maldives will be a luxurious tropical getaway. Located near the beach, the spa concept could be based on an ocean theme; its inherent beauty in its infinite variations.

A winding and private path leads to the spa, with quiet discoveries built into landscape along the way: a small stone carving, a bright fall of colourful flowers, a bridge over a stream. Passing through a carved wooden door frame, the opening leads to a more manicured but natural garden that gives an obvious sense of privacy. The path changes to smooth white stone, and a pair of carved wood doors opens into the spa reception.

Framed in the doorway to the spa reception is the ocean, at a distance, so that its presence is always felt. The spa reception is a cool space with smooth walls with exposed wood structure at the ceiling. There are no hard corners here; all the corridors will be sinuously curved to be reminiscent of the shapes of shells and the ocean, as well as to fit the contours of the land and beach. Lighting is provided by silk-covered lanterns suspended along one side of the corridor. There are also spaces between some of the treatment rooms that allow for operable full-height windows along the corridor at intervals to give glimpses of the ocean or a garden, and to allow natural light in during the day.

Each treatment room will have smooth stucco walls, painted the subtle colour that evokes a peaceful feeling, exposed wood structure at the ceiling, and stucco painted a deeper colour on the ceiling. Floors are smooth wide wood planks. Most treatment rooms will open to the ocean by means of full height sliding glass windows, offering an extended wood planked terrace for outdoor treatments or relaxation. Each terrace would be shielded from adjacent terraces by traditional stone walls and lush gardens planted on each side. A low chaise and side table would be the only permanent furnishings, so the view is not impeded. Shade would be provided by loosely billowing white shade fabric suspended on steel wires that could be opened or closed, and privacy from the beach by ephemeral curtains of the same fabric.

The treatment room itself features a central organic-shaped bath that is white stucco on the outside with a contrasting iridescent finish on the inside with white blossoms floating on the scented water. It is located just at the outside wall, so that if the guest wants the room open it gives the same feel as having an outdoor bath. Gardens are brought inward on one side of the room. The treatment table is immediately behind the tub, so that one may look over it to the ocean. Service areas in each room are hidden behind pierced wood sliding panels. Each room has its own shower and toilet and changing area, closed off by pierced wood sliding panels.

The couples' treatment rooms are over-water, expanded versions of the standard treatment room, with private sun terraces and ocean steps. There is a large lounge room in addition, with a huge daybed covered with pillows.

In both men's and ladies' areas, there is a chambered hammam finished in iridescent glass mosaic tile that evokes the ocean theme. Each experience shower is curvilinear for privacy rather than having doors, and will offer tropical rain, snow mist, and multiple body sprays. Locker areas are small but luxurious, since each treatment has its own changing area.

The yoga studio is tucked between the two couples' treatment rooms, over water, with stunning ocean views to infinity through full height operable doors that can open the room to the ocean breezes.

The fitness centre is tangential to the spa and has state of the art equipment in a traditional stone wall and thatched roof structure.

The resort also provides two large, sleek and sophisticated pools with infinity edges and dark linings that blur the distinction between pool and ocean. At one end of the pool is an area that is shallow enough to accommodate chairs and small tables. Here guests may lounge in ankle-deep water while sipping cocktails. The pool is surrounded in decking of local stone with crisp, simple details that do not compete with the beautiful simplicity of the pool. Water features are used extensively, but simply and with sophistication, being used to create a slight rippling of water or a faint trickling sound. Surrounding the pool are private cabanas with flowing, white canopies, ample additional shade structures and large lounge beds and chaise lounges. There are multiple fire pits on the stone deck. In all, the pool is a peaceful, sophisticated area where guests can relax and feel completely at ease.

Nestled in the centre of the island are two lighted tennis courts with a small toilet and service pavilion, which are designed so that they may be tented and used for functions if necessary. Guests may also choose to visit the arrival jetty, which houses the dive centre and other water recreation activities.

The only additional function space is a simple open-air pavilion. As this pavilion is mostly used for weddings, it is located near the beach in a private location yet easily accessible by staff and convenient to food preparation areas. The design of the wedding pavilion is simple and clean, with an exposed wood ceiling, thatched roof and authentic native carvings in the wood structure.

**Guest Villas:** Scattered around the island and over the water are the 90 private Guest Villas. Although there are two distinct types, each of the villas has the same open, casual yet luxurious feel. They are all as open as much as possible, allowing the ocean breezes to flow freely throughout. Each villa provides a separate service entry and is conveniently located near one of several butler's pantries.

The Beach Villas are located on land with direct access to the beach. Each villa is surrounded with as much natural vegetation as possible to provide the utmost in privacy. The feel of the space is open and airy; the line between inside and outside is blurred. Thatched roof and stucco walled structures form the villas themselves,

while the feature privacy walls for the gardens and perimeters are the traditional stone walls. A carved wooden door provides security and privacy for the garden, which contains an outdoor shower and bathing pool with carved stone coping. Thoughtful landscape lighting makes the garden and terrace a romantic and appealing evening retreat.

Once inside, virtually all walls facing the sea and into your own garden are wood framed sliding glass panels so that one can open the villa as much as desired to the outside. Cool polished cream stone floors with area rugs, stucco walls, and exposed wood structure ceiling which soars to 14' high combine to enhance the luxury of space in each villa.

The bed is central in the room, giving it an ocean view, with a half wall behind it where desk and minibar credenzas are located. There is lounge seating to one side. A large flat-screen TV resides atop a custom corner cabinet that is also an open bookcase designed to hold the DVD player, books, DVDs, board games for rainy afternoons. Sheer linen draperies, mounted in a ceiling pocket, and sliding wood shutters provide either privacy or black-out at each window wall.

The bathroom is extremely large and memorable. On a raised platform, a large free-standing tub for two stands. The wall behind it is large bevelled mirrored panels to bring as much of the outside in as possible. On either side is a wide granite vanity with a vessel lavatory; a wood shelf below holds rolled towels. One side has the room for the water closet and bidet, along with a wardrobe containing all wood built-in drawers, luggage storage and safe. The other side has the large shower with overhead rain showerhead, multiple body sprays, two hand-held showers, and a built-in bench. The shower walls and floor are clad in a beautiful and luxurious material. A sliding enamelled metal frame glass door leads to the outdoor shower, also clad in the material with multiple body sprays and dual hand-held showers.

The stone floor of the guest room extends directly out to the patio to the infinity-edge plunge pool and teak chaise lounges and dining table. At night, the lighting is soft, low and romantic.

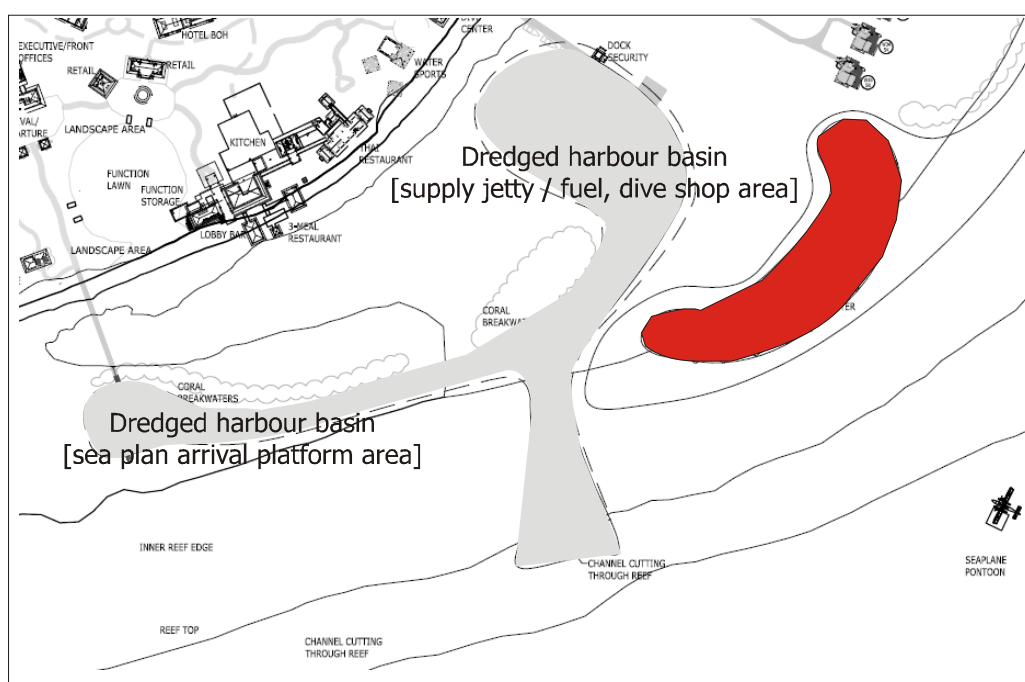
Over-water villas are accessible by a boardwalk over the water, and each villa is built on stilts over the water. Like the Beach Villas, they all have natural thatched roofs and local stone floors. The over-water villas have similar interiors to the beach villas, but the lack of gardens is compensated by the private ocean access. Unlike most over-water villas, however, these are designed more like the architecture of the cultures that influenced the Maldives, with an internal courtyard, ensuring absolute privacy. The courtyard here becomes the terrace and ocean access in the centre of a U-shaped villa. The villa has glass on all walls of the courtyard as well as the two ends facing the ocean. The upgraded villas have small infinity-edge pool, appearing to hover over the water. Each over-water villa also has a small roof-top terrace for star-gazing or sunbathing.

**Landscaping:** Landscaping will be minimal and natural. As many trees as possible will be kept to retain as much privacy as possible between villas. At public buildings, planting should be sensitive to the local environment and consistent with local culture and horticultural philosophies. Plantings should be informal and appear natural. Like many Maldivian resorts, the guest paths will be of crushed shell, while the employee maintenance paths will be of a more durable material.

### 3.4. Project Activities – Development Phase

#### 3.4.1. Clearing of Channel Entrance and Deepening of Harbour.

One of the most important project activity identified in the Scoping Meeting was channel clearance and harbour deepening works. The island has not been used for commercial activities and so there is no proper entrance channel to the lagoon. One narrow pass has been cleared on the western side through the thick growth of blue coral *Helipora* sp. The other has almost a natural entrance, a slightly deeper area, exists on the south eastern end. Here the lagoon is also slightly deeper.



*Figure 2: Proposed harbour basin and the breakwater. The total area for the harbour basin including channel is 30,000 sq m where the area proposed for the breakwater is 8,000 sq m.*

Taking into consideration of the views of the community, and based on the information that was provided by us to the design team, it has been decided that harbour basin would be located on south eastern side of the island (Figure 2). The decision was made after a series of consultation and field visits by the design team and their engineers. This choice will:

- a) have minimum impact to the reef because the area is also the deepest in the lagoon and therefore volume required for removal is minimal.
- b) ensure that harbour is located in the most protected side (see existing environmental conditions)
- c) allow the effective use of the dredged material for beach nourishment works (see below).

The total area, including the channels and the harbour basin that requires deepening is about 30,000 sq m. The depth of the area is 0.3 – 0.6 m and so would require dredge 1.5 – 2.0 meter of material generating roughly 50,000 cubic meters of material.

The entrance of the channel will be widened up to 5-8 m which would require removing coral patches on the path. The most effective method of the doing this work is using a small excavator mounted on shallow draft flat-topped barge. The excavated material is placed on the barge and later transferred to the shore. Alternatively a temporary causeway can be reclaimed as the excavator makes it way to the furthest point. The excavator can then work its way backwards to the coast and loaders and trucks transferring the material back to the coast. Coral removed during the channel opening and harbour deepening activity would be used for seascaping work (see below).

#### **3.4.2. Construction of Breakwater**

The construction of a breakwater to protect the harbour basin has been identified as a necessary development activity. The break water will be placed on the reef flat in the shape of an 'elongated kidney' directly in front of main harbour basin Figure 2. The breakwater covers an area of about 10,000 sq m. The area will be filled by the dredged material and elevated to height of about 1.5 m above the mean sea-level. It is estimated that around 30,000 cubic meters of material would be required for the breakwater works.

Protection and stabilization of the breakwater will be required to maintain the integrity and shape over time. Several choices exist, but depend on the type of material that will be available for infill. If the available material is mainly sand and rubble, a better approach would be to create a rubble mound type breakwater and use large stones and boulder on the sloping faces. The most common type breakwater found in Maldives is entirely built from the coral boulders. For instance, Fullmoon Resort, K. Atoll, has a series of breakwaters constructed from the coral boulders. This however, requires regular maintenance and replenishment of new boulders.

### **3.4.3. Site Clearance and Preparation**

As mentioned earlier, Ekuhivaru is a 'virgin island' and so the vegetation cover is almost 100% except for very small break on the eastern side. For a short period the island was used for agriculture<sup>6</sup>. The evidence, however, is now barely visible. The lay out drawing shows the proposed locations of the buildings (Appendix 3). The vegetation will be removed only from the areas where footprints of the buildings fall. Trees will not be removed unless it is absolutely necessary. In such cases it is recommended to replant the trees in appropriate areas.

Temporary housing and storage space would be required for the labours and for storage of equipment. A possible area for this would be eastern end of the island.

The main shrubs and small flowering trees that require removal will be stored at a site to be designated for replanting later during site landscaping or will be taken to close by island. Cut vegetation will be sent to Thilafushi disposal site or an appropriate site in Baa Atoll for disposal. Burning of vegetation and organic material on the site will not be allowed.

### **3.4.4. Seascaping works**

Examination the existing environmental conditions revealed that there is net erosion on the eastern end and net accretion on the western end. Effectively the island is slowly 'moving' westwards. The exact cause of this effect will be difficult to pin down and beyond the scope of the EIA. However, a plausible explanation is that dynamic equilibrium of the hydraulic regime (forces of sediment movement that causes accretion and erosion) has changed, and probably recently. This issue is elaborated in more detail in the section on Baseline Conditions.

Given the infrastructure on the will be expensive to relocate, at least in the medium term, a way to deal with this issue is to arrest the erosion on the eastern end through soft engineering approaches. In the end, and it has always been the case, such issues has been resolved through trial-and-error interventions. However, in this case, it is proposed to take a long term approach of combined adaptive management measures.

Given the situation the proponent, in the first instance, is proposing a programme of the coral transplanting and growing coral fences on artificial coral tray. Such approaches are beginning to be appreciated as means to coral restoration. In the Four Seasons Landaa Giraavaru, for instance they have grown large areas of corals as approach to control the erosion.

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<sup>6</sup> Hamid, Noonu Holhudhoo, Personal communication, April 2010.



*Figure 3: Sample seascaping works by Seamarc Company in Landaagiraavru, [www.seamarc.gov.mv](http://www.seamarc.gov.mv).*

The proponent will be employing professionals in coral transplanting work as possible in the resort development work. Several areas have been identified for coral transplanting and re-growth. The live coral colonies that would inevitably be removed during the channel opening and harbour deepening works will be used for this work. The overall results of this would be that better control of the erosion would be slowing down the wave energy reaching the beaches.

#### **3.4.5. Landscaping and Terrestrial Habitat**

The detailed design for natural landscaping has not yet been prepared but it should be noted that there is no intention to import exotic plants that have potential to introduce alien species to the environment. Every attempt will be made to utilize native and local plant species in a manner to create a habitat that will support even more diverse fauna on the island and keep the landscaping minimal and natural as possible. The challenge will be to creatively use landscaping as a market differentiator in a competitive industry. Most of the mature trees at the centre will be left intact. In

#### **3.4.6. Excavations and Foundations**

It is anticipated that the likely modes of failure for shallow foundation would be load induced shear failure and/or failure related to vertical or lateral deformation. Therefore, a foundation type that reduces or mitigates the effects of these possibilities will be most appropriate. It is proposed not to use an option that would first require excavation, de-watering and removal of soil so as to avoid creating environmental issues. The types of building foundation(s) to be used have not yet been determined but four options are to be evaluated on the basis of cost and availability of equipment and raw material.

The selected options will be one of those listed below:

a. Driven piles – In this method relatively long, slender columns are installed by impact hammering, vibrating or pushing into the earth. Driven piles can accommodate a wide variety of subsurface conditions. They are comprised of natural materials or pre-manufactured structural shapes built to precise tolerances utilizing high strength materials and reliable quality control. This is an environmentally friendly option as driven pile installations usually produce no spoils for removal and therefore no exposure to, or costly disposal of, potentially hazardous or contaminated materials. The site is thus left clean. The piles may be manufactured on site.

b. Vibrated stone columns – This technique is an economical and environmentally friendly process that treats weak ground to enable it to withstand low to moderate loading conditions. Soils with appreciable silt or clay content do not respond to deep vibratory compaction. To improve these cohesive soil types to allow building and other heavy construction, it is necessary to create stiff reinforcing elements in the soil mass. The stone column technique, also known as vibro-replacement or vibro-displacement, is a ground improvement process where vertical columns of compacted aggregate are formed through the soils to be improved. These columns result in considerable vertical load carrying capacity and improved shear resistance in the soil mass. Stone columns are installed with specialized vibratory probes, generally having a horizontal mode of vibration. Column diameters of 2 to 5 feet can be achieved, depending upon soil conditions and design requirements. The vibrator first penetrates to the required depth by vibration and air or water jetting or by vibration alone. Gravel is then added at the tip of the vibrator and progressive raising and re-penetration of the vibrator results in the gravel being pushed into the surrounding soil. The soil-column matrix results in an overall mass having high shear strength and a low compressibility.

c. Micropiles - Micropiles, also referred to as minipiles or pin piles, are small diameter reinforced piles that are drilled and grouted to support structures. These piles usually utilize some type of steel bar or bars and/or steel casing pipe. The bars are grouted into the ground and/or the casing pipe is filled with grout. The pipes used for micro or minipile installations are in segments that feature threaded lengths that allow them to be fitted together. Because the pipes are inserted one at a time in lengths of three to four feet, drilled installation methods can be used for new construction applications where surrounding structures are sensitive to vibration. The materials used are environmentally safe. The piles would likely be manufactured on site.

d: Beam foundations – This is the most common and probably most cost effective foundation type being adopted in the Maldives. Most buildings on the resort are low rise and single floor and so do not require withstanding heavy loads. Beam foundations however, require excavations along the beams with larger footings at the columns. This would mean some excavations and piling up of sand around the building footprint. For single storey buildings, the practice in the Maldives has been to excavate about 1 – 3 feet for foundation. They are sufficient and are known to last for 20-30 years. Whatever the method chosen by the proponent, measures

must be taken to protect vegetation around the building periphery and avoid removing any tree/shrubs unless it is absolutely necessary.

e: Foundation / Footings for overwater structures: Overwater structures in the Maldives is always built on concrete stilts (or piles) with beam footings. The footings are pre-cast from steel-reinforced concrete on site. The footings are positioned and placed at about 2-3 feet deep (800 mm standard) from the lagoon floor. The columns are normally encased in PVC sheaths and doubles as the form work of the stilt. Stilts are cast *in-situ* on the footings. Overwater structures in most cases are built on shallow sandy lagoons and therefore excavation is not difficult issue. Sand pumps are used to dig the pits, sometime done manually. In situations where boulders and large coral have to be removed excavators may be used. The impacts associated with construction of the overwater structures are discussed in subsequent sections.

#### **3.4.7. Construction system**

The developer is unable to provide the exact information on the construction system at time of this writing, the type of equipment of space that would be required for block production etc. Regular concrete mixer machines will be used to produce the volume of concrete that will be required during construction.

#### **3.4.8. Built Environment**

The main features of the built environments are as follows:

1. Beach Villas: 55 round the periphery average 6.0m apart.
2. Over-water Villas : 35 in three clusters; two on the east and one on NW side
3. Restaurants: 3 (three-meal restaurant, Thai Restaurant, Sea Food Restaurant)
4. Spa with treatment rooms
5. Boutiques and library
6. Administrative offices
7. Staff units x 4
8. Repair maintenance office
9. Buildings for powerhouse, water generation and recycling
10. GM's residence
11. Tennis pavilion
12. Dive Centre
13. Function area
14. Office buildings and arrival hall

The complete layout drawing of the project is attached in Appendix 3 and an indicative project schedule is given in Appendix 5

### **3.4.9. Power Generation and Water Production**

During the development phase a temporary power generation plant will be installed. Since the power requirements will be increasing as the development progresses the proponent is proposing to have works of the permanent powerhouse complete quite early in the project (see below power generation at the operational phase). To this end once the footprints of the all the buildings have been marked out, transmission cables will be laid out. Diesel storage tanks of about 10 x 15,000 litres (10 days of fuel storage) will be required and they will have bund walls as per tourism regulation.

It is proposed that ground water will not be used at any stage of the development or during the operational phase. Therefore and RO plant will be installed and commissioned at very early stages of the construction works. Two RO plants with a capacity of 200 cubic meters per day capacity are proposed. It is proposed that intake will be placed in the southern side and outlet on the northern side. The effect of discharge of brine is unlikely to have a visible impact to the environment. The effects if any would be immediately diluted to insignificant levels by the currents. It is planned to have 660 cubic meters of stored water (equivalent 3 days of use). These will be stored in steel-reinforced concrete tanks.

During the construction stage, rain water will be harvested from every possible roof available. However, many of these roofed-buildings will be dismantled when development work is complete.

### **3.4.10. Sewage and Solid Waste Disposal**

During the construction phase septic tanks will have to be installed on the island. Active pumping will take place at regular intervals where the untreated sewage is pumped out into deep water at discreet times. At this stage, it is not know how many people will be on the island at any given time during the construction phase. But the developer is proposing to install a system that will cater for 600 people. This system will be completely replaced by the Membrane Bio-reactor (MBR) sewage treatment plant.

The MBR is a technology that combines an activated sludge reactor with a membrane filtration unit to purify wastewater. The MBR has several advantages over the conventional activated sludge system. Compactness, production of reusable water, and trouble-free operation (such as bulking problem) make the MBR an ideal process for recycling wastewater where water and space are both limited. The capacity of the proposed MRB system is 176 cubic meter per day

Solid waste would be disposed according to the tourism industry standards using incinerators, compactors and bottle crushers. Food organic waste that is non biodegradable and non-floating may be disposed to the deep atoll sea. Non-biodegradable waste and chemical waste generated from various facilities would be

disposed to Thilafushi Waste Management Site by periodic transport or whenever required.

### **3.5 Project Activities – Operational Phase**

#### **3.5.1 Marine Water Sports and Diving**

The resort will offer the usual suite of water sports including small boat sailing, snorkelling and scuba diving. Water sports will be operated by licensed service providers. It is anticipated that the resort will ensure that guests are well informed about the marine protected areas and that it will encourage adherence to the relevant diving and snorkelling regulations. It is also expected that the resort will use mooring sites for dive boats so as to avoid anchor damage on the reef.

#### **3.5.2 Infrastructure, Utilities and Services**

Water demand, supply and conservation: Using a factor of 300 L/person/day and a guest staff ratio of 1:1.5, at full occupancy, the estimated daily water consumption of the resort is about 220 m<sup>3</sup>, inclusive of the requirements for irrigation of the grounds. The island's groundwater will neither be used for construction nor for the operations. All water will be generated using desalination plants. Resort's water supply will be metered and the water will be stored in RC water storage tanks capacity of 3 days consumption, i.e., 660 m<sup>3</sup>. The tanks for drinking water will be divided into two sections to facilitate cleaning and maintenance and it will be fitted with a chlorinator. A separate tank will store water for fire protection. Water demand will be augmented by the requirements for swimming pools and their associated evaporation losses.

Measures presently being considered to reduce water consumption include:

1. Water pressure booster system used to maintain a constant water pressure which could allow considerable savings of water each day,
2. Efficient hot water delivery system to reduce volume of water wasted while waiting for hot water in the tap,
3. WC cistern with double flushing mechanism (3/6 litres) or flush stop mechanism. Its effectiveness depends on the guest's choice,
4. Taps with flow and temperature restrictors could potentially save up to 20 m<sup>3</sup> per day,
5. Use of treated sewage effluent for irrigation,
6. Water from pool cleaning filters could be reused and mixed with other water in the irrigation tank., and
7. Grey water from taps, tubs and showers could be reused, once filtered and treated, in WC cisterns or for irrigation.

Sewage management: At full occupancy, using a factor of 300 litre/person/day, an estimated 135 m<sup>3</sup> of sewage will be generated on a daily basis. This sewage will be collected and pumped via ducts to the sewage treatment plant. On site, the sewage pipes will be trenched underground with manholes provided at every angle and positioned at almost every 40 meters. Kitchen waste water will be connected to the sewage line after first passing through a grease trap. Given the flat nature of the resort site it may be necessary to install lift stations to pump sewage to the sewer mains.

Electricity demand, supply and conservation: The generator sets run on diesel fuel. This fuel will be stored in a 10x 15,000 litre tank placed above ground and surrounded by a spill-containment wall to retain a volume of at least 1.25 times the volume of the tank.

In order to minimise the use of electrical energy, the resort intends to implement the following:

1. Install fluorescent lighting throughout;
2. a/c controlled with switches on room windows
3. central lighting control system for common areas
4. rooms outfitted with body detectors or card switches

Other energy demand, supply and conservation: The resort intends to use diesel fuel to produce hot water for bathing and sanitation as well as for the stand-by generators and LPG for cooking purposes in the kitchens.

Solid waste management: The total volume of waste generated by the resort is estimated at 3.15 tons per day based on a factor of 7 kg/person/day. This will largely be comprised of organic waste (primarily raw and cooked food waste), and complemented by plastics and glass. The resort will have all the necessary equipments required by MoTAC. Resort will pay particular attention to compost yard wastes and organic wastes that will then be used for gardening and landscaping. The residual wastes will be regularly removed from the resort by garbage dhonis for disposal at the Thilafushi dump operated by Male' Municipality.

Solid waste management machines and equipments: The solid waste management unit at the resort will have all the necessary machines and technologies to effectively manage the solid wastes generated from its operations. In this regard the following machines will be installed at the resort to manage solid waste.

- High temperature incinerator: As per the Tourism Regulations incinerator will be installed. The machine can incinerate sludge oil and solid wastes. The machine will have a temperature ranging 850-1200°C in the combustion chamber. Such high temperature will prohibit production and release of

carcinogenic dioxins from the machine. The stack emissions at the resort should meet the following criteria:

- Particulate matter <100mg/Nm<sup>3</sup> (per normal cubic meter)
  - Nitrogen Oxides (NOx) <600mg/Nm<sup>3</sup>
  - Sulphur dioxide <1,000 mg/Nm<sup>3</sup>
- High density compactor (6040-HDC): The machine can compact and bale tough materials such as PET – bottles, tin/steel cans, plastic jugs and containers, aluminium drink cans, paint cans etc. It will produce small and tight bales that can be secured by up to six straps including one cross strap. It has a high pressure of 1ton and requires 3x400v 50Hz electricity.
- Glass crusher: This unit can be used to dispose of all glass products (broken glass, old bulbs, glass bottles etc). All glass can be crushed to sand fine particles which would be used for beach rehabilitation or easily disposed of with sand or could also be used in preparing cement aggregate. The unit has a capacity of crushing approximately 600 to 1200 bottles per hour. The power requirement of the unit will be 1.25KW.
- Composting units: Efficient, easy to use and low maintenance composting units will be installed to manage composting waste. The system would not require any power source, has a capacity of about 10 cubic feet (53 gallons) and can be used for continuous composting. About five such units will be sufficient to manage composting waste. High quality compost will be available within 4 months. The system will fit nicely to a rustic setting.
- Shredder (COMBI CUT): The system consists of combined hammer and chipper assembly within 24 cutter blades particularly robust. It has a large inlet hopper for wide spreading tree branches. To minimize the amount of unsorted waste arriving at the waste processing unit, the resort staff will be trained to ensure that all the waste generated from the main sources (kitchen, bar area, maintenance shop, staff quarters and guest unit services) will be separated into distinct containers prior for transfer to the central processing unit.

### **3.5.3 Use of Pesticides and Fertilisers**

The proponent has no intention of importing exotic plants. Only plants that are occurring on the island will be used for landscaping. If for any reason, if it becomes necessary to import plants, they will be acquired from respected breeders who can provide Ministry of Fisheries and Agriculture's Animal and Plant Quarantine Unit's acceptable health certificates. Use of fertilizers and pesticides will be strictly controlled and will not be considered unless it becomes absolutely necessary.

### 3.6 Inputs and Outputs

The input / output analysis of a project helps us to define and understand the potential environmental impacts of the project in more informed manner. Linking inputs to processes and activities leads us to outputs and consequently impacts. The inputs and outputs relating to the construction and operation of a tourist resort island maybe primarily derived from the project concept and the project description and site plan of the Island.

For the construction of Ekuhivaru resort the following input materials and resources are required:

1. Construction workers and labourers: A large proportion of construction workers are expatriate labourers imported from countries within the region. Various socio economic impacts result from the import and management of such labourers. It is expected that construction sub contracts will also be given to islands in Noonu, Raa and Shaviyani Atolls. Both atolls are renowned for carpenters and building contractors. Significant income will be generated for the atolls from these contracts and the economic conditions will improve.
2. Construction materials: Multitudes of materials are required for the construction of a resort. Imported river sand and aggregate, concrete, timber and timber products, metal and aluminium products, plastics of sorts, gypsum boards and plywood, fibreglass materials, paints, varnish, thinners and hydrocarbon compounds / chemicals, ceramic tiles, electrical wires and many types of industrial cables, glass and plastic sheets. The isolated nature of resort islands require that all such construction material be transported to the site by sea and stored on the island itself. Depending how the project logistics it may be convenient for the storage of material to be placed in the nearby island of Hembadhoo or Kendhikulhudhoo.
3. Construction tools and machinery: small vehicles (loaders, dumpers) and construction machinery, excavators, lorries, concrete machines, and tools.
4. Power generation: 4 x 725 kVA diesel generator and cables and appliances
5. Water production: 200 cubic meter per day capacity RO desalination plant and piping and fittings.
6. Sewage treatment plant, MBR system 2 x 88 cubic meter per day capacity, its fittings, installation material and spare
7. Diesel and other heavy oils and lubricants for power generation and operation of all types construction and other machinery
8. Office equipment: Televisions, Computers, fax and copying machines, telephones and accessories, air conditioning equipment.
9. Kitchen appliances and tools: Refrigerators, ovens, microwaves and cooling equipment

10. Transport: Speed boats and power motors use highly inflammable fuels such as petrol and kerosene. Slow boats such as dhonies use diesel and other fuels. Floating jetties and anchorage for seaplanes will also need to be established.
11. Diving and dive centers: dive equipment including compressors and cylinders, masks fins and snorkels, lead weights and dive gear, knives, boots and suits.
12. All types of Fresh and processed foods: Constantly imported during the operation of the resort. Metal paper and plastic wastes will be the outputs of such food stuff.
13. Chemicals: laundry detergents, pesticides, insecticides, inorganic fertilisers, Cleaning products for kitchens and bathrooms, household chemicals such as floor cleaners, window cleaners, fire fighting and prevention equipment
14. Household paper materials including all types of cleaning tissues.

The Outputs of the development can be summarised as below:

1. Dredged and scoured coral sand and aggregate which will have be stored on the island or disposed
2. Construction wastes including leftover concrete
3. Organic wastes such as plant materials resulting from land clearings
4. Burnt fuel emissions and left over oil wastes and bilges
5. Scuba diving, snorkelling water sports activities (reef use)
6. Plastic and glass bottles and containers
7. Treated wastewater and dehydrated sludge and composting
8. Food and kitchen / restaurant wastes

## 4. Policy Context

Maldives is an archipelagic small island state built entirely by coral reefs. Hence the protection of the coral reef environment is a national priority in the Maldives and efforts have been made to incorporate environmental protection and preservation across all sectors. Sustainable development for Maldives is synonymous with coral reef health and vitality. Environment is granted ministerial status – Ministry of Housing, Transport and Environment (MHTE). In addition to this there is an Environmental Protection Agency (EPA) and at high level National Commission of the Protection of the Environment (NCPE).

### 4.1 Environmental Protection and Preservation Act of the Maldives (Law # 4/93)

The Environmental Protection and Preservation Act of the Maldives (Act# 4/93) was enacted by the People's Majlis in April 1993. The Environment Act encompasses the management of most environmental matters in the Maldives. The law provides provisions for the sustainable use of natural resources and their protection and conservation. Under Article 5 (a) of Environmental Protection and Preservation Act of Maldives, Environmental Impact Assessment (EIA) is mandatory for any project that may have the potential to harm the environment. The report has to be submitted to the Environmental Protection Agency of the MHTE for approval before commencement of a project.

In addition to the provisions for the EIA process, the articles of the EPPA address the following aspects of the environmental management:

- Guidelines and advice on environmental protection shall be provided by the concerned government authorities
- Formulating policies, rules and regulations for protection and conservation of the environment in areas that do not already have a designated government authority already carrying out such functions shall be carried out by MHTE.
- Identifying and registering protected areas and natural reserves and drawing up of rules and regulations for their protection and preservation.
- An EIA shall be submitted to EPA / MHTE before implementing any developing project that may have a potential impact on the environment.
- Project that has any undesirable impact on the environment can be terminated without compensation
- Disposal of waste oil, poisonous substances and other harmful substances within the territory of the Maldives is prohibited. Waste

shall be disposed only in the areas designated for the purposes of the Government.

- Hazardous / toxic or nuclear waste shall not be disposed anywhere within the territory of the country. Permission should be obtained for any transboundary movement of such wastes through the territory of the Maldives.
- The penalty for breaking the law and damaging the environment are specified
- The government of the Maldives reserves the right to claim compensation for all damages that are caused by activities that are detrimental to the environment.

#### **4.2 Maldives Tourism Act (Law # 2/99)**

This Act encompasses the issues related to the development of tourism in the Maldives. It came into effect in 1999, repealing the Law on Tourism in the Maldives (Act#. 15/79) and the Law on Leasing of Uninhabited Islands for the Development of Tourist Resorts (Act#. 3/94). Act#. 15/79 was the primary legislation that was passed by the Citizen's Majlis in November 1979. The major objective of this Act was to provide for the collection of a bed tax from the visiting tourists and to regulate tourism in the Maldives in general. While this Act only dealt with tourist resorts, hotels and guest houses, the amended act (Act#. 2/99) incorporates the determination of zones where tourism development can occur, as well as the development and management of marinas and the operation of tourist vessels, diving centres and travel agencies. This is evidence that the tourism industry has expanded since the enactment of the initial laws, both in magnitude and in the diversity of facilities that are provided for the visiting tourists.

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

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

In addition to the Tourism Act and the relevant regulations, there are circulars issued by the MoTCA, advising the tourism industry of their new policies or strengthening the existing ones.

- Circular #. 21/90 (April 21, 1990) advises all resorts having filled jetties to be modified so that they allow free flow of currents through them or new jetties composed of reinforced stilts to be built in their place by the end of June 1991.
- Circular #. CIR-ES/98/07 issued on the January 27, 1998 states that all resorts have to obtain permission from the Ministry of Tourism and Civil Aviation before commencing any coastal modifications. Hard engineering solutions are discouraged while environmentally friendly structures are encouraged.

More recently there has been a review of the tourism rules and regulation with regards to environmental protection and conservation. It addresses 6 main areas:

- Issues relating to environmental protection in building and construction works on the resorts
- Protected species and protected areas
- Planting trees, use of pesticide, and having pets
- Solid waste disposal
- Storage of water
- Disposal of sewage and sewage water
- Coastal modification and beach replenishment

A number of new regulations have been formulated to cater for the rapidly evolving legislative framework following adoption of the Constitution. Drafts new regulations are presently on MoTAC's website for comment. Some of these include

- Boundary Regulation
- Submission of the Annual Report of Registered Travel Agency
- Regulation on Tourist Guest Houses
- Draft of Tourist Guide Regulation
- Regulation on registration of tourist vessel names (88-LR/CIR/2010/04, Dated 02 February 2010) states that all vessel that are used for tourism purposes shall be registered with the MoTAC

#### **4.2.1 Resort Development Controls**

The Tourism Act empowers the MoTAC to impose strict regulations and guidelines for resort construction and operation. In the development of tourist infrastructure, MoTAC has taken up numerous measures so as not to exceed the 'carrying capacity' of the islands. The Government encourages the preservation of islands and in their

original natural conditions (both marine and terrestrial). Removal of indigenous vegetation, disruption of marine ecology, redirection of natural current patterns and disruption of wave movements within the lagoon by way of artificial structures, are discouraged. The measures taken to control and limit developments of resort islands include:

- limiting the maximum built-up area to 20% of the total registered land area of the island;
- the maximum height of the building has been limited to two storeys, provided that there is vegetation on the island to conceal these buildings;
- In the construction of tourist accommodation, all rooms should face the beach and five linear meters of beach line has to be allocated to each guest in front of their rooms.
- Only 68% of the beach length can be allocated to guest rooms, as 20% has to be allocated to public use and 12% left as open space; and
- Construction on reef flats and lagoons are discouraged.
- Over-water bungalows are permitted to be constructed provided equal open space is left on the land for each building developed on the lagoon.
- Solid waste disposal is also regulated in that bottle crushers and incinerators has to be in place before the permit for resort operation is given.
- control and mandatory replacement for each tree that is cut down (certain rare and large trees have to be avoided when constructing buildings);
- all buildings have to be located well away from peripheral vegetation – at least 5 meters away from the shore line – to ensure that peripheral vegetation most important to coastal protection is preserved;
- allocating space for vegetation between buildings. This is to ensure that substantial areas of indigenous vegetation are left untouched;
- construction of rock-filled jetties, groynes, seawalls and detached and submerged breakwaters are restricted. Instead, promotion of greater coral colonization on the peripheral reefs and other natural methods to protect shorelines are encouraged;
- coral and sand mining from resorts and inhabited islands and from their house reefs is strictly prohibited. Specific locations have been allocated for sand mining. Construction of structures using coral, is now being controlled

- to preserve the aesthetic integrity of resort islands, the height of buildings are restricted to the height of the foliage of the vegetation.
- all coastal works and larger projects must prepare and present a thorough environmental impact assessment (EIA) report;

The Tourism Regulation in the Maldives ensures that carrying capacity of the island and ecosystems are well within limits and 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, development of coastal environment and waste disposal which may cause harm of damage to the natural environment, which is the main tourism product.

Tourism regulations strictly discourage modifications to the natural environment of sand around the island. Therefore, Tourism Regulation requires that special permission from the MoTCA be sought before commencing any coastal modifications works on any tourist resort. It is also stated that hard engineering solution are not encouraged and construction of solid jetties and groynes be controlled and shall only be undertaken after conducting and EIA study. Similarly, design of the 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.

#### **4.3. International Context and Extrinsic Legislation**

Maldives is best known in global environmental forums for its sensitivity to global climate changes and sea level rise. Maldives has also been very vocal in International Meetings and Conferences relating to climate changes and sea-level rise. A Ministerial level meeting on sea level rise was hosted by the Maldives in 1992 (Small States Conference on Sea Level Rise) resulted in the Malé Declaration which calls for greater international recognition of the unique and fragile nature of coral reefs and island environments. Following this, the Maldives has continued the momentum on climate changes issues and has played a prominent role in bringing forward issues relating to small island states and their environmental issues. The Maldives is signatory to many international conventions relating to environmental issues:

- United Nations Framework Convention on Climate Change (UNFCCC)
- Kyoto Protocol
- Ozone Layer Convention (1985)
- Montreal Protocol on Substances that Deplete the Ozone layer
- (including ratification of the 1989 London amendments)
- Basel Convention on Trans-boundary Movement of Hazardous Wastes
- Civil Liability for Oil Pollution
- Convention on Biological Diversity (1992)

- UN Convention on the Law of the Sea (UNCLOS) and associated international agreements (e.g., Fish Stock Agreement)

The Maldives played an active role in the formulation of the Barbados Action Programme at the Global Conference on Sustainable Development of Small Island States (SIDS Conference). This action programme was based on the Agenda 21 and Rio Declarations, June 1992, which calls for shared responsibility to protect the world. Maldives also played an important role in recent UNFCCC CoP15 at Copenhagen in the negotiation of the Accord.

Maldives has an official policy of becoming carbon neutral by 2020 and is working to attract investors in projects relating to renewable energy and clean development mechanism.

The Maldives is also a key player in formulating and adopting various regional plans and programmes to protect the environment. As such, the Maldives is committed to the following:

- SAARC Environment Action Plan adopted in 1997 in Malé,
- SAARC Study on Greenhouse Effect and Its Impact on the Region,
- SAARC Study on the Causes and Consequences of Natural Disasters, and
- South Asian Seas Programme initiated by South Asian Association for Coastal Environmental Protection (SACEP).

#### **4.4. National Partner Institutes in the management of Environmental Issues**

Although environmental legislation and related regulations exists in the Maldives, their implementation and enforcements present real challenges due to shortages of human resources and institutional weaknesses. Environmental legislation is quite recent in origin (1993) compared to other sectors. Consequently a multitude of agencies and ministries are involved or responsible for the environmental affairs in the Maldives. The following are short descriptions of government institutions that play significant roles in environmental administration and management.

##### **4.4.1 National Commission for the Protection of the Environment (NCPE)**

The National Commission for the Protection of the Environment (NCPE) was established 1989 and was restructured and strengthened under the Environmental Protection and Preservation Act (EPPA) in 1993. The NCPE is mainly a consultative instrument consisting of key government sectors with a broad mandate for the protection and management of nationally significant environmental issues. The NCPE advises the government on all aspects of environmental management.

#### **4.4.2 Ministry of Housing Transport and Environment / Environmental Protection Agency**

The Environment Ministry plays the central role within the Government for managing environmental matters. As the agency entrusted to enforce and implement the EPPA, it has legislative powers and control over environmental protection and management. Generally, the ministry is responsible for policy formulation for development planning and monitoring the activities of the public and private sector projects to ensure that their activities and their management are consistent with government policies as defined in the Aneh Divehi Raajje, The Strategic Action Programme<sup>7</sup>. The MHTE regulates the management of domestic waste disposal and their management in the country. The Ministry sets national standards for waste management, energy conservation and the regulation of water and sanitation issues.

During 2009 the Environment Research Centre was transformed to Environmental Protection Agency (EPA) with more focused mandate on the implementation and ensuring compliance of environmental laws of the Maldives.

#### **4.4.3 Ministry of Fisheries and Agriculture**

The MoFA is mandated to ensure sustainable management of the nation's marine and terrestrial resources. Fisheries and Agriculture are governed by the relevant laws (Fisheries Law # 5/87, Law on Oceanic Delineation # 6/96, Law on Uninhabited Islands # 20/98). The Ministry formulates regulations under these laws and enforces these regulations relating to the sustainable management of living marine and terrestrial resources. The fisheries and agriculture laws give the MoFA the legal powers to protect marine and terrestrial life related to fisheries and agriculture. It also has the power to establish fisheries reserves and protected areas and species. Regulations relating to protected marine animals are formulated under the Fisheries Law of the Maldives by the MoFA. All uninhabited islands and their ecological components are also management by the MoFA under agriculture laws. Protected marine species include turtles, dolphins, black corals, the napoleon wrasse, sharks and rays, lobsters, sea cucumber, giant clams, and corals. Separate regulatory clause and notifications exist for all such species. Corals are the base of reef systems and their health and vitality is critical for the sustainable development of fisheries and tourism. Hence much importance has always been afforded for the protection of corals in the Maldives. Specific regulatory measures combined with well thought out education and awareness campaigns have almost phased out coral mining activities in the Maldives. The tourism industry needs to work very closely with the MoFA as both the tourism and fisheries industries use the same resources in different ways to achieve similar economic goals.

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<sup>7</sup> Aneh Divehi Raajje, The Strategic Action Programme, National Framework for Development 2009-2013, The Government of Maldives.

## 5. Baseline Conditions

This section describes the environmental conditions on the Ekulhivaru, especially habitats which are likely to be impacted by the proposed project activities.

### 5.1. Methodologies

Conditions of the existing environment of the study area were assessed using appropriate scientific methods. The environmental components of the study were divided into marine and coastal components. The marine environment includes the coral patches, the lagoon and the reef areas. The coastal environment covered the beaches, beach rock formations and coastal processes, currents, tides and wave climate of the area.

Field surveys were carried out on three different trips. They were in April 2008, September 2008 and more recently in April 2010.

Surveys undertaken for this assessment were:

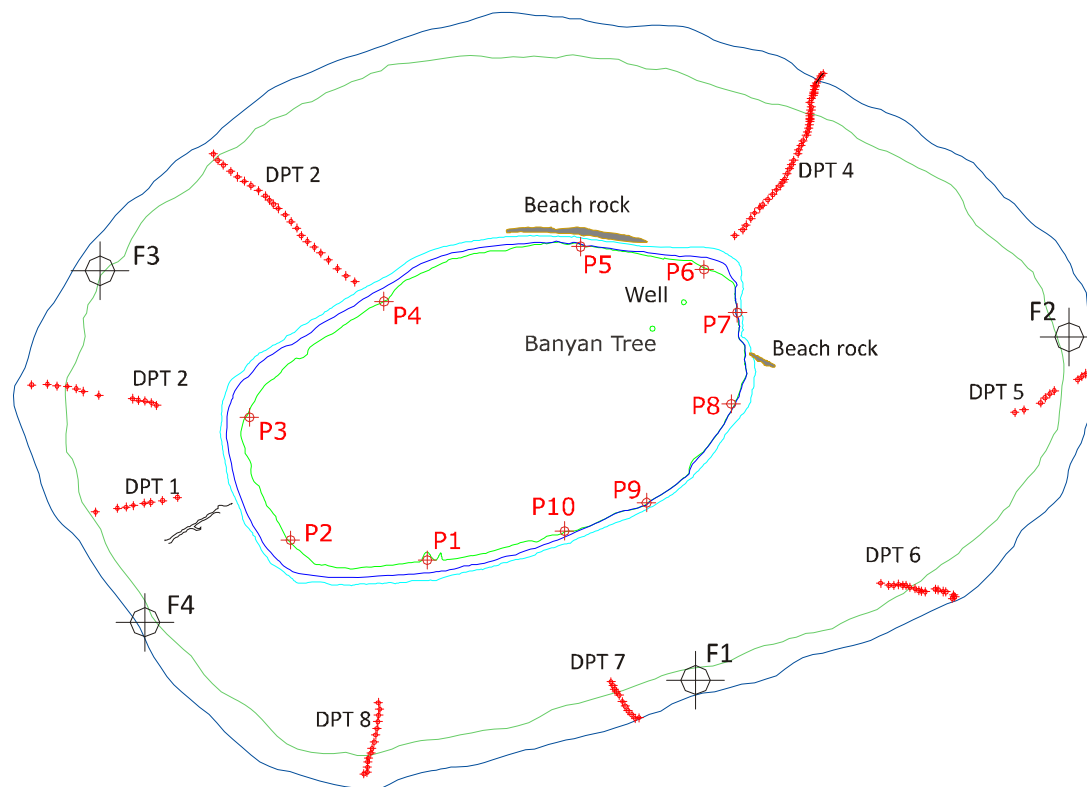
- a) Beach / vegetation lines: Standard survey methods were used to mark series of GPS positions of the beach line, vegetation line which was later integrated into a map. Linear lengths of beaches from different locations were also taken.
- b) Profiles: A 50 m tape was held taut horizontal (and leveled by eye) from a base point (i.e., line of vegetation). Using a second tape vertical distances were taken. This was done up to the water line from which point on the tape was held taut on surface of the water and vertical distances were taken from a plumb-line to ensure line measurements were taken. Profiles have been taken up to low tide mark, in the case of Ekulhivaru it is about 40-60 m. This method provided beach profiles with reasonable accuracy. Additionally reef flat / reef slope profiles were taken round the reef using handheld echo-sounder and a GPS.
- c) Manta tow survey: A broad scale survey methodology known as manta tow survey was used to assess the general status of the reef topography and various reef habitats of the reef complex of the entire reef. Manta tow technique is often used to assess broad changes in the benthic community of coral reefs where the unit of interest is often an entire reef or large portion thereof. It enables visual assessment of large areas of reef within a short time. Information from the manta tow reef assessment has been used for the selected sites for more detailed reef assessments that are representative of the various habitats have been used (English et al., 1997).
- d) Quadrat survey: photo quadrat survey was done in 4 different locations on reef slope. A 50 x 50 cm, 0.5 m<sup>2</sup> quadrat made from ½" PVC pipes were

randomly thrown on the reef slope about 2-3 m depth (Figure 4). In some cases quadrat needs to be moved to ensure it sits evenly on the reef. A photo image from above, looking flat on the quadrat, was taken for further analysis. Ten such quadrats were captured from each site to obtain replicate samples. Quadrat images were subsequently analyzed using Coral Point Count with Excel Extension in which benthic cover was estimated. Five different categories were used (live coral, dead coral, rock, rubble and sand). Additionally a sequence of photo images were taken from the round the island. The photo images proved to be very useful for qualitative assessment of the reef status and coral cover.

- e) Fish Census: At each site where quadrat samples were taken, fish census was also done. A ten minute observations moving along the reef was undertaken taking note fish species in the visual field.
- f) Vegetation Survey: a series of walking traverses on both coasts and through sections of the vegetation to identify the plants. Plants encountered were also photographed. The information gathered traverses was used to create a list of all the plant species occurring at the study site and to determine the level of dominance/importance of each plant species in the form of a DAFOR (Dominant, Abundant, Frequent, Occasional & Rare) ranking.
- g) Bird survey: Due to the rarity of occurrence of birds at the study site, bird survey was undertaken by visual observations and interviews with the resort staff.
- h) Turtles: Information on the presence of turtles was obtained through interviews with local staffs and from observations made of foot prints and nests during initial coastal assessments. Attention was also paid during manta-tow survey and fish assessment.



*Figure 4: Photo quadrat images, analysed using Coral Point Count for Excel Extension, roughly 10 images were obtained from each site.*



*Figure 5: Ekulhivaru to show the sampling locations and points; F1-F4 location of fish counts and Photo Quadrat; DPT1 – DPT10 Depth Profile Transects; and P1 – P10 beach profile locations. The positions of the beach rock is also shown.*

## 5.2. Climatic Conditions

Monsoons of the Indian Ocean govern the climatology of the Maldives' atolls. Monsoon wind reversal plays a significant role in weather patterns. Two monsoon seasons are observed: the NE and the SW monsoon (Fein and Stephens 1987). Monsoons can be best characterized by wind and rainfall patterns. Comprehensive analysis of local wind data from meteorological stations helps us to characterize the seasonality of the monsoons affecting the Maldives' atolls. Meteorological data from the northern station of Hanimaadhoo are used to characterize the climatic conditions around the project area. Figure 6 shows the predominant wind directions on northern atolls of the Maldives. Roughly 90% of the time wind blows from WNW direction. Most of the wind speeds are between 10-15 knots. Of the 4126 monthly wind observations for 1991-2006 there were only 5 observations where winds were greater than 35 knots and only once over 50 knots. Winds are strongest from July to October (Figure 7).

### Windrose, Hanimaadhoo (1991-2006)

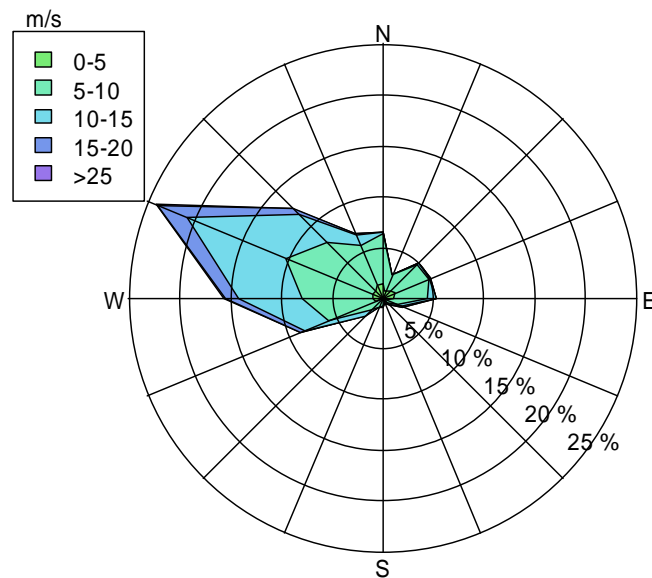


Figure 6: Frequency of wind direction in the northern Maldives (extracted from Naseer, 2003)

### Monthly wind speed - Hanimaadhoo, 1991-2006

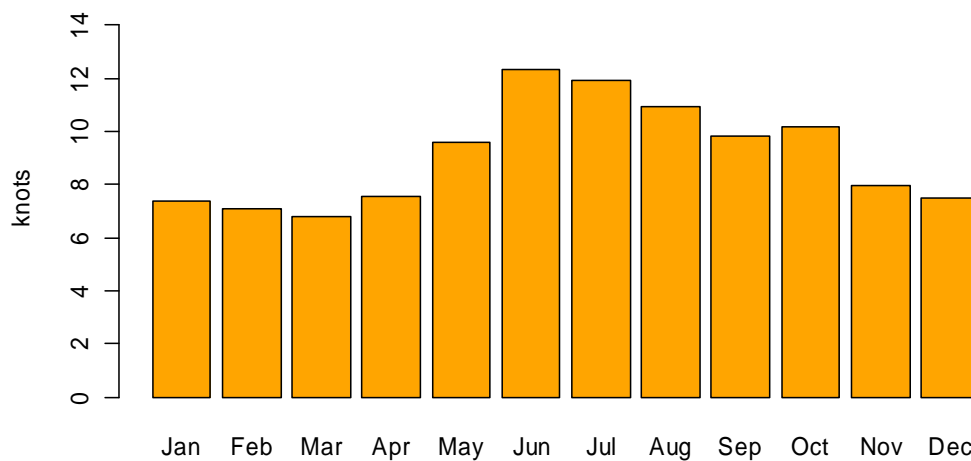


Figure 7: Mean monthly daily wind speed and direction in northern Maldives.

The graph below is taken from the UNDP report on Tsunami hazard in Maldives<sup>8</sup>. The graph displays return periods of the different wind speeds. For instance a storm event with a wind speed of the 40 knot is observed once every 35-40 years. This is consistent with the wind speed observations for the Hanimaadhoo.

<sup>8</sup> UNDP (2006). Developing a Disaster Risk Profile for Maldives, Vol 1: Main Report. Male, UNDP: 99 pages.

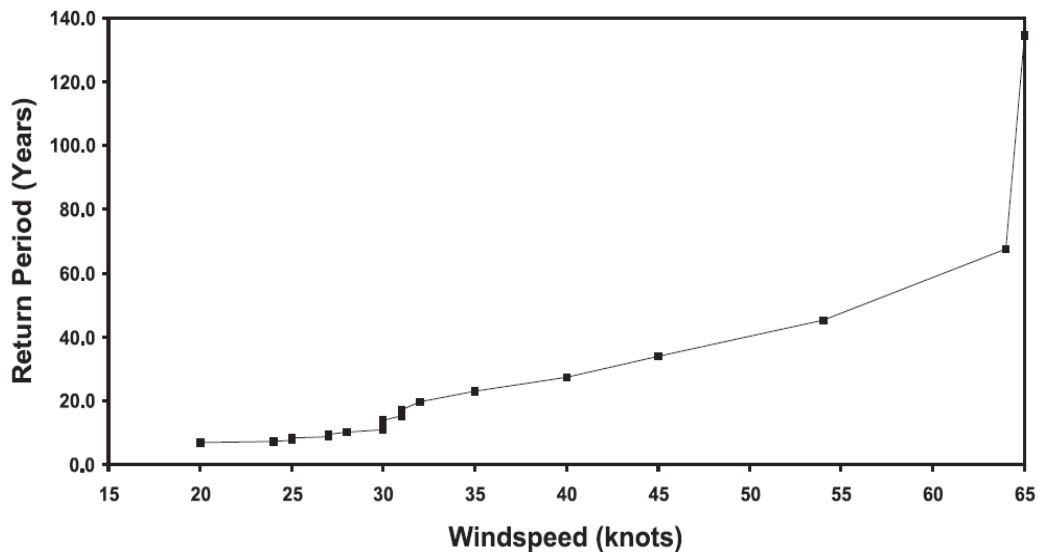


Figure 8: Return Period of Wind Speeds associated with Cyclones in Maldives: Source: UNDP (2006)

### 5.3. Tide and Waves

There are no observations of tides close to the project site. Tide gauge data is available from the Malé – Hulhulhe area. Data provided in Ministry of Construction and Public Works (1999) shows that tide range 1.2 m. and highest astronomical tide is +0.64 m where as lowest astronomical tide is -0.56m (Table 1).

Figure 9 is an extract from a study done in the southern Maldives about 10 years ago. The log-scale on the x-axis is the exceedance frequency (i.e., percentage frequency with which wave will exceed a given wave height HS). It shows, for instance there is 1% of the time there will be 1.0 m wave height from the easterly direction or 0.1 % of the time there will 1.5 m wave from easterly direction. Unfortunately there is no such data from the northern Maldives. It is safe to assume that these observations hold true for the northern Maldives as well. These data are for Malé area and for the period between September 1988 and July 1989.

Table 1: Water levels reported for Malé region (after Ministry of Construction and Public Works (1999).

Tidal level referred to MSL	
Highest Astronomical Tide (HAT)	+0.64 m
Mean higher High tide water (MHHW)	+0.34 m
Mean Lower High Water (MLHW)	+0.14 m
Mean Sea-level	0 m
Mean Higher Low Water (MHLW)	-0.16m
Mean Lower Low Water (MLLW)	-0.36m
Lowest Astronomical Tide (LAT)	-0.56m
Tidal range	1.2m

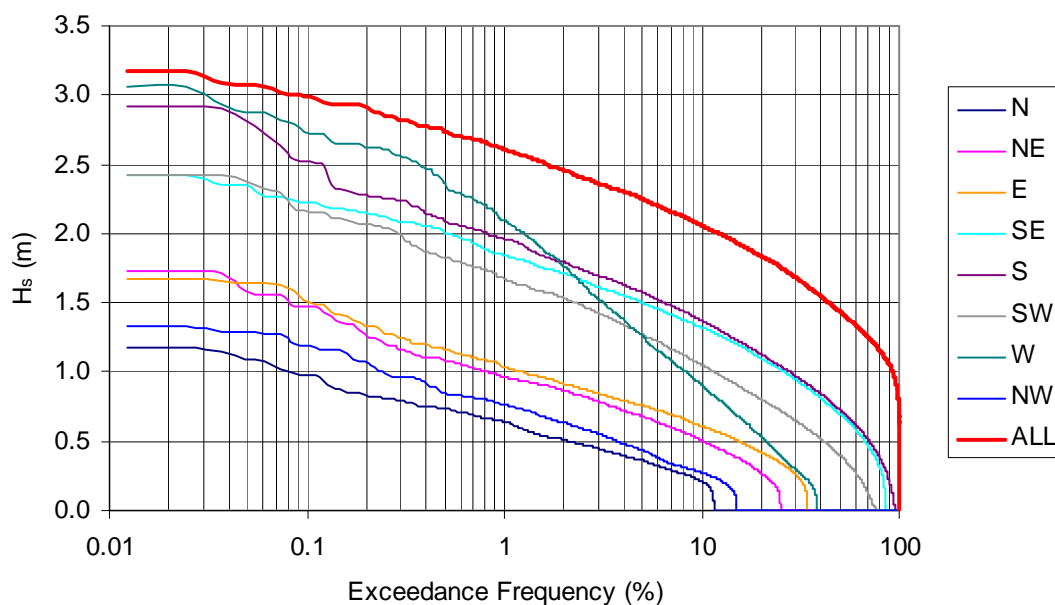


Figure 9: Water levels reported for Malé region (after Ministry of Construction and Public Works (1999).

#### 5.4. Rain fall

The closest place from Ekuhivaru where rainfall data is systematically collected is Hanimaadhoo in HD. Atoll (Upper North Province). The data is collected by the Department of Meteorology under the MHTE. Rainfall is measured every three hours and daily amounts in the gauge are recorded. From the daily data monthly averages of the rainfall is calculated.

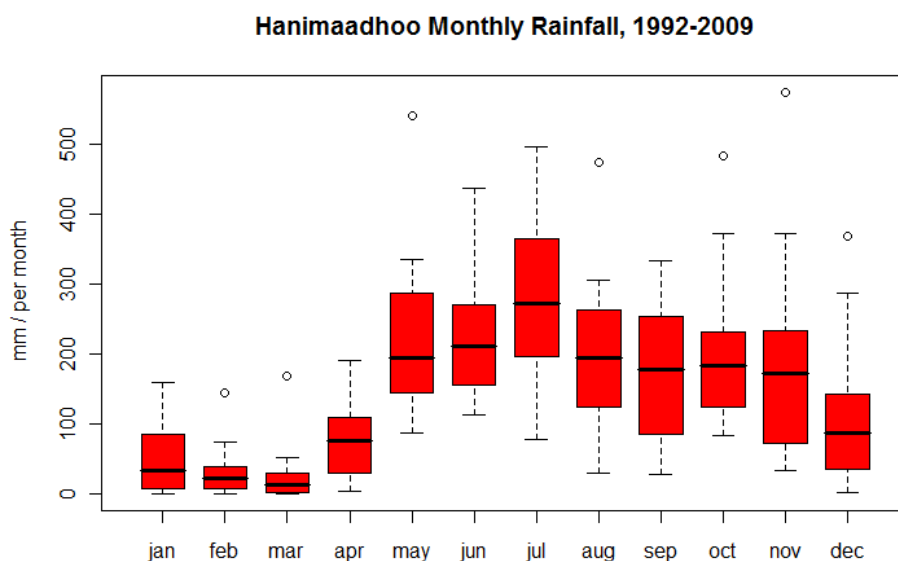


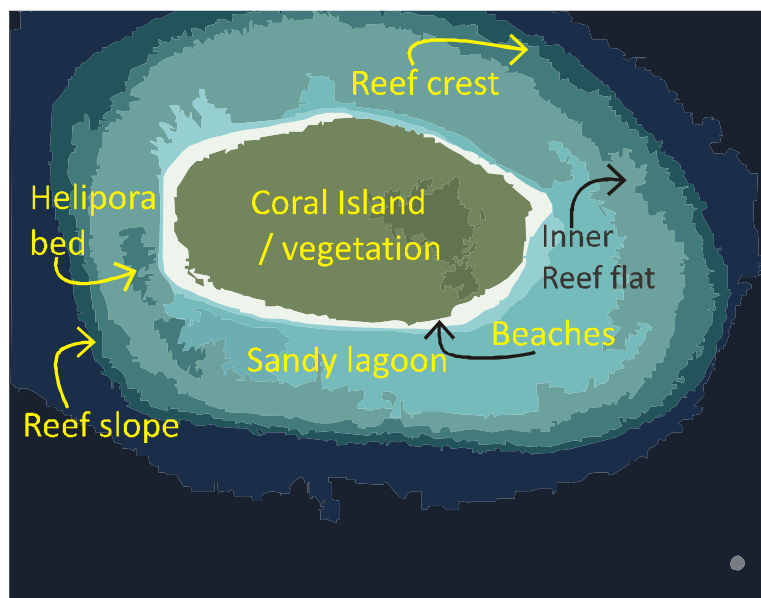
Figure 10: Boxplot of Hanimaadhoo rainfall data (1992-2009) to show the median value and the inter-quartile range (shown as boxes). Source: Dept of Meteorology.

Data from Jan 2002 through March 2010 were made available by the Department of Meteorology. Rainfall is heaviest in July and lightest in March. The variability (relative to monthly mean) as indicated from the standard deviations is highest in the months for Jan- April. During these periods relative humidity ranges from 80-90% with muggy conditions.

### 5.5. Characterization of Marine Environment

The reef of Ekulhivaru is in the south eastern section of the Thiladhunmathi Atoll (Figure 1). Unlike the islands in the south or on the atoll rim reefs, Ekulhivaru is a 'lagoonal island' (located inside the atoll lagoon) and so is slightly isolated. The reef is slightly oval shaped and has a continuous cap of hard coral based habitat all around the reef. Most of the reef inside this hard coral based rim consisted of a shallow lagoon of average depth 0.4-1.4m. Shallow sand flats occur in most areas close to the beach of the island. There are no deep lagoon areas which can be used as natural harbor on the reef. Small patch reefs (less 1-2sq meter in size occur in the shallow lagoon of the reef.

The reef of Ekulhivaru is about 80 hectares of which the island area is 20.8 hectares<sup>9</sup>. The island therefore represents about 26% of the total reef area. Reef habitats and environmental components on Ekulhivaru reef maybe categorized into 6 distinct zones



*Figure 11: Enhanced image of the Ekulhivaru (from Google Earth) to show major reef zonation and habitats.*

<sup>9</sup> Area given in the Official Atlas of the Maldives (2008), Ministry of Planning and National Development, Government of Maldives,

The reef habitats on Ekulhivaru reef maybe categorized according to the hydrodynamically induced zonations prevailing on the reef. Figure 11 shows a satellite image of the reef which depicts the major habitats on the reef.

1. Reef slope (Upper and lower slope)
2. Reef crest (wave breaking zone)
3. Inner reef flat (Helipora zone)
4. Sandy lagoon
5. Beaches
6. Coral Island: beaches and vegetation

In understanding these zoned reef habitats it is essential to note the direction and magnitudes of waves and swells reaching the reef of Ekulhivaru.

The strong / prominent reef zonation on the western periphery of the reef is the direct result of southwest monsoon waves pounding on the reef on the west. It was observed that eastern swells also reach the reef from the east. As per zonations the most hydrodynamically active areas of the reef are found on the north- west side of the reef. A well established reef crest and platform is found at this zone. The reef slope is wider, pronounced and gradual at the western periphery of the reef. It is noted that there is a homogenous zone of reef flat habitat. A shallow sandy lagoon of average depth of about 0.4 to 1.4 meters is the main feature of the reef.

Reef slope habitats: The reef slope around the reef is the most productive area of the reef with abundant fish and corals which will be described in detail. The reef slope is very prominent on the western periphery of the reef. This is believed to be the result of the western hydrodynamic forcing functions. The horizontal growth the reef towards the west is the result of the bidirectional growth (Bianci et al. 1997; Purdy and Bertram 1993).

The north eastern periphery of the reef lacks a gradual slope and has very steep walls of up to a depth of 25 meters. The biological environment of the reef slope was characterized by determining coral and fish life at 4 sites and a Manta tow survey which will be detailed in later sections. These sites were part of the transects profiles that were laid out across the reef flat perpendicular to the beach line extending up to the reef edge .

Reef Crest : A well established cemented zone with an algal ridge was observed on the western side of the reef. Field investigations for this EIA report was conducted at extreme low tide periods and hence this wind / wave generated crest and boulder zone was observed more pronounced as emerged rocks. Long term wind direction and speed clearly show that the dominant wind direction is from the western quadrants of a wind diagram (Naseer 2003). The resulting waves are probably the main reason for well defined crest zones on the western side. Swells and wind waves reach Ekulhivaru on all sides during stormy weather. Therefore the reef crest is developed on all sides although the prominence varies.

Inner Reef Flat Coral Habitats: This reef had a homogenous ring of coral reef flat habitat all around it. Hard coral boulder and substrates were the main features of this habitat. Coral cover was low to moderate but the reef habitats were generally in good condition with new growth and signs of recovery.

Shallow Sandy Lagoon: This is the main feature of Ekuhivaru reef. The shallow sandy lagoon habitat area was almost 400,000 sq meters which is 55 % of the entire reef area. Geologically such shallow sand flats show the significance of coral reef growth in the recent geological past and the productivity of the coral reef habitat around the reef.

Beaches and Nearshore Environments: The island of Ekuhivaru has extensive beach habitats around it rich in fine sand and generated by the reef. Wide beaches occur in most areas especially in the north. Beach rocks are exposed in two areas, along a section of north east side and on the south eastern side (Figure 5). Beach rock is a not well hardened but coarse and appears to be newly exposed.



*Figure 12: Beach rock exposed during low tide on the south eastern side (left) and on the northern side (right)*

Beach movements around the island were very significant as was observed from aerial photos of 1969, and Google earth satellite photos published in 2007. The accretion of beaches on the northwestern side is quite obvious.

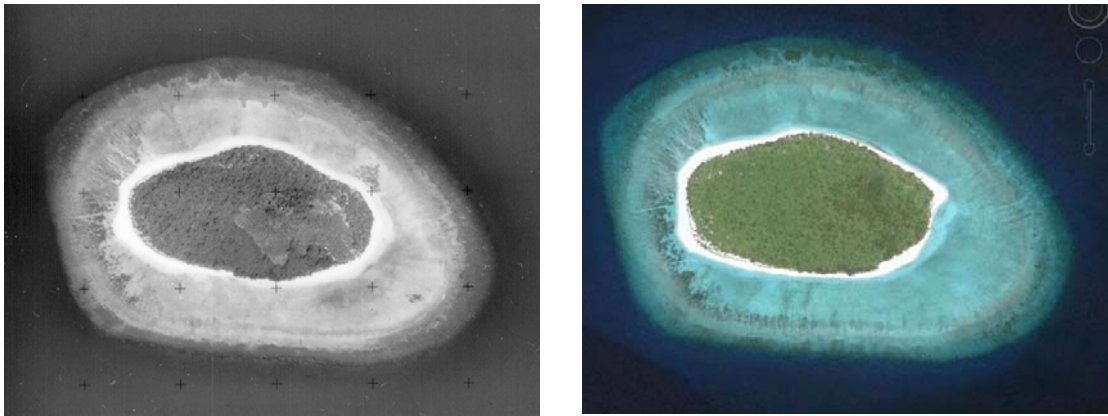


Figure 13: Images of Ekuhivaru - in 1969 (left) and in 2007 (right)

#### 5.5.1. Substrate Cover

Manta tow: The summary data for manta tow survey is given in Table 2. Overall the substrate cover was dominated by dead coral and rubble (70-80%). Live coral was estimated at 10-15%. Fish abundance was moderate with few tows observing in 'abundance'. Soft corals were recorded to be rare or non-existent. As mentioned in the description of method, manta tow is rapid assessment which may be subjective but nevertheless gives useful snapshot view of the reef status.

Photo quadrats: Substrate cover estimated from the photo quadrats are given in Figure 14. The results are shown as relative mean cover and its standard deviations based 10 or more samples. The results are remarkably similar to manta-tow surveys. The advantage of the technique is it is on smaller spatial area but with more detail. The general picture obtained from the manta tow survey was quite obvious; i.e. substrate dominated by rock, rubble and sand with 10-15% of live coral cover. The results of site #4 are different and stand from the rest of the three sites. The live coral cover was over 20% with the rock, rubble and sand at 60%.

#### Photo-image survey:

A third approach was used during the last trip (April 2010) to further study the coral reef. The approach involved taken images at about 3-5 second intervals using a submerged camera on a slow moving boat. The images were remarkably clear and so were useful in fine scale study and assessment of the reef. Images were taken at 10 long transects covering the entire perimeter of the reef. Selected sets of the images are included in a CD-ROM with the report.

Table 2: Manta-tow summary on Ekulhivaru reef, April 17, 2008.

Tow#	Dead Corals	Live	Soft	Sand	Rubble	Fish	Bomb Crater	Notes
1	3	1	0	2	3	+	no	Small coral heads
2	3	1	0	2	3	+	no	Milipora colonies, small coral heads
3	4	1	0	2	3	+	no	small live coral heads
4	4	1	0	3	4	+	yes	large school of fussiliers
5	4	1	1	3	3	+	no	Green turtle, 30 cm TL + bommies
6	3	2	1	2	2	++	no	toppled large bommie
7	4	2	1	2	2	++	no	
8	3	1	1	2	3	++	no	
9	3	1	0	2	3	+	no	murky water
10	3	2	1	2	2	+	no	school of Odonus niger
11	3	1	1	2	3	+	no	small corals
12	4	1	0	3	5	+	no	rubbly
13	4	1	0	3	4	+	no	

Numbers refer to coral categories, i.e., 0 = no hard bottom for corals, 1 = <10% living coral cover on hard bottom, 2 = 11-30%, 3 = 31-50%, 4 = 51-75%, 5 = 76-100%. Abundance indicators: 0 = absent, — = rare, - = uncommon, + = common, ++ abundant, +++ superabundant

Relatively large number of small sized colonies of about 5-15 cm were observed on the transects<sup>10</sup>. Most of these were table corals of the family fast growing *Acropora*. The frequency of occurrence of such small colonies was much higher on the western side.

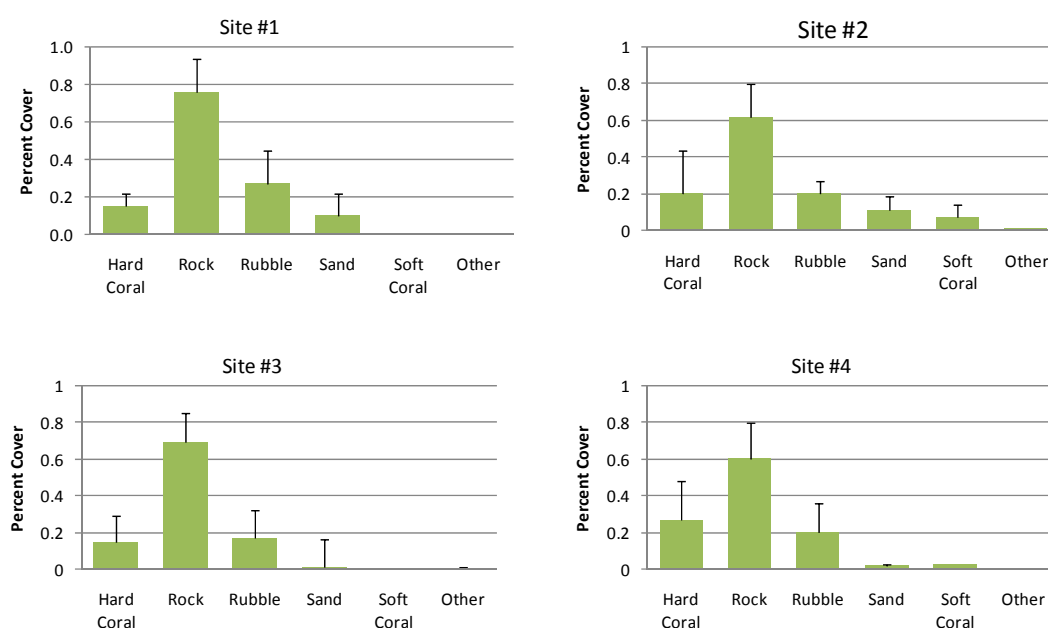
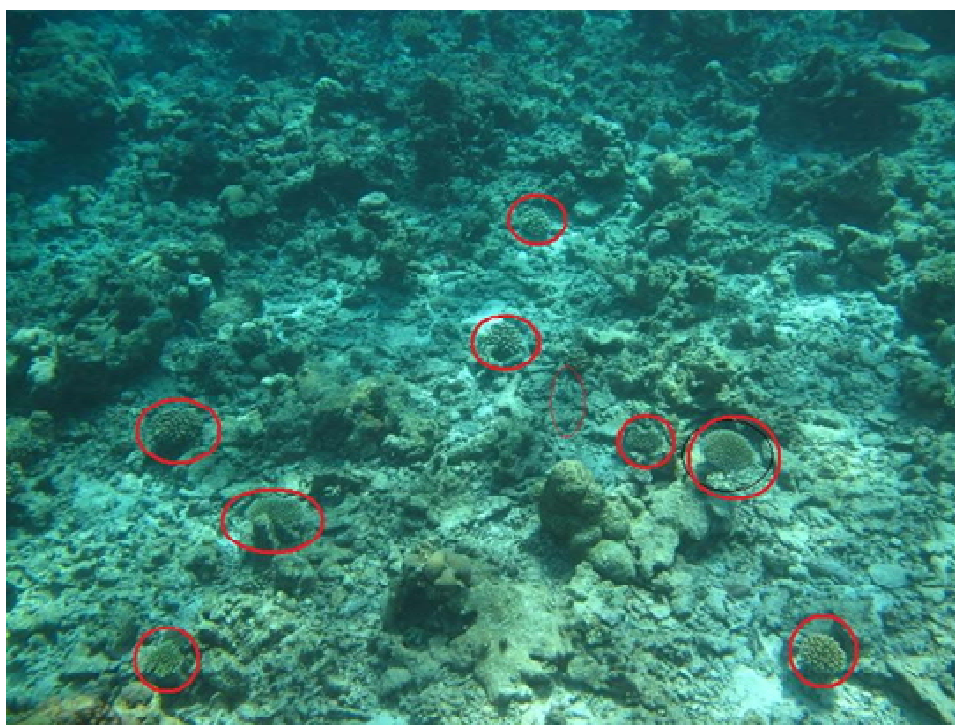


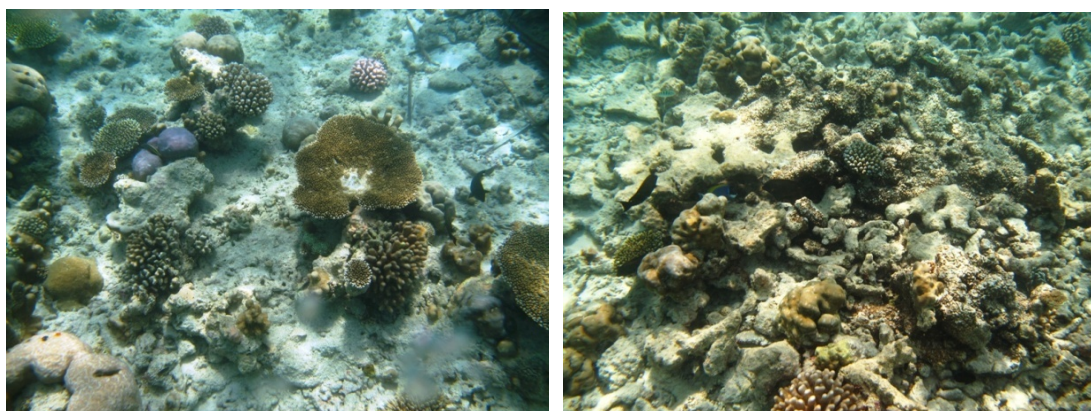
Figure 14: Mean cover by category and their standard deviations over the mean (n=10), Site locations refer to: Figure 5

<sup>10</sup> Our notes also showed that observation of large number of the small coral colonies of *Acropora* during the survey of April 2008.

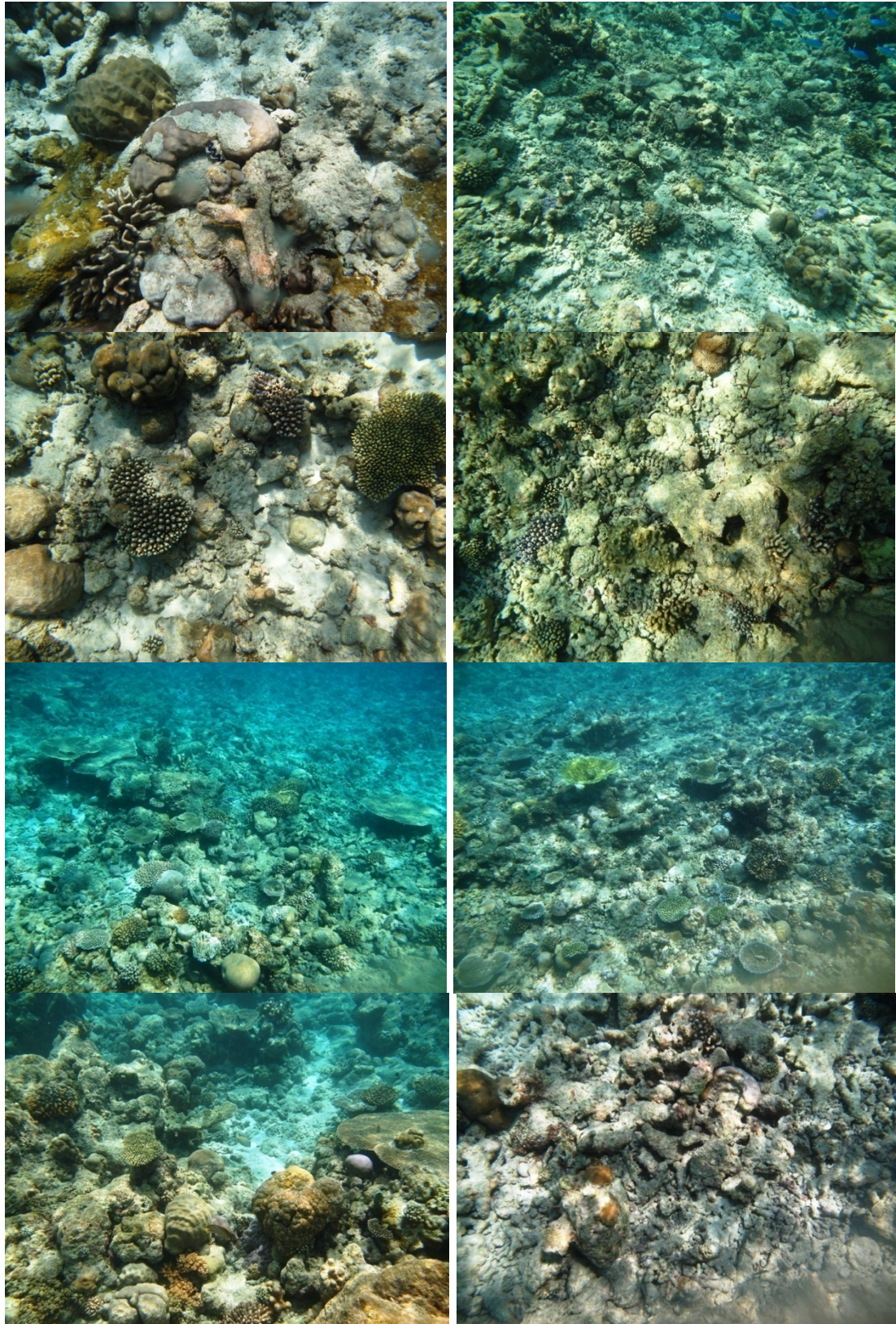


*Figure 15: A typical image of the photo-image survey during April 2010. Circled are small sized coral colonies observed on the western side.*

A likely explanation would be that these were new recruits settled following the mass coral kill event of the 1998 (Zahir, 1999). Thus it can be assumed that Ekuhivaru reef is also recovering relatively well, as observed in other reefs in the region. Further monitoring is essential to keep track of the recovery process<sup>11</sup>.



<sup>11</sup> Surveys carried under the National Coral Reef Monitoring Programme ([www.mrc.gov.mv](http://www.mrc.gov.mv)) also suggest that Maldivian reefs are recovering following the mass die-off event of 1998. The recovery rates are highly variable with exception recovery rates observed in the western central reefs of the Maldives.



*Figure 16: A mosaic of selected substrate images taken on the photo image survey – equivalent to manta-tow carried out at the upper reef slope.*

### 5.5.2. Fish Census

A total of 64 species comprising 42 genera and 15 families were observed in the fish census surveys. Major families include Acanthuridae, Labridae, Chaetodontidae, Scaridae and Pomacentridae (Figure 17). The levels of abundance as observed during the swim (categorized as rare, common and very common) are also given (Table 3).

The highest number of species were observed in family Acanthuridae (Surgeon fishes) followed by Labridae (Wrasses) and Chaetodontidae (Butterfly fishes). It should be noted that the species composition may be biased because this was done in a snorkel swim. It is likely that species that live deeper may not have been captured. Similarly small and cryptic species may also be under-represented. Nevertheless the fish composition and abundance information represent a useful summary of faunal composition on Ekuhivaru reef.

Four hawksbill turtles were seen during the first visit. Two of them came very close to the beach. They all appear to be small, around 30-40 cm total length. Turtles are protected in the Maldives and the number of hawksbill turtles are reported to have been increased. However, the green turtle has not.

A large number of red-toothed triggerfishes (*Odonus niger*) were seen on the reef. The species is quite common in the Maldives. They feed on plankton and occur in schools on current swept reefs. Reports of mass die-offs of this species were in 2007 and 2008 in the Maldives. The cause of the die-offs was believed to be a viral infection<sup>12</sup>.

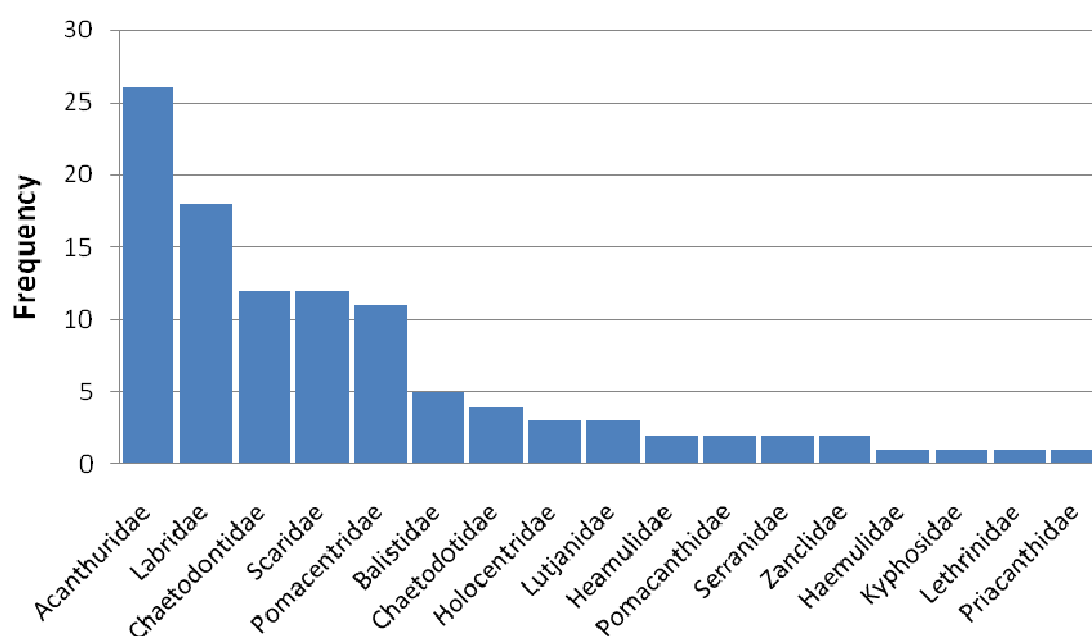


Figure 17: Number of species observed by family. Most common type of fish observed from Acanthuridae (herbivore)

<sup>12</sup> 4: A compilation of reported fish kills in the Maldives (July - December 2007), Marine Research Centre, Male, Maldives 32 pages, (2007). <http://www.mrc.gov.mv/index.php/publications/>

Table 3: Fish counts for each site, ordered by family; 18 April 2008.

Count# F1			Count# F2		
Family	Species	Abundance	Family	Species	Abundance
Acanthuridae	<i>Acanthurus leucosternon</i>	VC	Acanthuridae	<i>Acanthurus leucosternon</i>	VC
Acanthuridae	<i>Acanthurus lineatus</i>	C	Acanthuridae	<i>Acanthurus lineatus</i>	VC
Acanthuridae	<i>Acanthurus lineatus</i>	C	Acanthuridae	<i>Acanthurus lineatus</i>	C
Acanthuridae	<i>Ctenochaetus truncatus</i>	VC	Acanthuridae	<i>Acanthurus nigrofusus</i>	C
Acanthuridae	<i>Ctenochaetus binotatus</i>	C	Acanthuridae	<i>ctenochaetus striatus</i>	C
Acanthuridae	<i>Naso elagns</i>	VC	Acanthuridae	<i>Ctenochaetus striatus</i>	VC
Balistidae	<i>Balistapus undulatus</i>	R	Acanthuridae	<i>Naso vlamingii</i>	R
Chaetodontidae	<i>Chaetodon lunula</i>	R	Acanthuridae	<i>Naso brevirostris</i>	C
Chaetodontidae	<i>Hemitaurichthys zoster</i>	VC	Balistidae	<i>Balistapus undulatus</i>	C
Haemulidae	<i>Plectorhinchus vittatus</i>	R	Balistidae	<i>Leather jackets</i>	R
Labridae	<i>Bodianus axillaris</i>	R	Chaetodontidae	<i>Chaetodon citrullus</i>	R
Labridae	<i>Chelinus fasciatus</i>	R	Chaetodontidae	<i>Chaetodon lineatus</i>	R
Labridae	<i>Gomphosus caeruleus</i>	R	Chaetodontidae	<i>Chaetodon lunula</i>	R
Labridae	<i>Helichoeres virolikii</i>	R	Chaetodontidae	<i>Chaetodon trifasciatus</i>	R
Labridae	<i>Thalassoma hardwicke</i>	C	Haemulidae	<i>Plectorhinchus vittatus</i>	C
Labridae	<i>Thalassoma janseni</i>	C	Lutjanidae	<i>Maclor niger</i>	R
Lethrinidae	<i>Monotaxis grandoculis</i>	C	Pomacentridae	<i>Pomacanthus trimaculatus</i>	R
Pomacentridae	<i>Chromis opercularis</i>	C	Pomacentridae	<i>Chromis diimidiata</i>	C
Pomacentridae	<i>Dascyllus aruanus</i>	C	Pomacentridae	<i>Chromis opercularis</i>	C
Pomacentridae	<i>Pomacentrus chrysurus</i>	R	Scaridae	<i>Scarid ps (Large individual)</i>	R
Pomacentridae	<i>Stegastis nigricans</i>	R	Scaridae	<i>Scaridae (small school)</i>	VC
Scaridae	<i>Scarus prasiognathus</i>	R	Scaridae	<i>Scarus niger</i>	C
Scaridae	<i>Scarus psittacus</i>	R	Zanclidae	<i>Zanclus cornutus</i>	C
Scaridae	<i>Scarus niger</i>	C			
Serranidae	<i>Cephalopholis argus</i>	R			
Zanclidae	<i>Zanclus cornutus</i>	C			
Count #F3			Count #F4		
Family	Species	Abundance	Family	Species	Abundance
Acanthuridae	<i>Acanthurus leucosternon</i>	VC	Acanthuridae	<i>Acanthurus leucosternon</i>	C
Acanthuridae	<i>Ctenochaetus binotatus</i>	R	Acanthuridae	<i>Acanthurus lineatus</i>	C
Acanthuridae	<i>Ctenochaetus striatus</i>	VC	Acanthuridae	<i>Acanthurus lineatus</i>	C
Acanthuridae	<i>Ctenochaetus truncatus</i>	R	Acanthuridae	<i>ctenochaetus striatus</i>	VC
Acanthuridae	<i>Naso vlamingi</i>	R	Acanthuridae	<i>Ctenochaetus striatus</i>	VC
Acanthuridae	<i>Zebrosoma scopas</i>	R	Acanthuridae	<i>Zebrosoma scopas</i>	R
Balistidae	<i>Balistapus undulatus</i>	R	Chaetodontidae	<i>Chaetodon citrullus</i>	R
Balistidae	<i>Pseudobalistes fuscus</i>	C	Chaetodontidae	<i>Chaetodon falcata</i>	R
Chaetodontidae	<i>Chaetodon citrullus</i>	C	Chaetodontidae	<i>Chaetodon guttatissimus</i>	R
Chaetodontidae	<i>Ctenochaetus striatus</i>	C	Chaetodontidae	<i>Chaetodon triangulum</i>	C
Chaetodontidae	<i>Forcipiger longirostris</i>	R	Chaetodontidae	<i>Chaetodon triangulum</i>	R
Holocentridae	<i>Myripristis berndti (?)</i>	C	Chaetodontidae	<i>Forcipiger longirostris</i>	R
Holocentridae	<i>Priacanthus hamrur</i>	VC	Chaetodontidae	<i>Hemitaurichthys zoster</i>	VC
Holocentridae	<i>Sargacentron spiniferum</i>	R	Haemulidae	<i>Plectorhinchus orientalis</i>	R
Kyphosidae	<i>Kyphosus sp</i>	R	Labridae	<i>Anmpses melaegrides</i>	R
Labridae	<i>Helichoeres scapularis</i>	R	Labridae	<i>Bodianus diana</i>	R
Labridae	<i>Thalassoma lunare</i>	C	Labridae	<i>Helichoeres cosmetus</i>	R
Lutjanidae	<i>Lutjanus biguttatus</i>	R	Labridae	<i>Helichoeres virolikii</i>	R
Lutjanidae	<i>Lutjanus gibbus</i>	C	Labridae	<i>Labridae</i>	C
Pomacentridae	<i>Pygoplytes diacanthus</i>	R	Labridae	<i>Scarus sp</i>	C
Pomacentridae	<i>Pomacentrus atripectoralis</i>	R	Labridae	<i>Thalassoma hardwicke</i>	C
Pomacentridae	<i>Pomacentrus sp</i>	C	Labridae	<i>Thalassoma hardwicke</i>	VC
Priacanthidae	<i>Priacanthus hamrur</i>	R	Labridae	<i>Thalassoma janseni</i>	C
Scaridae	<i>Scaryus sordidus</i>	VC	Labridae	<i>Thalassoma lunare</i>	R
Scaridae	<i>Scarus caudofasciatus</i>	R	Pomacentridae	<i>Pomacentrus sp</i>	VC
			Pomacentridae	<i>school of Abudedefduf</i>	C
			Pomacentridae	<i>Sergeant major (Abudedefduf)</i>	C
			Scaridae	<i>Chlorurus strongylocephalus</i>	R
			Scaridae	<i>Scarus niger</i>	R
			Scaridae	<i>Scarus sordidus</i>	C
			Scaridae	<i>Scarus tricolor</i>	R
			Serranidae	<i>Cephalopholis argus</i>	R

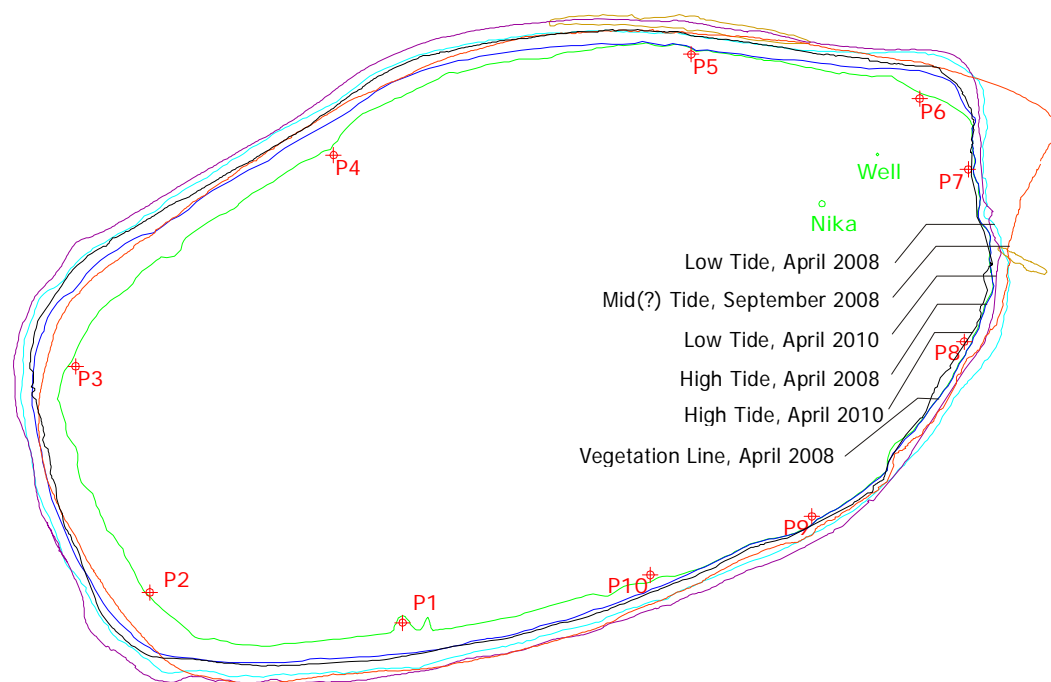
### 5.5.3. Beach Profiles

Beach formation on tropical islands is a complex process which involves winds, waves, distant swells and currents. Essentially it involves the deposition of the coral-reef-derived (biogenic) sediments by the process of littoral drift. The dynamics of beach accretion and erosion is largely governed by the interplay between the prevailing wind (direction and strength) and the seabed topography acting on the sediment in the water column. This hydrodynamic forcing creates the sedimentary environment for the deposition of the sediments of varying grain size in the formation of beaches.

The monsoon seasons has strong affect on beach profiles of the islands. During the calmer NE monsoon season wide and gently sloping beaches are present while in the SW monsoon season they become steep-fronted and narrow.

Monsoon related seasonal accretion and erosion of beach movements are well known in the Maldives. Beach accreted on one side (often a pointed end) of the island gets washed away but return in the following season.

Except for a short stretch on the south eastern side, beaches on Ekulhivaru were well developed. Beach widths on the western and north western side were in the range of 40-50m; the widest being the north western side (P1 - P4, Figure 18) with well developed beach front. On the south and south eastern side beach widths were narrower ranging from the 10-20m. The profiles of the beaches were moderate with slopes of about 20° (Figure 19).



*Figure 18: Changes in high and low tides on Ekulhivaru, April 2008 – April 2010, Points indicate where the beach profiles were taken.*

On the northern and north western side the high tide mark was prominent in the profiles; the explanation being that waves are strongest on this side with water pushing high up with a strong back-wash.

A highly dynamic area of the beach exists in the eastern tip of the island. Here a sand-spit was well formed in during the SW monsoon but gets eroded during the north east monsoon season (Figure 18).

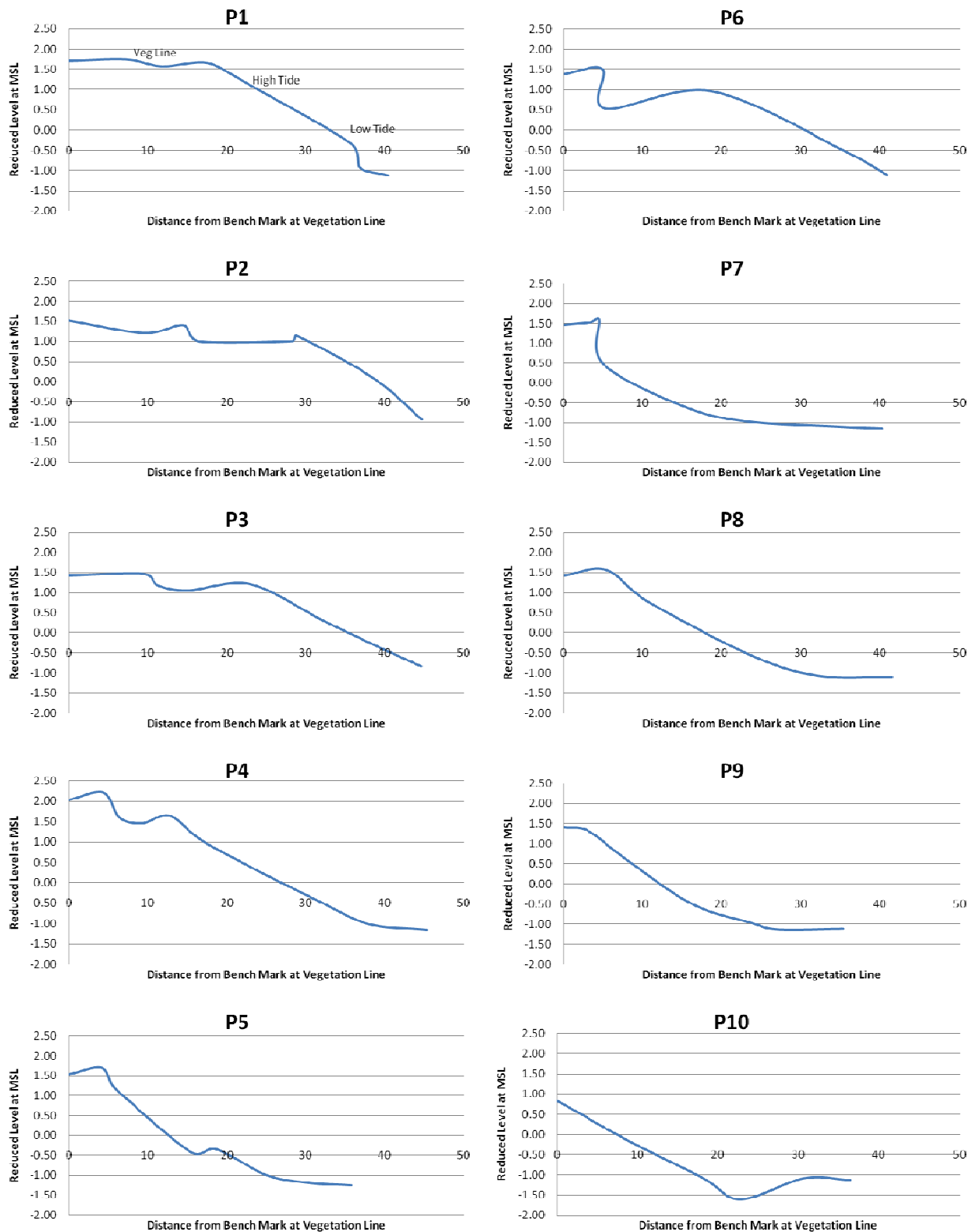


Figure 19: Beach profiles of the Ekuhivaru, April 2008. The points shown here are given in Figure 18

#### 5.5.4. Beach Erosion

Erosion and accretion is a dynamic process which maintains the beach in its natural form. When rates of erosion equal to the accretion the beach is maintained in

equilibrium. However, as the condition changes beach dynamics also changes leading to net erosion or net accretion.

The south eastern side of Ekuhivaru beach is undergoing net erosion. The eroding area extends about the 150 m along the south eastern side. High tide lines surveyed during April 2008 and April 2010 shows some 1-3 m of beach been lost from this area (Figure 20). Several trees of *Uni*, *Kaani*, *Coconut palms*, *dhigga* and *Pandanus* have fallen with additional trees in danger of losing due exposed roots. The erosion has extended well into the island exposing the humus (black) soil.

Usually seasonal erosion does not eat away the black soils of the island. More commonly we see seasonal erosion and accretion of sand according to monsoons. But at Ekuhivaru this natural balance has sharply shifted to net erosion on the east and deposition on the west. Erosion at the south east point of Ekuhivaru was so evidently seen from the surveys carried out in April 2008 to April 2010. Coconut palms that were intact in position in 2008 had completely fallen away in 2 years. At least 3 mature coconut palms have been lost to erosion.

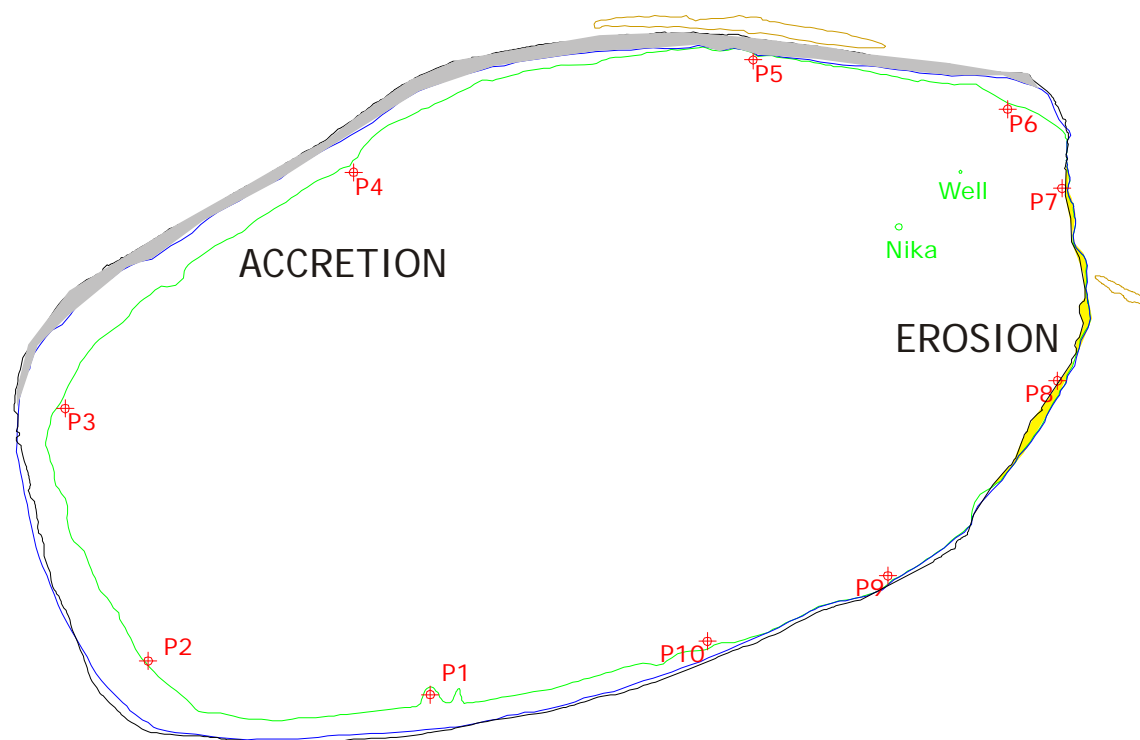


Figure 20: Areas of accretion and erosion as observed by the difference in high tide lines from April 2008 and April 2010. The island is being accreted in the north western side while on the eastern side it is eroding.

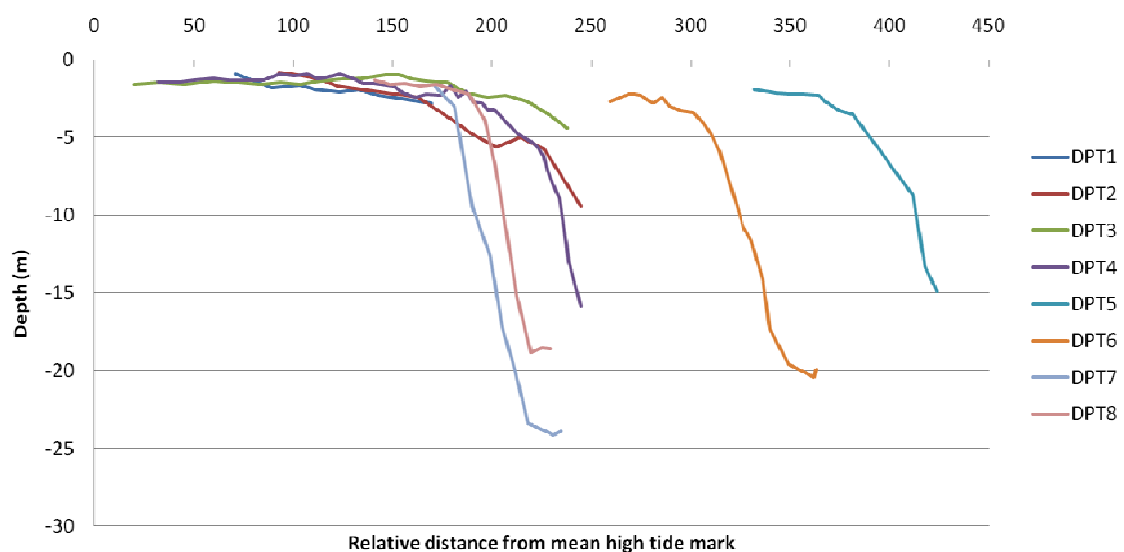
On the north-western and western side, however, beaches have been accreting (Figure 20). The high tide lines have clearly moved further west extending the beaches on this side. Our limited observation shows this severe erosion is recent. Understanding the finer details of the causes of this would involve continuous observation of the hydrodynamics environment over extended period of time. This will be difficult and beyond the scope of the EIA.

Comparison of 2007 satellite images of Google Earth and an aerial picture taken in 1969 shows that island is moving west and northwest wards (cf Figure 13). Effectively the island is extending and growing on the west while the land from east and southeast may be losing. This is discussed in more detail in the later sections.

The important point to note here is that the erosion of the island at its east end is very severe. It was noted that mature trees (at least 50+ years old) are being lost to erosion. The inner core framework of the island has been exposed and broken down. This has implications for the type of development at this point of the island. The setbacks will need to be carefully looked into.

It is important that this issue be addressed by the developers early on the project development. Several soft engineering options may be explored to mitigate and to slow down this erosion. Proposal for developing the harbour basin, service jetty and the construction of breakwater in the area was part of the mitigation plan.

Additional mitigation plans include the seascaping works by live coral in the area, particularly in the eastern side of the lagoon. There are many options available for biological accretion on artificial structures underwater. Such options maybe explored on Ekuhivaru reef. Artificial reef growth and bio accretion of structures have been experimented at some resorts in the Maldives.



*Figure 21: Depth profiles from various transects around the island to show the depth changes over distance from the beach. Explanations of the Transects are given in Figure 5*

#### 5.5.5. Lagoon and Reef Flat

During the last trip in April 2010, a series depth measurement on the reef flat extending into the reef slope were taken. The location of these depth transects are

shown in Figure 5 (page 44). The summarised data is depicted in Figure 21. These profiles show depth of the reef flat does not vary much

The reef sloped fairly rapidly once the from the reef crest. The steepest slopes were on the southern side (DPT7 – DPT8) while the slopes steeped less on the western side. The reason for this could be due to prolific horizontal reef growth in on the west. The western side of the reef indeed has the highest coral cover relative other areas.

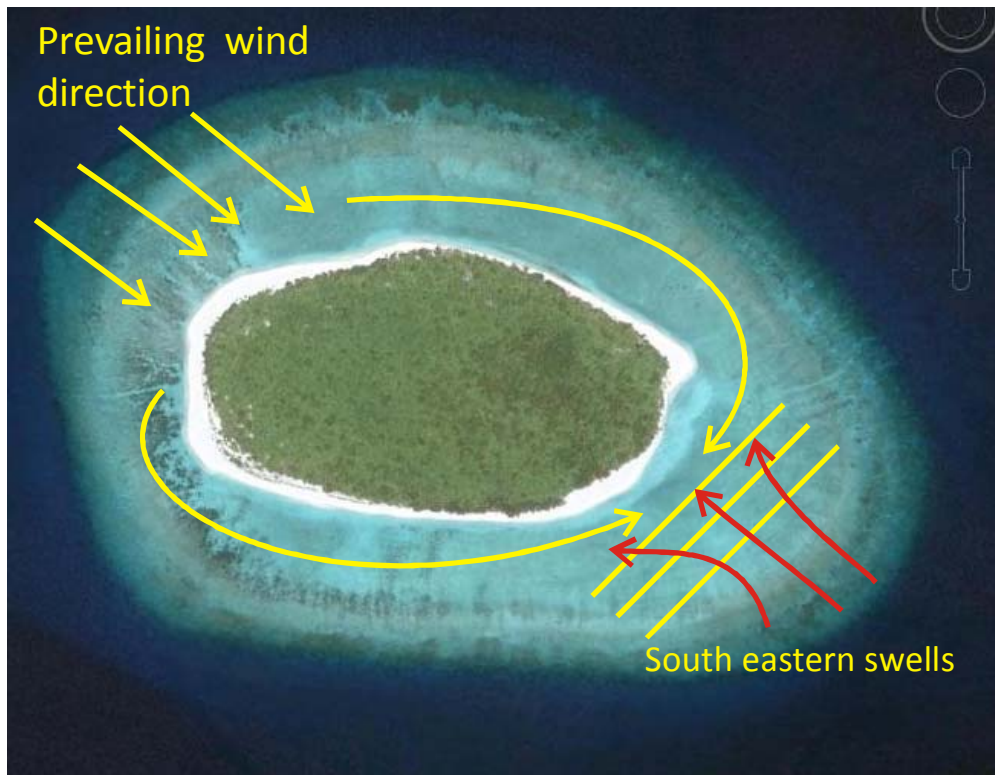
#### **5.5.6. Surface currents**

The ecology and health of a coral reef and the associated lagoons are intimately connected to the dynamics of water flow over the reef and its inner lagoon. The hydrodynamics of the reef, especially the current flow over the reef flat and lagoon is critically related to coral and fish health. Processes such as warm and cold water moments, nutrient exchanges, larval inflow and outflow are affected by currents and related circulation. Sediment moments around the island and over the reef flat are also related to winds and surface currents.

Understanding the way in which water masses move to and away from the reef is very important to understand reef related biological and ecological processes.

Surface currents around stand alone reefs in the Maldives such as Ekuhivaru reef are determined by the tide conditions, swells and wind waves. Figure 22 shows the pattern of wind and swell waves and possible current moments on Ekuhivaru reef. In general, the water flow over reef topography is complex and is known to be driven by the water surface gradients resulting from the wave set-up created by the breaking waves.

The main direction of current flow is east-west on Ekuhivaru reef. Wind waves reverse according the monsoons. Swell waves reach the island pretty much continuously from the east. Tidal currents around Ekuhivaru may not be as important as wind waves and swell waves. This is given its location and the openness of Miladhunmadulu Atoll where Ekuhivaru is located. The beach positions shown in Figure 18 are clear indications of beach dynamics according to monsoon at Ekuhivaru



*Figure 22: Wave patterns and direction of current on the lagoon.*

#### **5.5.7. Water Quality**

In order to measure COD, BOD and some of the sensitive tests water samples need to be transported to Malé, preferably in refrigerated conditions, within 12 hours from the time of sampling. This was not possible on our field visits. For the purposes of adhering to the TOR agreed at the Scoping Meeting, we report here sample water quality test results from an uninhabited island in the same region under similar conditions. The island is very similar in setting and size and we believe the water quality test results from Ekuhivaru would not be any different from these.

It is, however, proposed to undertake complete water quality tests, and particularly of ground water, before the development work begins. Sample water test results are given in Table 4.

*Table 4: Water test results for a typical 'Ekulhivaru type' uninhabited island. The samples were from Kihaavahhuravalhi, Baa Atoll obtained in July 2007.*

	Western Sea, Sample #1	Eastern Sea, Sample #3	East Lagoon, Sample #4	west lagoon, Sample #2	Ground water, Sample #5
Physical Appearance	Clear	Clear	Clear	Clear	pale yellow
Suspended solids	4 mg/L	5 mg/L	6 mg/L	6 mg/L	11 mg/L
Salinity	35500 mg/L	35600 mg/L	35500 mg/L	35300 mg/L	2300 mg/L
Ammonia	0.00 mg/L	0.00 mg/L	0.00 mg/L	0.00 mg/L	0.24 mg/L
pH	8.3	8.3	8.3	8.3	7.2
Electrical conductivity	54900 us/cm	54600 us/cm	53600 us/cm	54700 us/cm	4210 us/cm
Nitrate	0.0 mg/L	0.44 mg/L	0.89 mg/L	0.89 mg/L	0.0 mg/L
Phosphate	0.15 mg/L	0.03 mg/L	0.02 mg/L	0.11 mg/L	0.13 mg/L
Sulphate	3375 mg/L	3375 mg/L	3500 mg/L	3375 mg/L	220 mg/L
Turbidity	1 NTU	0 NTU	0 NTU	0 NTU	5 NTU
Nitrite	0.006 mg/L	0.007 mg/L	0.007 mg/L	0.006 mg/L	0.005 mg/L

## 5.6. Vegetation, beach dynamics and the Terrestrial Environment

Ekulhivaru Island has changed its shape and size over the last 40 years in terms of its beach vegetation and beach morphology. Observations clearly showed that the island has grown (accretion of sand and new vegetation) and moved towards the west. Figure 13 shows the aerial images of Ekulhivaru from 1969 and 2009 side by side. It is very clear that the island has grown considerably to the west and north wards. The 1969 picture shows that the island is sharper and narrower on the west whereas the 2009 picture shows that the island has grown at the NW and SW corners considerably.

Beaches occurred on all sides of the island but the eastern beaches were very mobile according the monsoons and showed clear erosion lines. The upper beaches around the western half of the island were more stable.

The stability of a given beach in the Maldives is related to the type of beach vegetation. Stable beaches are always characterized by thick growth of *Magoo* (*Scavola* sp.) and *Boashi* (*Tournefortia* sp). A stable beach means that waves and sea will not reach the vegetation during seasonal erosion. It follows that *Magoo* grow on net accreting beaches naturally. *Magoo* establishes quickly on the upper beaches and stabilize the sand. *Magoo* will not have a chance if salt reaches the vegetation directly on a regular monsoonal basis.

Eroding or dynamic beaches are characterized by mixed vegetation consisting of *Kuredhi* (*Pemphis* sp) *Halaveli* (*Surinama* sp), *boakashikeyo* (*Pandanus* sp) and sometimes *Uni* (*Guettarda* sp). *Kuredhi* and *halaveli* are much more salt tolerant than for example *magoo* and *boashi* and can with stand daily washing of sea.

Therefore beach vegetation type reflects the proximity of the sea and wave action on a given area of the beach. This was very clearly observed on beaches at Ekulhivaru. West end beaches are dominated by *Magoo* and *Boashi* and eastern beaches are dominated by *Kuredhi*, *Halaveli* and *Pandanas* and mixed vegetation (Figure 23 and Table 5).

Often beach rocks are also a feature on unstable beaches i.e. seasonally eroding and accreting beaches. Beach rock is often associated with *Kuredhi* lined beaches.

On Ekulhivaru Island northern beaches had sand washed on to the upper beach making the upper beach at vegetation line high and raised in many areas. This can be a onetime stormy event or could be an event relating to dominant westerly wind waves reaching the island at the NW side. The important characteristic is that the upper beaches area raised at least a meter in most areas.

Field observations confirmed these interpretations of the vegetation line and beach morphology. Extensive erosion was observed to the east end of the island and accretion to the west of the island. It was clearly seen that there was net erosion of the island to the east and net accretion and growth to the west end of the island. Detailed photos and video images of extent of beach erosion are enclosed on a data CD enclosed. Successional vegetation lines towards the SW and NW clearly indicates that beaches have stabilized around the western half of the island in recent years.

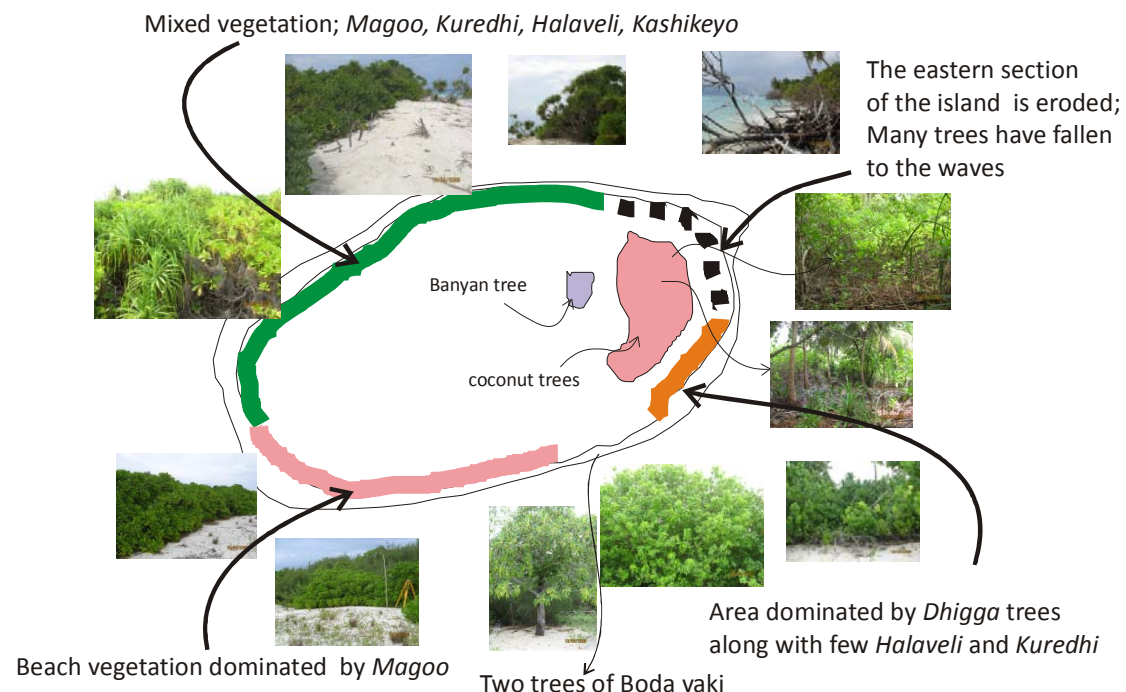


Figure 23: Vegetation themes of Ekulhivaru.

There was evidence of large scale clearing of vegetation for farming purposes in 1969. However this has stopped and now the vegetation has grown back to its

former thickness. The island now has lush green vegetation all over with very little impact from human activities. There was no evidence of felling trees and no clearings were seen on the island at the time of field assessments. According to local sources farming was carried out on the island at some time in the past. There was no evidence of farming now and no farm plots were observed. There were no clear walking paths on the island at the time of the survey but some clearings existed underneath the coconut grove at the east end of the island. Coconut palms only occurred at the eastern end of the island.

Coverage and maturity of coconut palms on an island is sometimes indicative of the maturity of the island and also the extent of usage of the island for coconut harvesting and firewood in the Maldives. Ekulhivaru had few coconut palms confined to the east end of the island. The larger part of the island was not covered with coconut palms and can be seen from the enclosed photos.

Table 5: List of common vegetation on Ekulhivaru

Scientific name	Divehi name	Abundance
<i>Alexander laurelwood tree</i>	Funa	*
<i>Amaranthus viridis</i>	Massagu	*
<i>Barringtonia asiatica</i>	Kimbi	*
<i>Cocos nucifera</i>	Dhivehi ruh	**
<i>Cordia subcordata</i>	Kaani	**
<i>Crinum asiaticum</i>	Kandholhu	*
<i>Cyperus polystachyos</i>	Hai	*
<i>Fcus benghalensis</i>	Nika	*
<i>Guettarda speciosa</i>	Uni	**
<i>Morinda citrifolia</i>	Ahi	*
<i>Ochrosia borbonica</i>	Dhunburi	**
<i>Pandanus tactorus</i>	Boakashkeyo	***
<i>Pemphis acidula</i>	Kuredhi	***
<i>Surinama maritima</i>	Halaveli	***
<i>Scaevola taccada</i>	Magoo	*****
<i>Terminalia catapa</i>	Midhili	*
<i>Thespesia populnea</i>	Hirundhu	**
<i>Hibiscus tiliaceus</i>	Dhigga	**
<i>Tournefortia argentea</i>	Boashi	**
<i>Brugiera sp.</i>	Boda vaki	*

Traditionally islands are leased on *Varuvaa* (form of rent based on the coconut palms on the island), basis to local communities and the *Varuavaa* or rent used to be based on the number of coconut palms on the island until a few years back. It follows that the rent is lowest on uninhabited islands with few or no coconut palms. Coconuts are harvested regularly for both domestic use and for revenue generation. While most islands have naturally occurring coconut groves, on young bushy islands

coconuts are planted manually by the lessee. It appears that coconut palms at Ekulhivaru have also been planted during times of farming on the island.

The beach vegetation of Ekulhivaru was thick and lush green on all sides except the eroding areas at the east end of the island. The beach vegetation was dominated by Scavola (*Magoo*), Pandanas (*boakashikeyo*), Guettarda (*Uni*), Pemphis (*Kuredhi*), Surinama (*Halaveli*) and other tropical vegetation (see Table 5 for a list of vegetation). Vegetation was thick and bushy towards the inner part of the island and consisted of few dominant varieties.

A database of photographic records of vegetation on the island and its beaches are provided as an appendix to this report (Appendix 8).

## **6. Environmental Impacts and Mitigation Measures**

Environmental impacts for this project were identified by studying the project activities carefully and visiting the project site on 2 occasions. The lengthy preparatory phase of the project allowed the consultants to look closely at local environmental aspects in detail. The project components and activities (both in the construction and operational phase) that have the potential to lead to impacts were identified and described.

Impacts resulting from the activities during the construction phase and the operation of the resort were predicted and described. Impacts were predicted based on the following aspects:

- a) technical aspects of the project (project description)
- b) survey of the existing environment (Chapter 5)
- c) experience and observations on other similar projects in the Maldives
- d) scientific and expert opinions of personal in such project developments and assessments

The impacts relating to resort development in the Maldives have been described for many resorts. All developments are carried out on a coral reef island surrounded by coral reef habitats. The nature and characteristics of impacts are very similar in most resort developments. Coral reefs in the Maldives are homogeneous in nature and therefore much of what's described below are largely based on experiences and outcomes from other similar projects. However the detailed study and assessment of the local environmental conditions help to single out aspects of the environment that stand out in a given reef.

### **6.1. Construction Phase**

#### **6.1.1. Opening the Reef Entrance**

The creation of a reef entrance channel that connects to the harbor basin would lead to the loss of bottom substrate including few live corals and other invertebrates. This is inevitable and cannot be remedied. An area of approximately 300 sq m of hard reef substrate (including reef flat and slope area) up to a depth of 2-3 meters will have to be sacrificed for this activity. Coral cover and fish life will be affected. The disturbance resulting from the activity will affect many life forms.

Impacts caused by this activity can be best estimated by calculating the proportion of hard reef bottom that will be disturbed or removed by the activity (i.e. modification of natural reef habitat). The total coral bottomed habitats around the reef are estimated to be in the order of a 300,000 sq m. Creating a channel/reef entrance will remove approximately 0.1 % of the hard coral substrate on the rim of the reef. There are no species which are endangered or threatened which will be affected by the activity.

Approximately 30,000 sq m of shallow lagoon will have to be dredged to create the proposed harbor basin including channel for landing equipment and materials. This basin will be the permanent harbor for the island. There are no significant coral habitats in the proposed location of this activity.

Dredging works using a barge and excavator and sand moving equipment is a complex activity that has the potential to generate a lot of rubbish, solid and liquid wastes. Such wastes include bags of different synthetic materials, wood, metals and many others. Different types of oil may reach the lagoon and sea accidentally. Waste material dumped into the lagoon and reef accidentally or deliberately quickly goes out of sight but will impact the marine underwater life in innumerable ways. Bags and ropes could kill corals and invertebrates. Fish life may be disrupted. Enhanced algal growth may lead to short term ecological imbalances in fish populations. Even small quantities of Hydrocarbons may disrupt food chains and physiology of reef corals and fish.

#### **6.1.2. Dredging the harbour and channel**

Irrespective of the method, dredging on coral reef environments produce large amounts of sedimentation. Fine sediments are set in suspension as a result of dredging. The suspended sediments may move over large areas of the reef and surrounding areas before they settle. This ultimately depends on the oceanographic regimes under which dredging takes place. Effects of sedimentation on corals and the marine environment have been widely described in reef environments.

Nutrients levels around the dredge site may also be altered to levels where algal blooms and flashy algal growth may be enhanced. This is a short term impact which will have to be monitored.

Dredging has direct impacts on the site (perishes most of the animals living at the site) and indirect impacts on other marine habitats by the export of fine suspended sediments. Productive coral reef habitats including Corals, reef fish and other reef organisms will be lost or displaced by dredging activity. Sedimentation affects corals directly and other key biological and ecological functions of reef organisms.

Dredging impacts include trapping and loss of bottom life during the removal of sediments and water by the dredger. This includes many species of mollusks, worms, crustaceans and fish. Benthic fauna are particularly affected by entrainment but some epibenthic organisms may also be affected.

Dredging a channel and harbor basin would alter the natural flow of physical (e.g. sand) and biological (e.g. larval and young marine animals) components around the island.

The most important irreversible impact of the deepening activity will be the alteration of the sediments movements. The harbor if left open would be a sink for

sediments which may bring about irreversible change to the sand budget of the beach and nearshore areas. If the harbor is enclosed from both sides then beaches will reshape on either side of the harbor until it reaches a new equilibrium. The impacts resulting from this will have to be monitored carefully throughout the construction and operation of the resort.

Young of many reef fish (including sharks, rays, and reef fish sp) spent a considerable period of their life close to beaches of islands. The young fry forage up and down beach at given times of the day and seek protection from larger animals in the food chain. This activity will be strongly hindered by the creation of an enclosed harbor basin. This is a seasonal activity relating to spawning periods and depends on that. In order to determine the real impacts of this monitoring of reef fish is necessary over a given period of time during and after the project activities.

A significant impact of the dredging activity is the transformation of the seascape of the reef by the channel and harbor basin. This is an impact which is irreversible and irretrievable.

Behavior of fish and invertebrates will be affected. Many pelagic lagoon fish will be forced to leave the area and will not be able to habit the area during dredging activities. This would lead to disruption of their activities and habitat.

The overall reef productivity will be affected by the suspended sediments in the short term. Planktonic organisms and the young of many reef organisms that habit the water column almost year around will be affected by suspended matter. This may lead to low recruitment rates of marine life for some years during and after the dredging activities.

Fine sediments that go into suspension by the dredging activity will lead to sedimentation and smothering of corals and invertebrates. Effects of sedimentation on corals are widely known from literature. Prolonged suspended sediments in the water column reduce light intensity and hence affect photosynthetic activity of algae living in coral tissues which in turn affects nutrition in corals. Sediments settling on corals can suffocate them and may lead to coral death if it is a chronic event. Some corals are capable of removing sediments by the action of polyp tentacles. Prolonged sedimentation will kill corals. Sedimentation in this case of opening an entrance is foreseen as a short term event and therefore it is predicted that if proper precautions are taken the affected organisms may recover quickly.

Experience from other dredging projects show that dredge sludge can be a major problem in location where water movement is low. Cased of dredge sludge at the bottom of the lagoon close to the beach can be problematic for some time. The dredge mud is usually a thin layer and gets suspended seasonally. Dredge sludge in the near shore environment can be a major problem leading to poor environmental quality.



**Figure 24:** Impacts of dredge sludge and anaerobic conditions during a dredging /construction project.

Dumping of dredged materials including sand and aggregates at the site if not planned properly may have negative impacts on the reef environment. Rubble dumped in the shallow lagoon will alter the bottom and affect the organisms there. Furthermore the rubble will eventually end up on beaches. This also becomes a source for rubble and other loose particles in the reef environment. Excess loose rubble and mobile material on reef and lagoon will restrict larval settlement of coral and other sessile organisms. This disrupts the natural revival of the dredged area. Sand and dredge remains will lead to disrupted and exaggerated sand movements.

Coral habitats around the reef of Ekuhivaru were carefully studied using still and video imaging of the underwater habitats (all images of corals and coral habitat are given on a CD attached to the report). The upper reef slope appears to be recovering from a major disturbance (possibly the 1998 bleaching). There are thriving colonies of many species of young corals (cf. Figure 15, page 53). It is important that dredging impacts on these corals be minimized.

### **6.1.3. Sand movement Around the Island**

When opening artificial channels on the reef rim on coral islands, there is the possibility of net loss of beach sand to the basin. The severity of sand loss will depend on the reef slope characteristics and the design of the harbour basin in relation to the channel. The distance between the island and the reef edge at the proposed opening is about 200 meters. The slope at this site is moderate to gradual. The loss of lagoon sand through the reef opening is likely if the channel and harbour basin are of the same depth. It is necessary the channel be shallower than the basin so that possible loss of sand over the slope is minimized.

Observations showed that the beaches around Ekuhivaru are very dynamic and move in tune with the monsoons and swells. Two forces are in play. One is the dominant wind generated waves from the NW. The second is the SE swells reaching the island. The overall outcome of these forcing functions is very evident on the island. There is net erosion at the east end of the island and net accretion and growth to the west of the island. The natural erosion and accretion on the island

will have to be controlled by soft engineering solutions. But for the first few months after the channel and harbor basin are constructed beaches will have to be monitored very closely. Erosion is very heavy at the east end of the island.

The reef top waves and current action resulting from this opposing forcing moves lagoon and beach sediments and deposits them at well defined positions around the island. Figure 13 shows the areas of sand accumulation around the island seasonally. These areas are interpreted primarily using aerial images of the island and also by local knowledge of inhabitants of the area.

It is very important that the sand accumulations around the island be preserved as much as possible so that the naturally eroded areas of the southern side of the island be replenished during the next monsoon season. Sand dredged to build the harbor will have to be deposited at the appropriate locations around the island so that get re distributed during the NE monsoon season.

Mitigation: The opening of the reef entrance involves the dredging of the reef framework. Loss of productive reef habitat and loss of biodiversity as well as changes in water flow are the main impacts. In order to minimize these impacts care must be exercised so that only the required amount of bottom hard substrate be removed to a minimum depth during the dredging works to create the channel.

To avoid loss of lagoon and beach sand through the channel the channel must be designed so that the reef opening /channel is shallower than the harbor basin. This would minimize the loss of sand through the channel by the possible funneling effect of the channel.

It should be noted the dredging proposed here results in impacts which will cease after the construction period. The fine sediments will have to be contained as much as possible through silt screens and other containment measures such as bund walls so that fine sediments do not get dispersed around the reef.

Dredging should proceed in a manner so that dredged material does not rain down over the reef slope killing more corals and other life forms at deeper regions.

Dredging times should coincide with the tidal movements so that suspended sediments get dissipated quickly away from the productive reef slope areas.

Considering the uncertainties of the real impacts of dredge-opening a reef entrance, efforts should be made to collect as much quantitative baseline information on the area before the dredging activity starts. Monitoring the baseline parameters is crucial to understanding the real impacts of dredging activities.

Dredged materials should not be dumped on either side of the reef at the deepening area in order to avoid further damage to corals by sedimentation and rubble movements. The materials should not be dumped in the shallow lagoon in the

immediate area of the site. It is advisable to use the dredged material in construction work for the resort or be donated to local communities if there is excess.

The use of protective silt screens are widely used in reef areas to protect reefs from sedimentation resulting from dredging activities. Such nets are recommended for dredging operations so that sediments are contained within the area. However it may be more cost effective to conduct dredging operations at peak current movements so that sediments are dissipated completely.

#### **6.1.4. Mobilization of Labour and Equipment**

A significant labour force will have to be mobilized on the island during the construction period. Construction equipment and machinery will also be mobilized. Careful management of both construction equipment and laborers is critical for environmental health of the island during the construction phase.

Impacts: Inexperience and lack of awareness of the coral reef environment and island may lead to damages to both terrestrial and marine environments. Unsupervised workers may indulge in felling unnecessary vegetation and affecting the island flora and fauna in a negative manner. These are impacts which can be avoided by planning.

Mitigation: Laborers should be clearly guided and supervised at all times on following proper environmental guidelines. Workers will have to be made aware of the environment and especially critical species and habitats will have to be explained in advance to starting work. Areas for construction activities should clearly demarcated by established rules. Areas for vegetation clearing should also be clearly marked and trees and plants that will not be removed also marked. Equipment and materials will only be landed at the designated point on the island developed for this purpose. Beach vegetation will only be cleared at this point. Workers should be trained at an early stage to follow strict environmental guidelines by the use of notices, bill boards and other awareness creating media.

#### **6.1.5. Vegetation Clearing**

Tourism in the Maldives is based mainly on the quality of the reef and the Island on the reef. The lush green tropical vegetation will have to be protected and preserved carefully as per tourism regulations. Tourism regulations and planning strategies strongly emphasize on preserving this special quality of the island environment. There are height restrictions of buildings on the islands and also vegetation clearing guidelines set by the Ministry of Tourism. Consequently vegetation on an island will have to be removed with care so as not to lose the natural beauty of the island.

Interestingly it is noted that the island was cleared of its natural vegetation by almost half its size for farming activities 40 years ago. Food crops such *Bimbi*, *Dhonalha*, *kudhibaiy* and *zuvaari* were cultivated on the island. Farming activities ceased on the island completely 20-25 years ago and now the island vegetation has grown back to its previous state. The extent of vegetation clearance 40 years ago is clearly seen by the Aerial photo of the island taken in 1969 (Figure 13).

It is estimated that about 13% of the island will be developed as built areas and less than 20 to 30% percent of the island vegetation will have to be cleared for built structures on land. The major types of vegetation on the island were listed in Chapter 5. *Coconut palm*, *Funa*, *Uni*, *kaani* and *Dhigga* are the main trees of valuable timber on the island. All efforts should be made not to remove hard woods and timber growing wild on the island. The island has a coconut grove to the east end of the island. It is not fully covered by coconut palms as in most mature islands and coconut palms are only restricted to certain areas. Coconut palms should not be removed or relocated unless it is absolutely necessary. Built structures should be located so that large mature trees are clearly out of the way.

When clearing vegetation for built structures and paths, only *magoo*, *kuredhi*, *boashi*, and *boa kashikeyo* and other common bushy types of vegetation will have to be removed. These are fast growing, hardy and abundant plants that grow wild on all islands of the Maldives and they can be easily rehabilitated in time.

It was observed that the island may have had mangroves growing around a swamp at some time in the past. There were a couple of mangrove trees (*Brugieria* sp. *bodavaki*) on the south eastern side of the island. There was no evidence of a swamp currently on the island. However it should be noted that inner areas of the island were not fully checked for such habitats as it was not accessible due to thick vegetation.

Impacts: Some 20-30% of common mixed vegetation of the island such as *Magoo*, *Boashi*, *Kuredhi* and *Halaveli*, *boakashikeyo* and other common bushy vegetation will have to be cleared for buildings. No beach vegetation will be removed from any area. Only path will be cleared for access to beaches. This will only have very minimal impacts on the island environment and is of short term duration. The naturalness of the island may be lost or altered by the import of non indigenous exotic plant varieties on to the island for use in landscaping and gardening. With the import of alien plant and trees come pests and diseases that may have disastrous consequences for the resident flora and fauna.

Chemical fertilizers and pesticides are commonly used for gardening imported varieties of plant to the island. Many of the chemicals in these fertilizers and pesticides are harmful to humans even in small quantities.

Sometimes fertilizers may get into ground water and may also end up on the reef environment as land run offs. Known cases of chemical effects have been described for reef species.

Mitigation: Vegetation should be cleared under strict supervision by project staff and in line with constructions works as specified in site plans. Clearing activities for buildings will have to be carefully supervised by staff with ample background in understanding local vegetation types and their importance. Only required and specified areas of vegetation should be cleared for the construction of buildings and amenities. Mature timber trees should be preserved. Import of exotic plant should be discouraged and the use of chemical fertilizers and pesticides will be limited and carried out only by experts in horticulture. Landscaping and gardening should be based on local varieties of plants. The cleared areas will have to be rehabilitated with original plant varieties as much as possible. Equipment and machinery used for this activity will have to be carefully supervised and regulation with clear instructions and guidelines relating to vegetation clearing.

#### **6.1.6. Disturbances to Resident Fauna**

Tropical islands are abound with varieties of insects and seabirds birds. Seabirds were observed to nest on Ekulhivaru. A large number of extensive events of turtle nesting were observed on Ekulhivaru. At least 20 turtle nests were observed in the survey of 2008. There was strong evidence that turtles home on this island regularly. It is also to our knowledge the local visit the island for egg harvesting although both egg harvesting and catching them is illegal, as all the nest have been dug. But care should be exercised during the construction phase so as not to disturb nests.

Impacts: Turtle nests were observed on all sided of Ekulhivaru but dominant on the northern side. Turtle nesting areas will be disturbed by developments close to the beach. Resident insect populations are critical for facilitating reproduction and recruitment of plant varieties. Construction related clearing, felling of trees and possible chemicals and air pollution from machinery may drive or kill insect populations. This may be a short to medium term impact. Birds nest on this island and care should be taken to minimize disturbance to resident and nesting bird populations.

Mitigation: Turtle nesting areas will be clearly marked and construction should be planned in such a way not to disturb nesting turtle populations. Laborers and construction workers should be educated on protected marine and terrestrial fauna particularly of turtle and bird species protected by law.

#### **6.1.7. Use of Ground Water Resources of the Island**

The quality of the ground water on Ekulhivaru was reported to be of good quality. The water aquifer is at a reasonably mature state in terms of salinity levels. Farming has been practiced on the island at some time in the past according to local people. Ground water would have been then used to water the plants. Experience from other similar small islands show that ground water can easily be exhausted under construction stages on major development projects. It can also be polluted easily. In general tourism regulations prohibit the use of ground water in the operation phase of the resort. Nevertheless water will be used indirectly by construction related activities.

Impacts: Use of ground water for construction may lead to the depletion of the resource given the small size of the island. Some construction may require dewatering of ground water. In both cases this leads to salinization of the ground water. Ground water pollution is likely from chemicals and oils if proper precautions are not taken. Many cases of ground pollution have been reported in the Maldives. Oil if it reaches ground water maybe difficult to clean up and my render the water unusable and affect the fauna of the island too.

Mitigation: A temporary desalination plant should be installed on the island during the construction stage to provide water for construction workers and for other uses

during the construction stage. No ground water should be used for any major work during the construction phase. The water should be left to natural recharge. Precautions should be taken not to pollute the ground water aquifer with chemicals, pesticides and hydrocarbons.

#### **6.1.8. Piling and Construction of for Over-water Structures**

Overwater villas will be constructed within the shallow coastal lagoon at Ekuhivaru towards the east end of the island. These water villas are built just a few meters from the beach on concrete pillars on shallow water. They are connected to the main island by a wooden platform or jetty. Two jetties on piles will also be built in the northern and southern sides of the island. The construction of the water bungalows and jetties requires moderate dredging to place the concrete pillar foundations for the above water structures. The piles will be prefabricated on land and placed in water using suitable machinery.

Impacts: Dredging by excavators will create fine sediment affecting the coral habitats. Sedimentation from dredging for water bungalow structures may affect nearshore coral communities. The shallow lagoon habitats around the over water developments have scattered small patch reefs teeming with life. Some of these coral habitats will be perished if not managed properly. Small patches of massives occur in the shallow lagoon and these should be carefully avoided in the construction of water villas. Bottom sediment structures around the building sites maybe altered and burrowing fauna such as mollusks and crustaceans may be killed directly. The over water structures will modify the lagoon environment leading to ecological changes. The shading effects of the structure will certainly bring about ecological changes to the site. New species may move to and habit the area. This will be a temporary change which will eventually balance out. For example shade loving species may find refuge around the over water villas.

Mitigation: The construction of piled coastal structures should be carefully supervised such that impacts on the marine environment are kept to a minimum. Debris remaining from the activity should be promptly collected and disposed on land. Solid construction materials such as nylon bags, wooden planks and plastics lost to construction sites offshore get carried away and eventually end up on reef habitats. These should be recovered and disposed of properly.

#### **6.1.9. Construction Related Waste Disposal**

A variety of construction wastes and residue are generated in usually large amounts during the construction stages of resort developments. Occasionally these materials have found their way to the coastal and nearshore lagoon environment. Materials of concern include non biodegradable matter such as nylon material, plastic bags, glass

bottles and PVC materials and metals. Construction debris gets dumped around the island affecting habitats and animals living therein.

A fair amount of oil, household and construction related chemicals would be used during the construction phase of the project. A clearly plan should be in effect so that construction related materials are disposed of properly during the construction stages. Chemicals and accidental leakage of oil to the ground leached into the ground or discharged to the marine environment would have long term consequences.

Impacts: Non-biodegradable solid waste material may linger in the reef environment for long time periods of time unnoticed and causing significant damages to the marine environment. Marine animals have the habit of biting stuff they come across as with other animals and they can become sick. Most industrial cleaning products, chemicals and hydrocarbons are harmful to the environment. Such chemical can play havoc in marine food chains. Contamination of water affects organisms especially filter feeding and bottom dwelling organisms. Long term effects include bioaccumulation of chemical compounds and animal health. Solid wastes in the marine environment lead to the disruption of marine life and killing of corals nearshore. Such material could smother and kill bottom animals by cutting off oxygen supplies thereby creating anoxic conditions underneath such materials. This is a common case of environmental deterioration in reef environments where construction wastes are mismanaged. The cumulative effects of solid wastes and dredge residue can be very undesirable leading to deterioration of beaches and neashore environments and resulting in low environmental quality.

Mitigation: Proper systems should be in place to collect and sort construction wastes. Designated area should be marked at sited for designated types of wastes generated during construction. Such wastes shall be disposed of per government regulations. Wastes on the island should be minimized. Oils, chemicals and batteries and other harmful substances should be stored at designated area under strict guidelines and regular supervision until they can be safely disposed at a disposal site.

#### **6.1.10. Sewage and Wastewater during Construction**

A temporary sewage and wastewater management system will have to be established on the island during the construction stages. It is proposed that temporary septic tank system be established during the construction stages. These temporary arrangements will have to be designed in such a manner that they can be decommissioned soon after the permanent system is established.

Impacts: Untreated Sewage and nutrient enriched wastewater if disposed to coral reef environments can lead to serious ecological imbalances primarily due to

phytoplanktonic blooms and growth of filamentous and turf algae. The consequences of such ecological disturbances have been reported in literature.

**Mitigation:** Temporary septic tank systems placed for collection and disposal of sewage and wastewater will have be planned so that they run for the shortest possible time period where the actual sewage treatment plant for the island is installed. It is expected that the soak pits for the septic tanks will be short lived and would have minimum impacts on the ground water resources of the island. The outflows of these septic tanks should not be let into the shallow lagoon at any rate.

## **6.2. Operation Phase**

### **6.2.1. Water Resources and Conservation**

In the Maldives all resorts are required to produce and distribute their own water by desalination processes. This is the standard for all resorts. It is estimated that Ekulhivaru resort will need 200 ton capacity desalination plant for the operation of the island. During the operation of the resort the demand for water both for guests and staff will be met by 2 x 200 ton per day Reverse Osmosis desalination plants.

Tourism regulations require that all tourist resort islands in the Maldives produce water by desalination. This water will be used for all toilets, washrooms, and kitchen and laundry facilities as well as charging the soils in garden environments.

**Impacts:** Correct location of water intake for the RO plant is critical for human health. In most cases water is pumped from the lagoons or the seas adjacent. Seawater taken from the surrounding waters of the island may often be contaminated by naturally occurring pathogenic organisms and bacteria. It is best to pump seawater from beneath the island by a deep borehole. This would ensure that the seawater obtained is free from any pathogenic organisms and chemicals.

If the intake seawater is contaminated this may have serious health concerns for the users. Water borne diseases may breakout if contaminants get into to the system. In order to avoid this it is necessary to locate the seawater intake from a source that would be free from contaminants at all times. This is achieved by taking seawater from a borehole located at suitable depth on land.

Reverse Osmosis desalination plants generate highly concentrated brine as a bi-product of the desalination processes. The brine is contains high concentration of salts that is harmful to marine animals if disposed improperly. It is expected that brine will be discharged over the reef flat at suitable depth and at a point of maximum dispersal. This will be determined during the construction phase of the resort. Given the nature of ocean circulation around reefs and the availability of a large body of water it is almost always expect that maximum dilution will be achieved in brine discharges.

**Mitigation:** Water conservation plans will be in place during the operation stage of the resort. Established methods of water production by desalination and relevant regulations set by the Maldives Water and Sanitation Authority and conservation will be strictly adhered to in water production and distribution. The establishment of a desalination plant on the island would effectively stop all usage of the ground water of the island there by conserving the island ground water lens for the future. Brine from the plants will be discharged in a manner where maximum dilution is achieved. Water saving appliances such as water saving taps and shower heads will be fitted at all baths and toilets and water distribution points on the island for water conservation.

### **6.2.2 Sewage and Wastewater Treatment and Disposal**

Sewage will be treated completely at Ekuhivaru. There will be no discharges of untreated sewage to the surrounding lagoon or the reef environment. A modern Membrane Bio-Reactor (MBR) type sewage treatment plant will be installed on the island. The proposed sewage treatment plant is capable of treating 100 cu. m of sewage per day to secondary level treatment and would easily cater for a population of 500. Treated water from the treatment plant may be used to irrigation and for flushing toilets.

The proposed treatment plant works by passing the sewage with water over a series of screening, filtration process (anaerobic filtration and contact aeration) followed by series of sedimentation and disinfection before the effluent water is pumped to storage tanks. The excess/waste sludge which passed over sludge digesters and sludge dewatering tanks will leave only sludge cakes which will be either disposed to or burnt in the incinerators regularly. The plant can stock sludge for a long time. The plant is capable of treating sewage and waste water to secondary treatment levels so that the grey water produced by the plant can be used safely for a variety of activities such as watering plants and ground water recharging and flushing toilets. There will be no impact on ground water as no seepage is foreseen. The system requires occasional removal sludge cake and grit which will need to be disposed of at deep sea or at designated waste disposal site in the atoll.

**Impacts and Mitigation:** The proposed installation of a state-of-the-art sewage and wastewater treatment system on the island to deal with all liquid wastes and will solve most of the sewage and wastewater on the island. No major impacts are foreseen from this activity.

### **6.2.3. Power Generation and Conservation**

Power generation at Ekuhivaru is planned by using diesel generators. This is common on all resorts in the Maldives without exception. Alternative energy sources such as solar are used at some resorts. Electricity for all purposes on the

island will be provided by 4 x 725 kVA diesel generator sets. The power house will be out of the way at the inner area of the island along with similar service facilities such as the desalination plant and the sewage treatment plant.

The power house will be fully sound proof, fitted with soot filters and insulated for heat containment. Electricity distribution and usage will be centrally managed through computerized panels so as to conserve and optimize electricity. The power house will be served by a Diesel fuel tanks of fabricated of Steel with a total capacity of 10 x15,000 liters. These tanks are enclosed by a protective concrete bund wall that can effectively contain all the oil in the tank in the event of a leak or an accident. Fuel to the tanks will be filled using a specialized pump station at the service jetty.

Impacts: Hydrocarbons (HC) are harmful to both terrestrial and marine animal life. The long and short term physiological effects of HCs are well known. Oil leakage to ground will contaminate the ground water requiring expensive clean up operations.

Mitigation: Smalls spills and waste oils will be contained within the concrete water proof structures of the power house compound and collected promptly to be incinerated later. The delivery and storage of diesel and other fuels at Ekulhivaru will be carefully managed and there is little chance of accidental oil spills. However a contingency plan will have to be developed and staff trained in an accident and possible clean up operations. Electricity conservation measures will be implemented via the environmental management plans to be produced during the operation of the resort. The developers are committed to install and use power saving electrical appliances where necessary. The guests and staff will be educated on power conservation. Wind and solar energy options will be sought as further measures to conservation energy and contribute towards the government's carbon neutral policies.

#### **6.2.4 Solid Waste Disposal**

During the operation of the resort large amounts of solid wastes will be generated on the island. A list of possible solid waste items that may be generated on the island and their disposal methods and means are given in Table 6. Major types of solid waste include material such as metal cans, bottles, paper, wood, and plastics. Specialty restaurants are planned for the resort including a staff canteen. These would produce substantial amounts of kitchen and food wastes. Food wastes will be composted and excess will be disposed via the Sewage system using Kitchen appliances such the InSinkErator type waste food disposal systems. In accordance with government regulations a bottle crusher, can compactor and an incinerator will be installed on the island for the disposal of selected solid wastes.

*Table 6: List of Common types of Solid wastes generated on the island and their disposal*

Waste Material	Anticipated form of Disposal
Metal cans	Compacted by Compactor
Glass bottles	Crushed by the bottle crusher and disposed at site
Plastic bottles	Recycled and /or disposed
Papers of sorts	Incinerated
Wood	Incinerated
Domestic organic wastes	Incinerated
Kitchen and food wastes	Composted or disposed via InSinkErator type waste food disposal system
Waste oils	Incinerated at Thilafushi or other suitable facility

**Impacts:** Proper Solid waste management is the key to sound environmental health on small islands. The impacts of solid wastes in coral reef environments are well known. Food wastes will attract pests and pose a potential threat to useful birds on the island. Oils, plastics, metals and paper wastes, and chemicals all pose a danger to human and marine life. The developer is aware of the fragility of the coral reef environment and undertakes to and plans to deal with solid wastes as per government regulations and for their safe disposal as per internationally excepted norms and standards. A solid waste management strategy will be developed for the island which identifies mechanisms for sorting and recycling of solid wastes in order to minimize the impacts on the environment.

#### **6.2.5. Transportation**

Sea transport using different sources of vessels is a significant activity at all resorts in the Maldives. Ekulhivaru Resort will have to manage a fleet of vessels for resort use. High speed jet powered and outboard speed boats will be used for guest transport. Local dhoni type boat activity is also a sustained activity at resorts. The inner harbor basin will be constantly used by these boats of various sizes and power.

**Impacts:** Observations of boat activity in Maldivian harbors show large scale bottom sediment (especially fine sediment that gets constantly set in suspension) constantly released into suspension during boat activity. Continued sedimentation from the harbor may be a source of sedimentation effect on nearby coral habitats. Sedimentation from the harbor activities may affect the health of corals growing near the vicinity of the harbor and furthermore inhibit the new settlement and growth of corals around the area. Increased boat activity also increased the potential for impacts on corals by way of soft groundings, brushing and anchoring. Pollution from boats is also a major issue. Bilge and oil wastes get dumped occasion into the surrounding waters. This is very harmful to marine life. Marine littering is a

critical and lingering issue. Plastics and other synthetics thrown overboard can kill marine life.

**Mitigation:** Deep water moorings should be installed on both north and south sides of the island. These should be used whenever feasible. Boat captains should be trained and educated on caring for the marine environment during boat handling and operations. Special training sessions should be held regularly on the resort for new crew and upgrading of existing crew.

### **6.2.6 Pest Control and Management**

Human interventions (introduction of food and wastes and similar products etc) in tropical islands create ideal conditions for flourishing different type of insects and animals classified as pests. The populations of pests, which usually are in equilibrium under normal ecological conditions on a uninhabited island, can change dramatically in response to development. Pest management practices will have to be implemented on the island but care need to be exercised in the management and use of chemicals and pesticides to control pests.

Mosquitoes become the most persistent problem when the island gets habited by humans. The common control of mosquitoes is to use diesel or temephos granules as a larvicide and fogging (with a organo-phosphatecompound) as an adulticide. This is seldom truly effective as the control of mosquito larvae is only conducted effectively if the applicator is diligent. Additionally, areas that applicators 'miss out' will become areas of profuse breeding. Adulticiding was seldom truly effective as this is only an effective control measure for adults, and immediately after a fogging operation, larvae emerge and mosquito situations still persist on the land.

Crows occur in close-by islands. Crows are considered pests and they are sometimes controlled by the use of chemicals.

**Impacts:** Larviciding methods are not environmentally friendly. Larviciding water receptacles with diesel or temephos have the effect of killing ecologically favorable aquatic insects and other organism that utilize the concerned water areas, there by killing useful insects or animals. Fogging operations are not selective to mosquitoes only and had the effect of killing many ecologically beneficial species such as dragonflies, bees and other insects. The loss of populations of insects can be detrimental to the island ecosystem as the ecosystem services provided by these insects are affected. Reproductive ability of some plants may be affected as most depend on insects for the dispersal of their pollens.

**Mitigation:** It may be necessary to initiate most pest control measures during the construction phase so that a proper management protocols can be developed in time for the operation stages of the resort. Pesticide use should be species specific as opposed to genera specific so that the impacts of populations are minimal. Care should be exercised in the use of chemical pesticides and national regulations should

be adhered to at all times. All the chemicals are monitored and daily usages of each chemical used is tracked. This ensures all chemical used are used in accordance with all labeled. Active ingredients for each pesticide are rotated on a bi-annual cycles to prevent the pesticides resistance by target insects.

Chemical usage of mosquito control should be discouraged. The application of *Bacillus thuringiensis var. israelensis* is common in many islands. This non-pathogenic bacterial mosquito larvicide is specific only to mosquito larvae. They have been known to be widely used in tourism industry and considered to be very effective and ecologically sound. When applied to water receptacles both small and large (including tree axils and leave litter), only mosquito larvae are killed. The product has no effect on other insects. This serves to encourage other insects to thrive and breed. By initiating control for ONLY mosquitoes, other insects are not affected. With this, the need fogging can be eliminated entirely from the island.

### **6.2.7 Water Sports activities**

Maldivian resorts are built for water sports and most recreational activities are centered on the marine environment. Diving is the single most popular service provided to the guests where as the lesser adventurous have the option of exploring the shallow reef flat and slope habitats by snorkeling. Other water sports available at resorts include wind surfing, boating, swimming etc.

The quality of the marine environment around Ekulhivaru including the nearshore lagoon environment and coral reef habitats were described in section 5 of this report. Ekulhivaru has extensive coral reef habitats accessible by snorkelers around many parts of the island. The narrow channel which winds through the *Helipora* bed at the west end of the island leads to the most diverse and lively reef flat and slope area on Ekulhivaru. The upper reef slope has thriving coral and fish communities. It is likely that this area due to its beauty will be promoted as the best area for snorkeling at Ekulhivaru. There is the possibility of impacts on the corals and reef life by unskilled swimmers, snorkeler and other guest with no knowledge of the sensitive nature of the coral reef habitats. Ekulhivaru has extensive *Helipora* beds at close proximity to the beach at very shallow waters. *Helipora* are delicate corals which can be easily damaged if stepped on. Special efforts will have to undertaken to preserve the coral reef habitats within the lagoon slope towards the west end of the island.

Recreation fishing is a significant recreation activity at most resorts in the Maldives. It is also a traditional activity skillfully and enthusiastically undertaken by locals.

Impacts: Swimmers, snorkelers and waders on reef flat habitat around the island can disturb and damage corals if their activities are not managed. Snorkeling and diving is the most important activity on the reef it also is often interpreted as the most destructive activity on shallow reef habitats. Waders and swimmers will have

to be educated as not to damage fragile corals and also not to disturb the ecology of coral reef fish and invertebrates by feeding, treading and breakages other undesirable activities.

Shallow reef flat habitats around the reef and nearshore coral habitats are probably recovering from major disturbances in recent years. These habitats need to be monitored for further impacts in the coming years. Coral reef habitats were described in Section 5 of this report. It is important that these habitats be well looked after in the operation of the resort. Snorkelers will need to be educated on the code of conduct for responsible diving and snorkeling. Recreation water sports especially swimming, wind surfing, etc. would also have to be regulated in a manner so that they do no impact coral reef habitats.

Mitigation: All guests should be well oriented for the marine environment. Regular evening session shall be held to increase awareness on the marine environment for both staff and guests.

## 7. Alternatives

### 7.1. Reef Entrance / Channel Opening Site

In seeking alternative to the reef entrance, harbor basin and temporary landing site, several factors need to be taken into consideration. First of all this is an activity without which the development of the resort cannot function. Whatever the alternative chosen for operation phase, some form of jetty or access to the island is required.

The following are alternative development options and considerations for the jetties, reef entrances and harbor development:

1. Do not have channel opening and consider constructing a jetty on piles all the way up to the reef edge. This option is not possible given the shape of the island and the hydrodynamic regimes around the island for a given monsoon. The location of the Ekulhivaru reef and hydrodynamic forcing meant that waves sometime break on all sides of the reef. At such times it will be impossible to operate from a piled jetty at any point around the island. Given this situation it is absolutely necessary to have a reef entrance and a harbor basin at Ekulhivaru as planned.
2. Build a temporary entrance, harbor, landing platform for equipment and decommission these at the end of the construction phase. As in # 1 the climatic conditions around the reef meant a harbor was necessary.
3. There was an existing cleared channel to the island on the west end of the island. It was tempting for the developers to locate the reef entrance at the point of the reef. However after careful consideration this plan was abandoned as it would mean the destruction of the Helipora coral bed in this area. The non reef building coral Helipora was observed to be a significant ecological habitat on Ekulhivaru reef. It was noted that the west end location was also the area of maximum hydrodynamic action during the stronger SW monsoon with prolific growth of coral. Given these factors the west end reef entrance and channel opening was abandoned.

Ekulhivaru has a well developed algal ridge all around it. It is not possible to access the lagoon during mid to low tide levels. There was also a well developed shallow reef flat all around the reef and a shallow lagoon behind it. These characteristics mean that a landing facility will be needed as part of the initiation of any development activities on the island. A permanent structure will be required at the outset. This will involve dredging and deepening a channel. Option one cannot be chosen.

A permanent piled jetty up to the reef edge is desired for most coral reefs. However, such a jetty can only be constructed at relatively sheltered conditions. This is not the case for Ekulhivaru. Swell and wind induced waves reach the island at all times to

varying degrees. A piled jetty cannot be used to unload construction material and equipment during the construction period. Option two cannot alone serve the development objectives.

The proposed site selected for the opening of a reef entrance at Ekuhivaru has been chosen after careful assessment of the monsoonal wind patterns based on long term wind data analysis and local knowledge. Previous caretakers of the island were also consulted. The reef entrance and channel opening was located at the south east side of the island because it was the most stable of the lagoon area around the island. That was the most protected area of the island for most of the year. It was also the area where minimum habitat damage was envisaged.

The proposed option is the most favorable option in order to meet the development objectives of the resort both for the construction stage and operation stages. The reef of Ekuhivaru is exposed to strong currents and waves during the strong SW monsoon and a protected harbor would be a prerequisite for the operation of the resort.

## **7.2. Clearing and Deepening Activities**

There are 3 different methods of dredging commonly carried out in the Maldives. Basically the method employed in a given project depends on the type of dredging required, the location of the project and the objective of the dredging activity.

1. Use of a sand pump to suck up the sand: This type of deepening is only suitable for small jobs such as beach replenishment and beach modeling. It is a slow process which is designed to suck fine sand from lagoons. The advantage of the method is that it creates less sedimentation at the source area. This method certainly cannot be used to dredge the channel. But maybe used to deepen the harbor area. However this may be impractical given the slow nature of the process. The method also depends on the bottom structure of the reef.
2. Using a cutter / suction dredger (CSD). This is a method for heavy dredging and reclamation which also generation most sedimentation both at the sources and dumping area. Use of CSD will be prohibitively expensive and not justified method for this project.
3. This project proposes to use an excavator for channel opening as well as deepening the harbor. This is the most common method in use by all major harbor development projects in the Maldives. The consequences of this type dredging are largely dependent on the reef type, location, hydrodynamic regimes, proximity of the island to the reef edge. It is very important that regular monitoring be in place during the dredging operations to determine impacts and mitigation measure proposed.

Dredged sand and other materials will have to be properly managed. It is proposed that dredged sand be used to replenish the eroding area of the island. Alternatively the dredged material may be temporarily piled at the upper non vegetated stable areas of the *thundi* (sand spit) at the east and west of the island. In this way they can be reused to replenish beaches if necessary.

## 8. Environmental Monitoring

The activities pertaining to this resort development project has the potential to cause moderate to low impacts on the marine environment. Despite widespread dredging activities on coral reefs in the Maldives, direct impacts of dredging activities have not been well documented locally. Most impacts have been described based on literature from other sites, local knowledge and qualitative interpretations. In order to determine the long term impact and mitigation of the dredging works proposed for Ekulhivaru, a monitoring programme should be developed to understand the impacts of the initial dredging activity, at least monthly, in the construction stages of the resort. This is critical so that appropriate remedial measures be implemented in a timely manner. Monitoring is also critical to attend to any urgent issues that may arise during the construction. The following parameters should be monitored once every three months for the first year and bi-annually thereafter:

1. Percent coral cover of coral reef habitats adjacent to the dredge site:  
Detailed baseline data has been collected at selected points along the productive reef flat and slope of the reef. Using the same methods adopted in this report, coral cover should be recorded at the same locations throughout the construction period. Coral cover should be monitored on the reef slope, reef flat and lagoon habitats.
2. A reef fish census has been carried out around the reef of Ekulhivaru by manta tow surveys and timed swims at selected points. The methods for these surveys were explained in the Methodology section of this report. Using similar methods, fish surveys should be carried out as above during and after the dredging operations.
3. Baseline water quality parameters have been established<sup>13</sup> for the waters around the island and the ground water. The water quality analysis is designed for mitigation purposes and the same parameters shall be analyzed once every two months during the construction period.
4. Beach profiles at baseline points and sediment movements were predicted and reported in this report. It is crucial that beach morphology be closely monitored during the dredging and deepening activities and also during the operation of the resort. Beach profiles should be taken every month during the coastal works proposed in this report.

Considerable baseline information has been collected for the site and physical observations have been made of the site during the initial field survey. Data collection for the monitoring programme should focus on methods used to collect the baseline information in this study in order to make valid comparisons temporally.

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<sup>13</sup> Water quality tests will be done before any construction work begins (see Section 5.5.7, page 57)

The developer undertakes to allocate the necessary budgets and to prepare and present the reports of the monitoring programme outlined here to the authorities.

Parameter	Frequency of Monitoring / Locations	Approximate cost of monitoring & reporting per event/ Responsibility
Substrate cover (live coral, dead coral, rock, rubble, sand)	Once every three months 50 m on each side around channel clearance area; After that depending on favorable outcome once every six months.	US\$ 250; Proponent
Water Quality (Nitrate, Nitrite, Phosphorus, Ammonia, fecal coliform)	Once every three months; after that once every six months	US\$ 150; proponent
Beach profiles / beach measurements	Once every three months for the first year from the start of operational phase; following that once every six months	US\$ 500; Proponent

Similar to many resorts, Ekuhivaru may want to establish a long term Environmental Management and Monitoring Programme. Such programmes have been proved very useful in detecting the environmental issue and therefore adoption of mitigation measures in good time. In other resorts the programmes have also been successfully used to as an education and awareness tool for both guests and locals.

## 9. Public Participation and consultations

Noonu atoll has 6 resort islands some of which are under development:

1. Kudafunafaru
2. Huvandhumaa vattaru
3. Medhafushi
4. Randheli
5. Maavelavaru
6. Ekulhivaru

Consultations with local communities at Velidhoo, Manadhoo, Kudafari and Holhudhoo revealed that the communities would like to see resort development in the atoll. The main occupations of the island communities are fishing, farming, building and construction works and boat building. The islanders feel that the development of Ekulhivaru will lead to job and income earning opportunities for them. In general people had high hopes for tourism development close to their islands. People felt quite strongly about providing employment opportunities in the building and construction phase of the Ekulhivaru development. No negative comments were received from the locals regarding this project.

The perceived negative impact of the project on local communities on Kudafari, Hembadhoo, Kendhi kulhudhoo etc are that they will not be able to tap any resources from the island after the island is developed. People will not be able to fish at the house reef of the island. NO concerns were raised on any fishing issues or bait fishing.

As in other existing situations, Ekulhivaru operations will be another added opportunity for air travel to Male and back on Air taxis. This is also a beneficial event related to tourist arrivals.

Potential conflicts of tourist operations at Ekulhivaru may be related to fishers and resort management attempting to fish, dive or snorkel at selected hotspots for both parties. Such issues could be settled by communication and cooperation.

Turtles nest extensively on Ekulhivaru. During the visits to the island by the consultants in 2008 and 2010 at least 20 turtle nests were observed. Fresh turtle tracks were also observed and recorded. Although turtle populations have been totally protected by law in the Maldives, some locals still have a tendency to hunt for turtles and collect turtle eggs illegally. Developments at Ekulhivaru will protect the turtle populations indirectly. At the same time developments on the beach will disturb nesting turtle population.

## 10. Conclusions

Tourism has undoubtedly become the pillar of the Maldivian economy and represents the most important economic vehicle for employment, trade, transport and many other economic sectors.

The government has outlined its strategies for tourism development in the Maldives Tourism Masterplan 2007-2011 emphasizing on developing tourism in harmony with nature, facilitating private sector investments, increasing employment opportunities, diversifying tourism markets and products and spreading the economic benefits of tourism across the entire Maldives archipelago more equitably.

The government has earmarked new resort developments at strategic locations around the country to meet these. Ekulhivaru is one of the 11 islands jointly managed by the Maldives Tourism Development Corporation. Ekulhivaru is located in the Noonu Atoll. Employment and trade opportunities will be created directly from the project for the inhabitants of the atoll.

This report presents the environmental impacts of developing a world class resort at Ekulhivaru as per the concept proposed by the developers and activities associated with the project. Significant impacts have been discussed and mitigations have been proposed. Most impacts are short term which will be mitigated by monitoring the environmental components that will be affected. Some impacts are irreversible such as the opening of a reef channel and the creation of a harbor. These are long lasting impacts which will have to be managed during the operation of the resort.

Given the long-standing experience of resort developments in the Maldives, it is expected proper surveillance and monitoring commitments would avoid significant damage to the environment from the overall development of this resort.

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## **Appendices:**

1. Commitment Letter from the Developer (ENA Holdings)
2. Official TOR (Scope of the EIA)
3. Approve Project Concept Drawing
4. Beach profiles data / depth profile data
5. Indicative Project schedule
6. Typical details of the footings for overwater structures
7. CV of the non-registered consultant (AN)
8. CD of complete photo-images