Assessment of Eidhigali Kulhi and Koattey Area

S. Hithadhoo, Maldives

Ministry of Environment, Energy and Water
Malé, Republic of Maldives

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Contents

Abbreviations and Acronyms

AMSAT	Australian Marine Science and Technology
AusAID	Australian Agency for International Aid
BFS	Business and Financial Services
BML	Bank of Maldives
CITES	Convention in International Trade of Endangered Species
FAD	Fish Aggregating Device
GBRMP	Great Barrier Reef Marine Park
GIS	Global Information System
GPS	Global Positioning System
HPA	Hithadhoo Protected Area
IDC	Island Development Committee
IDF	Island Development Fund
IUCN	International Union for Nature Conservation
LIT	Line Intercept Transects
MAA	Ministry of Atoll Administration
MMA	Maldives Monetary Authority
MPAS	Maldives Protected Area System
MPHRE	Ministry of Planning Human Resource and Environment
MRC	Marine Research Centre
NGO	Non Governmental Organizations
PA	Protected Area
RDP	Regional Development Project
SCUBA	Self Contained Breathing Apparatus
TV	Television
UNDP	United Nations Development Programme
VCR	Video Cassette Recorder
VOM	Voice of Maldives

Local words used

Rabaali	A locally used bait, common English name is Slender Sweeper
Farubeyru	Bait fishing Ground located within the proposed protected area
Fehivina	An environmental program broadcasted by the Television Maldives
Eidhigali Kulhi and Koattey	The proposed protected area located in S. Hithadhoo
Ranihanaafengadu	Queens Bath, a historical site located within the protected area
Odessa	Local name given to the area within the protected area
Kulhi	Brackish water pond
S.Hithadhoo	Capital Island of S. Atoll

Foreword

Mr. Ahmed Abdullah
Minister of Environment, Energy and Water

It is with great pleasure that we are introducing this publication on the occasion of the Environment Day 2006. The publication aims to improve understanding of the biodiversity of Maldives focusing on the protected area of Eidhigali Kulhi and Koattey area of S. Hithadhoo.

Eidhigali Kulhi and Koattey Area of S. Hithadhoo, Addu Atoll has exceptional biodiversity features. The site is the location of the largest breeding, nesting, and feeding ground for many birds such as the Eastern Grey Heron and the endemic Maldivian Pond Heron. Many migratory birds transit the site. It is a mangrove habitat; a threatened species throughout the country. The site prides itself as having one of the best reefs in terms of diversity and healthy reef systems. It is a habitat of the protected Napoleon Wrasse which is favoured by high class diners and is famed for sighting Melon Headed Whales. The site is also socio-economically significant with its legendry past with Koattey being one of the historical locations with archeological remains of the British base in operation during the World War 2. With extensive coconut harvesting area and potential for agriculture production along with its sand and rubble beach it is a spectacular nature spot as well as educational and recreational site.

Due to its unique biodiversity significance Eidhigali Kulhi and Koattey area was declared as a protected area in 2004. Prior to that from January 2000 to June 2003, the site was extensively studied under the Maldives Protected Areas System Project. The goal of the project being to contribute to the protection of the ecological resources in the Maldives and thereby supporting long-term ecological sustainable development and biodiversity maintenance. One of the important objectives of the project was to raise educational awareness in relation to the country's biodiversity. It is hoped that this publication will help in achieving the objective and will increase awareness and understanding of the benefits and costs of environmental conservation.

As we are all aware since time immemorial Maldivians have been surviving on the use of biological resources thus incorporating biodiversity as part of their tradition and culture. Our biological resources have been the basis of our economy and livelihood on which the present and the future generations depend. Efforts at conservation was given more prominence with the formulation of the Fisheries Law in the early 1970's.

As the country's precarious and fragile ecosystem coupled with economic development faced new threats to its environment, Maldivian government's commitment and dedication to the protection of the environment became the top most national priority. Numerous initiatives were taken by President Maumoon Abdul Gayoom both internationally and at the national level to increase the efforts in protecting the environment. The Fisheries Law was revised in 1985 giving protection to a wider range of marine resources such as turtles, whales, dolphins, certain corals and fishes. Recognising the need for a more comprehensive and integrated approach for environmental management, the First National Action Plan, was developed in 1990. In 1992, Maldives took another important step towards its commitment to protect and preserve the biological resources by becoming one of the first nations to ratify the UN Convention on the Biological Diversity. The enaction of Environment Protection and Preservation Act in 1993 was another milestone, which gave a very high priority for the protection and conservation of biological resources on a broader scale with regard to ecosystem and habitats. Under this Act, several species of seabirds, endemic birds, unique islands, and several dive sites are protected. The Maldives Protected Area System Project implemented from 2000 to 2003 and the Baa Atoll Ecosystem Based Project, which is being implemented presently are aimed at managing these protected areas.

The main objective of this publication is to increase awareness and knowledge in the importance of biodiversity conservation. The book is a vital contribution towards the existing knowledge of biodiversity of the Maldives. The publication abounds with information that can serve as a foundation for protection and conservation of future programs. I hope that many will find it useful and will inspire us all to raise commitment to environmental protection and preservation of our unique environment.

Acknowledgements

The studies undertaken under the Maldives Protected Area System Project were largely funded by the Australian Agency for International Aid. As a major component of the project three post graduate scholarships were funded. The socio-economic assessment and the proposal for zoning included in this publication are part of the research work undertaken under post graduate study programs.

The team leaders and consultants of the Maldives Protected Areas System Project, Dr Ian Dight, Dr Lea Scherl, and Geoff Dew had imparted and shared their knowledge on the protected area management. The Marine Survey published in this report was lead by Marine biologist, Steve Lindsay, in collaboration with local counterparts. The Vegetation Survey was undertaken by the local team lead by Bill Gardene. The Ministry of Environment, Energy and Water gratefully acknowledged their assistance and support.

The Ministry of Environment, Energy and Water would also like to thank the community of Hithadhoo, and the staff of the Island Office of Hithadhoo and the Atoll Office of Addu Atoll for providing information and sharing their knowledge which are incorporated in the studies of this publication.

Abstract

The document is published with the aim of improving the understanding of the Maldivian environment and to promote sustainable utilization of our natural resources. This document deals exclusively and in great depth on the protected area of S. Hithadhoo and consists of original research results of three studies; vegetation, marine and socio-economic survey, and a proposal for zoning undertaken under the Maldives Protected Area Systems Project implemented from 2000 to 2003.

Maldives Protected Area System was aimed to build institutional and human resource capacity at the government and the community level to support the establishment of a comprehensive system of marine and terrestrial protected areas within the Maldives. Under the project Eidhigali Kulhi and Koattey Area of S. Hithadhoo was selected as a pilot protected area with the purpose of establishing a replicable and sustainable system for protected area management. The protected area encompasses land and reef area adjacent to Hithadhoo community. The goal of the project was to contribute to the protection of the biological resources in the Maldives and thereby support long-term sustainable development. The objective of the MPAS project was institutional strengthening, establishing protected areas, raising education and awareness and capacity building in planning and management.

The project was executed by the Ministry of Environment, Energy and Water with the implementing agencies being Ministry of Environment, Energy and Water and Australian Agency for International Aid. Australian Agency for International Aid contracted Australian Marine Science and Technology Limited as managing contractor for Australia.

Socio - Economic Assesment of S. Hithadhoo

Executive Summary

The core objective of this socio-economic assessment is to gain an understanding of the way of life and the socio-economic linkages held by the community of S. Hithadhoo in relation to the protected area of "Eidhigali Kulhi and Koattey" area located in S.Hithadhoo. The study was undertaken under the MPAS project. The purpose of the MPAS project is to establish a replicable and sustainable system for protected area planning declaration and management which has competent administration and broad-based stakeholder and government support and which achieves the joint objective of biodiversity protection and stakeholder participation.[1] The focus of the study is the community of Seenu Hithadhoo where the first model protected area site is to be established under the umbrella of a system of protected areas in the Maldives. A participatory approach is applied in collecting data, which includes a household survey, a series of community consultations, in-depth interviews with key informants, analysis of secondary data and personal observations. Several limitations were experienced due to time and budgetary constraints. Decisions were made in light of these constraints limiting the household survey to 6% of the total households.

Socio-economic status

Hithadhoo is the administrative capital island of Addu Atoll where the Atoll Office is located. Hithadhoo is the largest island in the atoll with 41% of the population of the atoll, and is the focus of RDP, which is underway. RDP is targeted towards the southern atoll of the country of which the regional base is located in S. Hithadhoo. The island has a population of over 12000, where 39% population are under 16 years of age while 49% are females. A typical household consists of 7 members with 1 male income earner, 3 children attending school and 2 other dependent members. The community lives in good housing structure with 99% of the households living in houses for which most parts are built with cement bricks and or coral and limestone.

In terms of infrastructure and services facilities, Hithadhoo ranks high among other islands of the country. There is a regional secondary school located in Hithadhoo teaching up to A' level and 32 other educational establishments are in operation. Health services are provided by a regional hospital employing 63 health staffs. Rainwater is often used as drinking water with 12 community water tanks and 700 houses having their own tanks for storing water. An airport is located in Gan, which is an hour's drive from Hithadhoo. A link road connects Hithadhoo to Gan where the airport and some of the government buildings are located. In

1 Ministry of Home Affairs Housing and Environment, 2002. Project Design Document.

addition, passenger cum cargo ships travel from Male' to the islands and round the region. Transport vessels and speed launches are used to travel to nearby islands. Bicycles, motorcycles and taxi are the common mode of transport. The island is well connected with telephone, fax and internet. TV, VCR and satellite dishes are in use providing entertainment and bringing the community out of isolation.

Over time social and economic activities have altered the traditional lifestyle, which has revolved around fishing in the lagoon and ocean, and coconut and taro grown on the land. Today, a number of government and private organizations are established and are in operation in the island, consequently 29% of the community earn their income by working in these organizations. Additional income earning activities are fishing, coral and sand mining and construction. To a limited extent, employment avenues are available by making snacks, taxi driving and carpentry. As employment opportunities are limited on the island around 18% are working in the resorts and 8% are working in Male' to earn their income. This has resulted in many of the people even in some cases the whole family migrating from Hithadhoo to Male'. Inequality in income or a rich-poor gap is visible among community. To some the cash flowing from their business in Male' and the island has paved way for a better and an easy life, while the majority has limited means of earning an income.

Today one of the major issues confronting the people of Hithadhoo is the limited job opportunities available for the children who complete schooling each year. Annually more than 100 students leave school each year with not enough job opportunities existing in the island leading to social disharmony among the community. For school leavers the best alternative is to go to Male'; the capital to seek jobs. This issue is common through out the country and the government of the Maldives has to deal with the issue at a macro level. To alleviate this issue the government has planned to develop a tourist resort in Vilingili of S.Atoll for which the people of Addu are looking forward as significant potential source of employment and revenue. The community, especially the young school leavers hopes that this would provide them the employment opportunities that they are desperately in need of alleviating them from employment constraints and improve the economic status.

Interaction with the Eidhigali and Koattey area

The community draws resources from the land, the beach, the lagoon, the reefs and the deep sea within and adjacent to the proposed protected area. From the land within the protected area the community draws firewood and coconuts for home use. Leaseholders sublease the area to undertake agricultural activities though at a limited scale. Traditional medicinal plants are also found in the area

and are being utilized by the traditional healers of the region. To a limited extent tourist from the Equator Village, a hotel located in Gan, visits the area as part of their recreational activity. Going for picnics to the Koattey area is common practice of the community, in particular such an outing before Ramazan is almost a must for most the people in the region.

Dumping rubbish within the land area, is a common practice although it is illegal to do so, and this is a source of income for the drivers of the vehicles and as well as an easy and cheap alternative in discarding rubbish. The pickup drivers who use to carry these waste explained that although the island office has allocated a certain site for waste disposal, in practice they believe that this is not a feasible or an easy alternative to implement. The allocated site is far away from certain areas of the community and hence drivers prefer not to take the risk of damaging their vehicles as waste has accumulated at the edge and attempts to go further inside the area results in the vehicle getting scratched and dented.

Sand, pebble and rubble mining are contributing to the erosion of the coastline. From the beach on the western side of Eidhigali Kulhi and Koattey area illegal sand mining is undertaken. This is an income earning activity to limited group of people. Sand bags are sold within the island, to other islands in the atoll, outside the atoll and in some cases sold to Male'. Sand and rubble are used for construction purposes.

Collecting pebble is also done illegally. This is collected from the Koattey area adjacent to the sand mining area locally known as the Eidhigali area. The frequency of pebble collection is highest 3 month before Ramazan, the Islamic fasting month. Generally, this is done as a tradition to decorate the floor, but as more and more houses are being built with stone floors this practice is done to a lesser extent now. However, as there is still demand for pebble this has become an income earning activity for some women who would otherwise be economically inactive.

With regard to marine resources, bait fishing and reef fishing in the north eastern side of Koattey have been the focus of many discussions. Tuna pole and line fishing comprises two fisheries, one for live bait and the other for tuna. The fishermen rely directly on regular and plentiful supplies of bait for their fishing activities. Both are carried in the same day with the live bait being caught first thing in the morning before going offshore for tuna. Time spent for bait fishing is certainly time lost for tuna fishing.

"Farubeyru" is the bait fishing ground located within the proposed protected area. The extent of the fishermen interaction with the particular location is revealed through the discussion and analysis of the available secondary data. "Rabaali" or

slender sweeper a bait similar to cardinal fish is available in that particular fishing ground during certain seasons. The smaller vessels, which cannot compete, with the bigger vessels in terms of speed often relies on this particular ground and on this particular species for bait. Quantitative monitoring of longer period of this resource use pattern is important to verify these fishermen's perspectives. For both subsistence and semi commercial activities different types of reef fishing is conducted within the area. Lobster fishing and sea-cucumber fishing is a lucrative business that is very profitable during the time of the survey. In general, islanders use the ecosystem of the area but nothing is put back in terms of management of the resources.

Awareness and perception

The level of awareness on environment is linked to the regular use of the radio, television and the newspaper. The Voice of Maldives broadcasts environmental programs weekly, while the "Fehivina" program of Television Maldives updates the environment of different atolls on a weekly basis. Environmental issues are often expressed in the newspaper which has a very positive effect in raising the awareness of the people in this area

The assessment revealed that most of the people are aware of environmental issues and the on going program of the protected area management system in relation to Eidhigali Kulhi and Koattey area. It is felt that scarcity of resource, and limited employment opportunities more than lack of awareness drives the community to exploit the resources within the protected area. Community understands that sand mining is detrimental to the local environment but is undertaken as an income-earning alternative, which again has its root cause to lack of job opportunities that is prevalent throughout Addu atoll. Rubbish dumping raised by 22% of the people perceived this problem in relation to poverty too. With limited job opportunities, there is a critical need to find productive avenues. The assessment revealed that the community is very much interested in using the resources within the area to raise income.

1. Introduction and Objectives

As part of the MPAS project activities a socio-economic assessment was conducted focusing on the community of Seenu, Hithadhoo where the first model protected area site is to be established under the umbrella of a system of protected areas in the Maldives. The aim of the assessment was to gain an understanding of the way of life and the linkages held by the community in relation to the protected area, to provide baseline data, and to understand the communities' perception regarding the establishment of the protected area of Eidhigali Kulhi and Koattey area. The assessment was based on a participatory approach where the methods applied include a household survey, a series of community consultations, in depth interviews with selected people in the community, analysis of secondary data and personal observations.

2. Background

2.1. MPAS Project

The Hithadhoo protected area site was selected as a pilot area for the broader MPAS project for the Maldives. The MPAS project aimed to establish a system of protected areas for the Maldives that is consistent with the sustainable management of atoll across the country. The selection of the Hithadhoo as a pilot site means that the focus of attention was on the Atoll and the island of Hithadhoo. The project was a three year project that commenced on 11 January 2000 which was later extended until June 2003.

The goal of the project is to contribute to the protection of ecological resources in the Maldives and thereby supporting long-term ecological sustainable development and biodiversity maintenance. The purpose is to establish a replicable and sustainable system for protected area and management which achieves the joint objective of biodiversity protection

2.2. General Description of the site

The Hithadhoo Protected Area is situated on the northern end of Hithadhoo Island. The area is locally known as Odessa, includes the Koattey area, the large fresh water pond, mangrove area, large area of island's vegetation and very shallow semi-enclosed lagoon area of fine silt on top of the sand. The vegetation is dominated by coconut palms. On the northern side the area extends offshore in the sea around the peninsula to include fringing coral reefs and islands. Extensive growths of sea grass beds are found, mostly in the shallow lagoon areas.

Today with historical and archeological remains, the site is considered as an important cultural site. There are a number of grave sites, wells and other building structures within the protected area.During the World War II the British were using Addu atoll for defense purposes and British personal were stationed even in the Koattey area within Hithadhoo. The area is important to the local community for recreation, farming, and fishing and in some instances the collection of traditional medicines. Most significant environment of this area is found to be the coral reef systems especially on the eastern side. (MPAS, 2001)

Site:
There are gravesites, highlighting historical importance of the site

Site:
Freshwater ponds known as Kulhi are unique to few island in the Maldives

Site;
The area contains coconut trees, which are harvested for coconuts.

Site:
The area of reef and lagoon within the protected area is said to be the most beautiful in the country.

3. Methodology

Data for the socio-economic assessment was collected based on a participatory approach using 4 main methods as depicted in fig 1.

1 Household survey
2 Series of community consultation based on focus group discussions
3 Key informant interviews
4 Data collected from secondary sources
5 Personal observations

Figure 1: Methodology applied for the socio-economic assessment

3.1. Household survey

3.1.1. Questionnaire

The questionnaire was designed to understand the socio-economic status and to determine the linkage between the community of Hithadhoo and the natural resource system of the protected area of Seenu Hithadhoo. The study focused on demographic details, income generating activities, and perception of the community regarding the environment and the protected area.

Sand, pebble and rubble mining are activities conducted by the people of the Hithadhoo and are also the focus of the survey. The purpose, the selling price, the market aspects and the locations of sand mining are some of the aspects, which are looked in detail. In addition, the meaning and importance of the protected area as well as perception regarding the environment of Hithadhoo were questioned.

3.1.2. Interview Procedure

From the atoll office, a map of the island with locations of the houses was obtained and the households were selected at random. The selected household was located with the assistance from a staff of the atoll office. The interviews conducted with

the head or the spouse of the head in most of the cases. In very few cases, the respondent happens to be the children. Child respondents were above 15 years. Interviews were conducted between 8.00 am to 10. pm during March 2002

3.1.3. Sample size

Simple random sampling was used to identify households for the survey. Using this procedure each household would have an equal probability of selection. The study was based on sample size of 100 out of a total population of 1601, representing 6% of the total number of households. The sample size of 100 was determined due to the limited time available at the field. To verify the applicability of the sample size the following formula was applied using the statistical tables..

$n = N/1+N(e)^2 = 1601/1+1601(10)^2 = 94$ households.

According to the table the level of precision or the sampling error is + or – 10 percent. Thus a sample size of 100 is valid from a population of 1601. It is known that out of the 1601 household a number of houses are vacant and the people have moved to Male', thereby the true population will be less than the 1601.

3.1.4. Trial survey

A trial survey was conducted during the later period of February 2002 to determine whether the questionnaire formulated was suitable for the survey which was scheduled to be conducted later. It was found that the questionnaire worked well except for the agriculture sector. With regard to agriculture it was found that region within the protected area known as Odessa was leased to two members of the community thereby agriculture related questions were irrelevant for the household survey.

3.2. Focus group discussions

Focus group discussions were held on different occasions with the community of Hithadhoo. In each of these meeting information was collected regarding the socio-economic conditions of the groups and the island itself and the perception of the community with regard to the proposed protected area.

The first community consultation was held from the 5th-10th September 2000. Meetings were conducted with the Island Chiefs, NGO's, Women's Committee, and with consultant of the RDP. One of the major objectives was the identification of stakeholder support and participation in terms of establishing and managing the Eidhigali Kulhi and Koattey area. The second focus group meeting was held from

Focus group discussions: Maps were used to stimulate the discussions

14th-19th November 2000. In addition to the above stakeholder groups meeting were conducted with the Equator Village representative, school representatives and fishermen.

Between 10th-13th July,2002 a series of focus group discussions were held with 7 stakeholder groups. In addition to the above groups, discussions were held with coral and sand miners, people living near the protected area, businessmen of Hithadhoo, leaseholders and people engaged in agricultural activities. Visualization techniques, such as maps, diagrams and pictures using power point presentation were used during the discussion.

Focus group discussions: Fishermen's group discussing the issue of bait fishing in "Falhubeyru" within the protected area

3.3. Semi-structured interviews

Interviews were held with practitioners of lobster fishing, beche-de mer fishing, tuna fishing and boat owners. Interviews were also conducted with key informants regarding the historical aspects of the Koattey area within the site.

Focus group discussions: Thought provoking discussion using maps and pictures.

3.4. Secondary sources

Secondary sources of data include island and atoll office records. Analysis of bait fish records collected by the RDP office was integral to the bait fish issue under discussion. Socio-economic data relating to the population, literacy rate, housing, economic activities, labour force working outside the island, fish catch, educational status, health services, electricity, transport, communication facilities existing in the island, water and sewerage system and infrastructure existing in the island were collected using the Island Fact Sheets. Island Facts Sheets are forms filled by each island office once in three months updating the socio-economic status of the island.

3.5. Field observations

A number of field visits were made to observe the activities that were being undertaken in the site. As coral and sand mining as well rubbish dumping are illegal activities field observations proved very appropriate, given the sensitivity of the issues. In addition to field visits a field monitoring program was conducted by the project staff. This program expanded over a 4 month period where random field observations were conducted for 17 days. On average 1.30 hours were spent on each observation.

3.6. Statistical Analysis

The data from the household survey was entered into SPSS for analysis. In addition, SPSS excel was used to compile and analyze data obtained form the from the Island Fact Sheet.

3.7. Outline of the report

The report is presented in 8 chapters. The first and second chapters focus on the background of the study followed by a brief outline of the methodology also reviewing the limitations.. Section 4 highlights the respondent's characteristics focusing on the demographic details. A profile of S.Hithadhoo is outlined in the next section, directing on location and physical features, population and housing, and economy. This is followed by community infrastructure and services of the island.

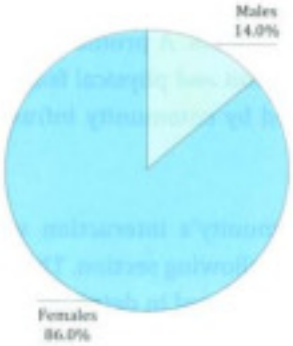
The exploration of the community's interaction with the Eidhigali Kulhi and Koattey area is outlined in the following section. The dependence on the marine as well terrestrial resources are explored in detail. Awareness and perception of the community with regard to the establishment of the protected area is illustrated in the subsequent section. The report concludes with its main conclusions and recommendations.

4. Characteristics of the respondents of the Household Survey

4.1. Gender and position

Graphical representations of the gender of the respondents are illustrated in graph 1. The graph depicts that 86% of the respondents are females while the rest are males.

Graph 1: Gender of the Respondents



Source: Household survey, 2002

As a significant number of males are working away from their home island, in Male' or in resorts this is expected. Furthermore, during the time of the interview the males who are working in the island were out of their homes working in their jobs therefore, as anticipated women were the majority respondents of the survey. Table 1 reveals the position of the respondents categorized into "head or spouse of the head" and "children". From the 100 households 89% of the respondents were the head or the spouse of the head while 11% accounts for the children. Head or the spouses of the head are categorized in the same. Children were interviewed in cases where head or the spouses of the head were not at home. During the time of the interview the head or the spouse of the head were working or in the case of the women would have gone out to fetch the children from school.

Table 1: Position of the Respondents

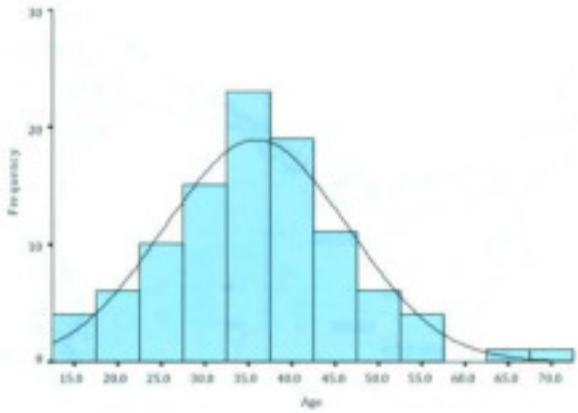
Position	Frequency	Percent
Head or spouse of the head	89	89
Children	11	11
Total	100	100

Source: Household survey, 2002

4.2. Age of the respondents

A histogram of the respondent's age is graphically represented in Graph 2. According to the histogram the highest number of respondents are between the age of 30-34 followed by the age group between 35-39.This is 26% and 15% respectively.

Graph 2: A histogram of the age of the Respondents



Source: Household survey, 2002

5. Profile of S. Hithadhoo

5.1. Location and Physical Features

Addu, the southernmost atoll of Maldives is located 332 miles south of the capital Male' just below the equator. Hithadhoo is the capital of Addu and is where the selected protected area of Eidhigali Kulhi and Koattey area is located and a replicable and sustainable management system is to be established. The atoll consists of 7 major natural islands located along the coral reef forming a large deep lagoon. Out of the 7 natural islands 4 are inhabited and 2 are uninhabited coconut groves. The other island (Gan) is serving as the major service centre for the atoll. There are several other islets, which are uninhabited. Unlike many other atolls there are no small islands inside the lagoon. The total size of the atoll is 8 miles north to south and 10.5 miles east to west (about 45 sq mile). It is a relatively a small atoll in size. However in terms of useable land area and population it is a relatively large atoll. Since 1982, with the establishment of the Addu Development Authority, Gan island is being developed as the main service centre of the atoll.

The airport, jetty, garment factories, power station bank post office, and all other important government offices are located in Gan Island. After moving from Srilanka

the British had their military base in Gan Island from 1956-1976. As a result most of the physical infrastructure facilities such as airport, harbour, extensive network of tarmac roads, pipe water, electricity, large number of unused buildings are available in Gan.

Figure 2: Map of Addu Atoll and the Location of the Proposed Protected Area

5.2. Vulnerability and Poverty of S.Hithadhoo in the national context

S. Hithadhoo is placed in a national context in terms of vulnerability and poverty, by reviewing the living standard dimensions outlined in the Poverty and Vulnerability Assessment of 1998 published by the Ministry of Planning and Development. Living standard dimensions were formulated based on a number of relevant indicators. These dimensions for S. Hithadhoo are compared with the dimensions of the atoll average and the national average to understand challenges, opportunities and the island's progress in social and economic development. Table 2 outlines these figures.

Table 2: Vulnerability and Poverty

Indicator	Maldives	Atoll Average	S. Hithadhoo
Composite Human Vulnerability Index on a scale 0-10	4.1	4.8	2.8
Income Poverty-HVI	.25	.29	.17
No electricity	.23	.14	0
Transport-HVI	.32	.43	.25
Communication -HVI	.92	1.00	.81
Education-HVI	.37	.50	00
Health-HVI	.42	.57	.04
Drinking Water-HVI	.27	.36	.74
Consumer goods-HVI	.39	.46	.30
Housing-HVI	.22	.16	.13
Environment-HVI	1.00	1.00	.80
Food Security	.42	.50	Na
Employment	.19	.23	.08

Source: Vulnerability and Poverty Assessment, 1998, Ministry of Planning and National Development

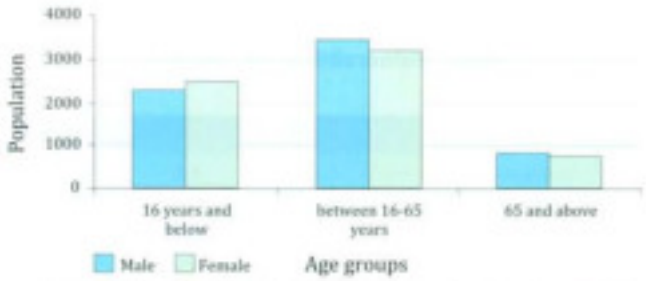
As can be seen from the above figures in comparative terms the overall levels of well being and wellfare of S. Hithadhoo is high. Hithadhoo has composite human vulnerability index of 2.8 while the atoll average and the national average is around 4. The composite human vulnerability index serves to synthesize the main finding and is based on 12 other dimensions. Performance is high in numerous areas. This is particularly the case with electricity and education. Electricity is universal among the community while education is stated is 00 on penalty point of 0-1. The lowest performance recorded is drinking water. Insufficient drinking water and unsafe drinking water are the main reasons.

5.3. Population and housing

The total population of Hithadhoo is over 12000 and is the highest population in the atoll.

Graph 3 illustrates the population distribution within major age group. The distribution pattern reveals that the age group between the ages of 16-65 consists of 51% of the total population. The population under 16 years of age is 37% of the population.

Graph 3: Population Distribution of S. Hithadhoo



Source: Island Fact Sheet, Ministry of Atolls Administration, 2002

Analysis of the household compositions revealed that a typical household in S. Hithadhoo consists of 7 members with 1 male income earners working in the home island.

Table 3: Composition of a typical household in S. Hithadhoo

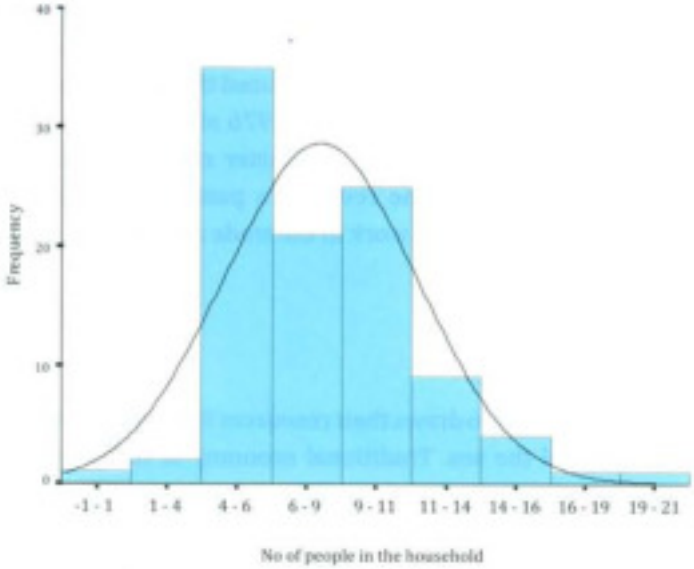
	In the home island		Away from home island		
	Male	Female	Male	Female	Total
Income Earners	1.07	0.58	.73	0.02	2.40
School Children	1.61	1.63	.13	0.05	3.42
Others	0.66	1.65	0.08	0.03	2.42
Total	3.34	3.86	.94	0.10	7.00

Source: Household survey, 2002

In many households an additional male works away from the home island. An average household has 3 children attending schools in Hithadhoo. In addition, an average of 2 non income earners live in the household.

This figure is in line with the figure obtained from the census of 2000, which shows average household size being 7. Histogram reveals that households with 4 to 6 members are the most common. The highest number of people in a household is 21.

Graph 4: Histogram of the number of people in the household



Source: Household Survey, 2002

In terms of housing the population have enjoyed significant improvement over the years. Generally the community lives in good housing structures with 99% of the households living in houses which for most parts are built with cement bricks, and/or coral, and limestone, as opposed to the thatched huts of the past.

5.4. Past

Fishing was the major economic activity of the people of Addu in the past. In the 1911 census it showed that 44% of the employed population accounts for fishing while cultivators and toddy drawers account for 17% and 7% respectively. (Bell, 1940)

Site:
"Ranihanaafengu" or the Queens Bath is an historical site

Separated from the rest of the Maldives by an eight kilometer wide channel, Addu Atoll has always tended to maintain their identity. The dialect is different and during the past they have their own trade routes directly from Addu atoll to Srilanka and India. Later, large quantities of Addu dried fish were carried to Male' by the people of Addu in their own boats and disposed of mostly by the barter to the Borah merchants for exports to Srilanka and India. From 1939 to 1945 the British operated a makeshift runway on Gan in Addu atoll. From 1956-1976 the British re-established its war time airfield on Gan in Addu atoll. The establishment of this infrastructure facilities as well as employment prospects resulted in the local population being skilled in other activities not possible in other parts of Maldives.

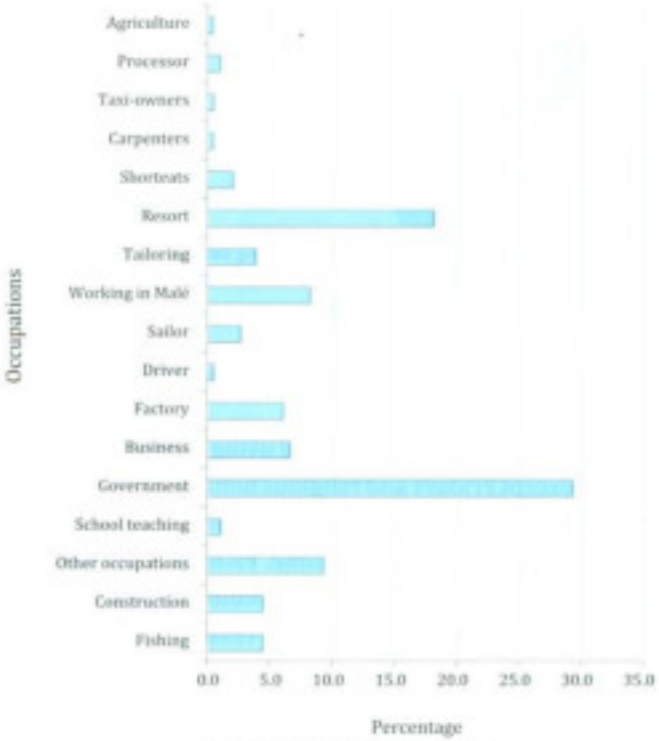
The development of the various semi-skilled populace required by the service and the construction was the direct result of the employment opportunities that existed during the British period. The presence of the British in Addu from 1939-1976 opened up opportunities, which had reduced the dependency on fishing that existed in the past. The British withdrew in 1976 at a time when tourism, which was introduced in 1972 was growing at a faster rate than the fisheries sector. Migration figures during this time revealed a pattern of large-scale migration from Addu towards Male' seeking work in the trade and services sector which has continued until today.

5.5. Economy

The community of Hithadhoo draws their resources from three natural ecosystems: the land, the reef and the sea. Traditional economy of the people of Hithadhoo revolves around fishing in the lagoon and the ocean and coconut and taro grown on the land. The reef provides protection to the island and its economy, and the corals that built the island provide building material for house construction for the islanders. In contrast, today the community's life style has been reversed. Social and economic activities have altered the traditional life style. As depicted in graph 5 the highest number of people work in the government sector (29%). In addition to the island office and atoll office of S. Hithadhoo telecommunication services, BML Hithadhoo Branch, STO super mart, the garment factory and post office provides employment opportunities among others. As employment opportunities are limited to these avenues around 18% are working in the resorts and 8% are working in Male' to earn their income.

This has resulted in many of the people and in some cases the whole family migrating from Hithadhoo to Male'. Today around 14% of the population works away from Hithadhoo. Out of the population working away from Male' around 3% are females. Inequality in income or a rich-poor gap is visible among the community. To some the cash flowing from their business in Male' and in the island has paved way for a better and an easy life, while the majority has limited means of earning an income.

Graph 5: Economic Activities of the people of S. Hithadhoo

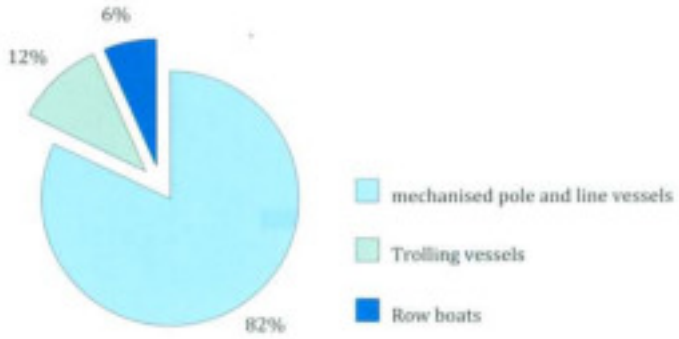


Source: Household Survey, 2002

Today one of the major issues confronting the people of Hithadhoo is the limited job opportunity for the students leaving school each year. Annually more than 100 students leave school and not enough job opportunities exist in the island. For them the best alternative is to go to Male' to seek jobs. The government in collaboration with the private sector is investing to develop Vilingili island as a tourist resort for which the people of Addu are looking forward as significant potential source of employment and revenue. At present the Equator Village located in Gan island provides limited source of revenue and employment opportunities for the people of Addu. Lack of employment opportunities, has increased the number of young people migrating from Addu to Male' seeking career opportunities. It is hoped that the potential employment opportunities from the Vilingili tourist resort and RDP that is underway will alleviate these constraints and improve the economic status of the people of Addu.

The household survey revealed that fishing provides income to 5% of the people. Hithadhoo has 27 vessels registered as pole and line fishing vessels. On a regular basis few vessels, operate as fishing vessels. The reason for fewer vessels involved in fishing are depressed catches, in efficiency of the smaller vessels in terms of speed and not enough people available in the island to go for fishing. Around 228 people are involved in tuna fishing in the island.

Graph 6: Percentage of vessels registered



Source: Island Fact Sheet, Ministry of Atolls Administration, 2002

The main type of fishing is pole and line fishing using live bait. Fishing is conducted through out the year except Fridays and religious holidays. The North East Monsoon is usually calm and falls between December to March and is stated as the good fishing season with March being the best time. Fishing is conducted even during South West Monsoon, which is from April to November. The fish caught are mainly sold unprocessed to the commercial collector vessels of MIFCO, a state owned enterprise for buying and selling fish. In some cases during periods of abundant fish catches fishers are unable to sell all the fish to the collector vessels. This is due to the limitations in the capacity of the collector vessels and deterioration of the quality of fish. In such cases, fish is brought to Hithadhoo and sold locally and or processed into dried fish.

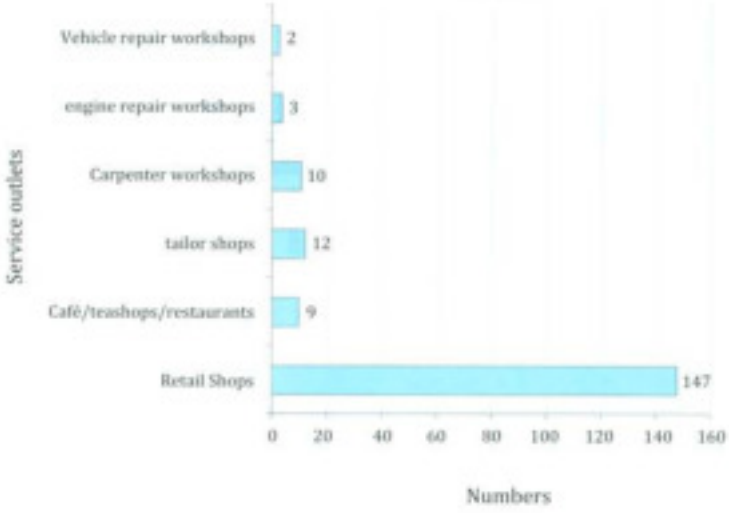
Coral and sand mining is undertaken by about 6% of the people as a major income earning activity. The activity is allowed in the lagoon which is on the Eastern side of the Hithadhoo area, outside the Eidhigali Kulhi and Koattey area. Attempts were to quantify the amount of sand collected legally. Graph 7 depicts the number of sand collected during November 2001 permitted through the island office During the month under analysis, active sand mining was undertaken on 6 days. During these 6 active days over 2500 bags were mined per day. On a monthly basis this is equivalent to 517 bags per days.

Graph 7: Quantity of sand mined legally during November 2001

Source: S.Hithadhoo Island Office, 2001

Approximately 6% of the people are employed "Velaveli Fashion factory" in Hithadhoo and an additional factory located in Gan providing much needed employment opportunities to an extent.

Graph 8: Some of the retail outlets providing services to the community of S.Hithadhoo



Source: Island Fact Sheet, Ministry of Atoll Administration, 2001

Diverse range of activities are practiced on the island such as making shorteats or snacks, taxi driving, carpenters, vehicle repair and maintenance, construction and tailoring. Retail trades being major activity retail outlets are common in the island. Graph 8 outlines the number and type of other service outlets where some of these activities are provided.

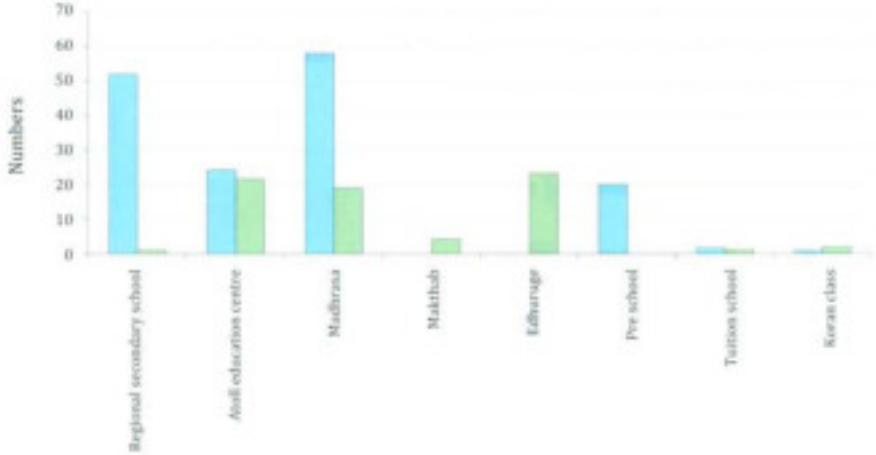
6. Community Infrastructure Services

6.1. Educational Services

There are altogether 33 educational establishments which includes one regional secondary school, 1 atoll education centre, 6 madhrasas, 1 makthab, 19 edhuruge, 2 preschools ,2 tuition classes and 1 class for teaching Quran. All schools are co-educational. The regional school teaches up to Advance level while the atoll educational centre teaches up to secondary level. The madhrasa teaches up to grade 7. Edhuruge provides religious education and teaching for the children in Arabic so that they can read and write Quran in its original text. The tuition class provides tuition for the weak school children while the Quran tuition class teaches Quran at a higher level. A total of 229 teachers provide education to 9066 students. Over 60% of the teachers are trained teachers. The student to teacher ratio is 39.

Over 51% of the students are females.

Graph 9:Number of teachers teaching in different educational institutions of S. Hithadhoo



Source: Island Fact Sheet, Ministry of Atoll Administration, 2001

6.2. Health Services

A regional hospital has been functioning over a number of years employing 63 people providing health services to the region. The government runs the hospital. The ratio of number of people per doctor is over 1000. Local medical practitioners also provide medical services in specific areas. The serious cases that cannot be helped by the regional hospital are brought to Male'. Two health centers provide health care facilities for people suffering from ordinary diseases.

Graph 10: Number of Health Professionals in S. Hithadhoo

Source: Island Fact Sheet, Ministry of Atoll Administration, 2001

6.3. Electricity

All the houses in Hithadhoo have electricity which is provided by a 750 KVA generator. A 800 KVA generator is kept on standby. Similar to Male' but in contrast to other smaller islands of the Maldives electricity is charged at an increasing rate for increasing utilization of electricity. For the first 30 units a Rf2.50 per unit is charged. From the 31st unit onwards Rf3.75 is charged for each unit.

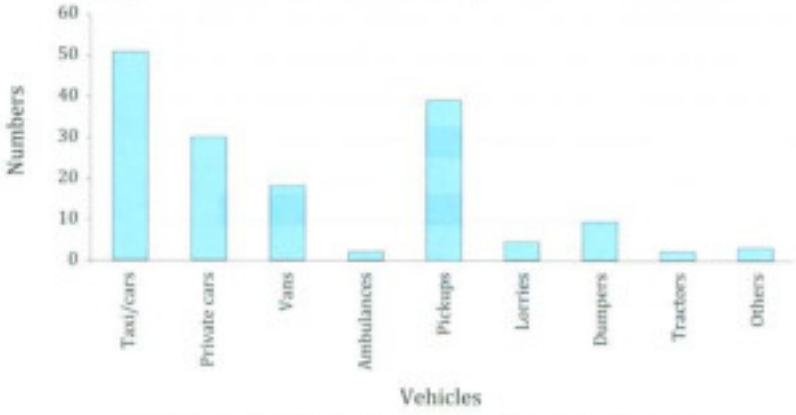
6.4. Water and Sewerage System

A total of 12 community water tanks provides water to the community. In addition, over 700 water tanks are privately built in the household compounds. Well water is also used for drinking. Water contamination through human and wastes is also prevalent in some areas. Over 66% of the houses use septic tanks with pumps to draw water. There is no direct sewage pipe system which discharges the waste to the lagoon or sea.

6.5. Transportation

There are 6 passenger cum cargo ships that serve Hithadhoo community and connect it with Male' and other islands. In addition, 4 launches provide transport facilities to nearby islands.

Graph 11: Some of the vehicles in operation in S. Hithadhoo



Source: Island Fact Sheet, Ministry of Atoll Administration, 2002

An airport has been functioning in S. Gan for a number of years. It takes about 1 hour by taxi for the people of Hithadhoo to reach Gan. The aeroplanes provide services from Gan to the capital Male'. There is link road connecting Hithadhoo to Maradhoo, Maradhoofeydho, Feydhoo and Gan. Bicycling is a common method of road transport in Hithadhoo and to nearby islands. For every 4 persons there

is bicycle and for every 6 persons there is a motor bike in operation. Graph 11 depicts some of the vehicles in operation in addition to bicycles and motorcycles. Similar to Male', as the society becomes more affluent, demand for motorcycles are on the rise in S. Hithadhoo too. Taxi's and pickups are common followed by private cars and vans.

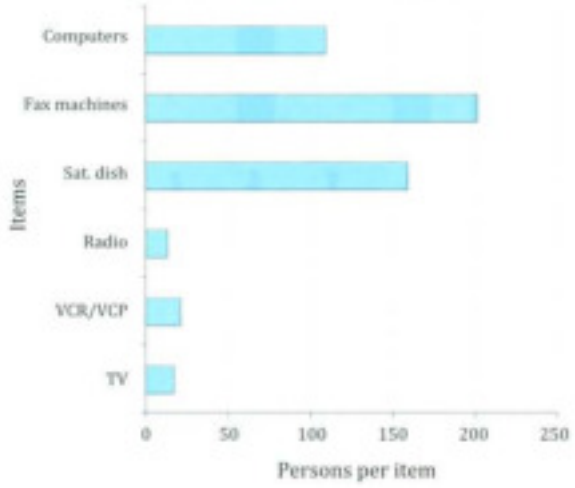
6.6. Mosques, Clubs and other associations

The island has 3 mosques which are used for praying by both men and women. A number of clubs and associations registered as non governmental organizations are working for the development of the island.

6.7. Communication

The island is well connected with telephone services and direct dialing facilities both international and national. There are over 1696 telephones and many telephone booths are established in Hithadhoo. Internet access and fax services are available in the island. The island also has 1 post office. The growing consumerism is reflected in the number of television sets and video machines in the island. There is one TV per 17 persons and one VCP/VCR per 20 people. The lack of entertainment opportunities available, the up linking of the national television signal to satellite to enable reception in the far flung island communities, and the increased hours of electricity, have all contributed to this trend. Graph 11, depict the communication facilities on per person basis in S.Hithadhoo

Graph 12: Number of communication and entertainment facilities available in the Island

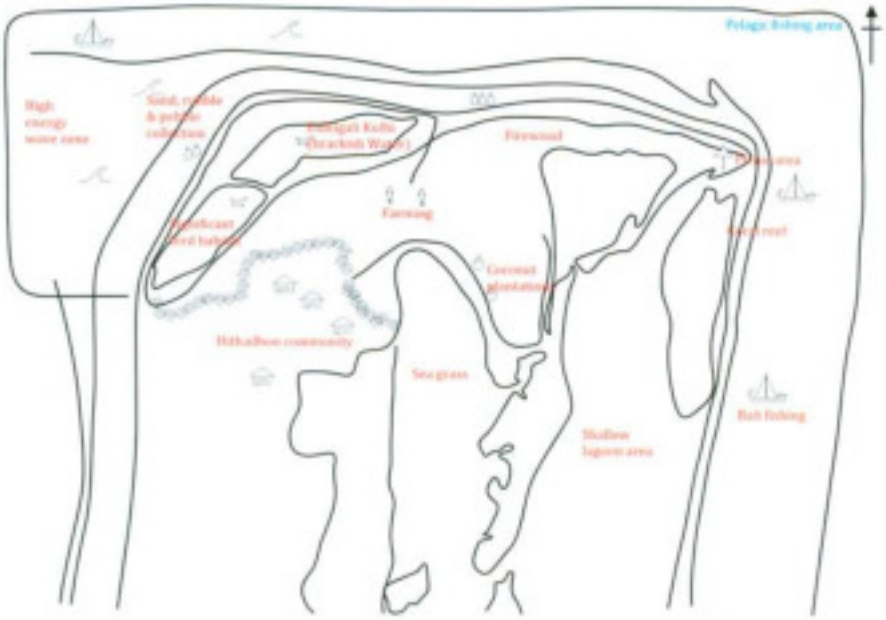


Source: Island Fact Sheet, Ministry of Atoll Administration, 2002

7. How the community interacts with the Eidhigali Kulhi and Koattey Area

The islanders draw resources from the land, the beach, the lagoon, reefs and the deep sea within and adjacent to the proposed protected area. Fig 3 depicts the resource use pattern of the area.

Figure 3: Resource Use Map of Eidhigali Kulhi and Koattey Area



From the land within the protected area the community draws firewood and coconuts for home use. The leaseholders earn money by selling these products. In addition to coconut, harvesting the leaseholders subleases the area to undertake agricultural activities, though at a limit scale. From the beach, the community collects sand, pebble and rubble used as a tradition as well as to earn money. Going for picnic to the Koattey area is a common practice of the people of Hithadhoo. Rubbish dumping within the area is also a common practice though illegal, provides income to the pickup drivers. To a limited extent tourist visits the area as part of their recreational activity. The community also enjoys recreational outing to the Koattey area.

The northeastern side of Koattey is a bait fishing and a reef fishing ground. Reef fishing is conducted at the reef for both subsistence and semi commercial purposes.

User conflict between the bait fishers and reef fishers exists. The tuna fishing grounds are located within half a mile offshore from the reef edge. The islanders use the ecosystem of the area but nothing is put back in terms of management of the resources.

7.1. Bait fishing

Resource use: Vessels that use the marine resources of the protected area

Tuna pole and line fishing comprises two fisheries, one for live bait and the other for tuna. The status of tuna fishing depends on bait availability among other factors Tuna is caught by pole and line requiring copious supplies of small live fish used as bait. The fishermen rely directly on regular and plentiful supplies of bait for their fishing activities. Both are carried in the same day with the live bait being caught first thing in the morning before going offshore for tuna. Time spent on bait fishing is certainly time lost for tuna fishing. It is well known that scarcity of bait is a limiting factor confronted by the fishermen of the island. Consequently, they are the first communities in the Maldives, which have developed catching bait fish using light to attract the bait fish.

As depicted in figure 3 one of the bait fishing grounds known, as "Farubeyru" is located within the proposed protected area. A certain type of bait known as "Rabaali" or slender sweeper (*Parapriacanthus ransonneti*) similar to cardinal fish is available in that particular fishing ground during certain seasons. Slender Sweeper is nocturnal, live in dense aggregation and live in small caves on reef slopes by day. (Anderson and Hafiz,1987) The smaller vessels which cannot compete with the bigger vessels in terms of speed often relies on this particular ground and on this particular species for bait.

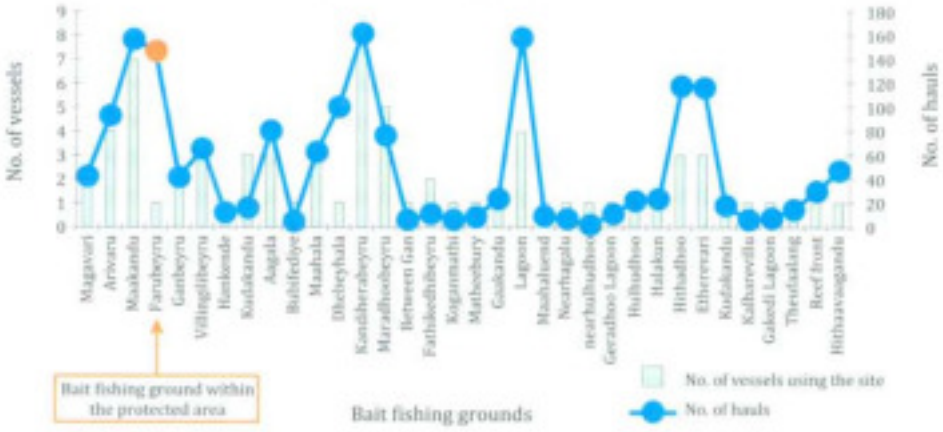
Although "Rabaali" is not a popular species of bait, smaller vessels tend to rely on this species when bait is scarce in the atoll due to its abundance in certain seasons. Particularly for the smaller vessel, which has to compete with the bigger vessel in terms of speed, this particular location is reliable and convenient. When more time is spent in search of bait the consequence is less time to spend for fishing or returning late to sell fish to the collector vessels. Even at present, the fishermen of Addu have problems in selling their catch to the collector vessels due to the limitations in the capacity of the collector vessels. Vessels, which come late in the evening to sell their fish, are more disadvantaged in selling the fish and on some occasions have dumped the fish into the sea. Often these vessels are the smaller vessel, which are less powerful in terms of speed.

During the focus group discussion the issue of bait fishing was discussed. If bait

fishing were to be banned from the particular location, as a management measure many highlighted an alternative as necessary. Banning of bait fishing from the area was supported by 1 fishermen out of 12. Seven of the fishermen outrightly rejected the suggestion while 5 fishermen did not comment. Their preferred alternative is a bait FAD. They highlighted that bait FAD, which was installed earlier in their atoll although, lasted for a few months was a successful FAD. They stated though it was not proven as a success due to its short duration they felt that signs of bait aggregation was present. They emphasized that it was due to the FAD itself and not due to weather, season, or mere coincidence bait was being aggregated during that time. The fishermen highlighted this in order to emphasis the importance of bait for them.

In order to verify the fishermen perception revealed through the discussion the secondary data available for the bait fish caught from the island was analyzed. A graphical representation of the number of vessels using the sites and the number of hauls made by these vessels are illustrated in graph 13. These data have been collected from May to June of 2001. The importance of the each fishing ground for bait fishing in terms of number of vessels using the site, effort in terms of numbers hauls, the main species caught and the size of the catch in terms good, medium and poor are highlighted in Appendix

Graph 13: Number of vessels and number of hauls of bait by location –May to June 2001



In terms of number of vessels using the site "Falhubeyru" ranks last along with some other sites. The table and the graph reveals that "Falhubeyru" the area within the proposed protected area has been used by only one vessel for bait fishing during the sample period. Many other sites such as "Hankede", "Dhebeyhera" are also used by one vessel. The particular vessel that used bait fishing in "Falhuberyru" is a medium size vessel of length 12.82 meters In terms of number of hauls the site

Hussein Ali, a boatowner built his boat in 1999. He was the first person who built a boat equipped with GPS system in Hithadhoo. The boat is 78ft in length and 21ft in breadth and has a hp of 280 travel speed of 12 knots. A team of 13-17 members work as a crew going out fishing 6 days per week. Most of the fish is sold to the collector vessel. If fish is not sold to the collector vessel the catch is brought home and processed into Maldive fish. Firewood is bought from the "Odessa" Region of the Protected Area and is used for smoking the fish.

Hussein Ali also stated that larger vessel similar to his own does not rely on the "Falhubeyru" for bait fishing. He believes that smaller vessels rely on the particular ground as the area is located near the island.

ranks 4th The quantity of bait caught from the particular location was stated as good.

As can be seen from the table and graph compared to other sites "Falhubeyru" is not very popular among the vessels during the sample period. Nonetheless, effort-wise in terms of number of hauls the usage of the location is high. The fishermen highlighted that "Rabaali'" not being the preferred bait among the fishermen the particular location is not being used by most of the vessels. Vessel which prefer not to spend time in searching for bait may rely on the particular ground during certain times.

7.2. Fishing for lobsters and sea cucumbers

Fishing for lobsters and sea cucumber has gained momentum during recent times in S. Hithadhoo. A popular location is the reef within the proposed protected area. Lobster fishing is seasonal, more confined to the calm weather as it involves diving and snorkeling in the reefs in the night. The usual method of lobster fishing is very labor intensive. Lobsters are hand collected whilst reef walking and free diving on the reef crest, reef slopes and within the lagoon at night. In rough weather it is difficult and dangerous and sometimes impossible to undertake reef walking and diving at night. Rough weather is prevalent during the Southwest Monsoon, which is usually within April to August. The lobsters caught are mostly sold to the Equator Village located in Gan and it is also brought to Male' and sold to the nearby resorts. Few groups of people with diving equipments actively engage in lobster fishing. The main species caught in Hithadhoo are the double spine lobster (*Panulirus penicillatus*) long legged spiny lobster (*P. longipes fermoristriga*) and the painted lobster (*P. versicolor*). According to the regulations formulated under law number 5/87 (Law on fishing) lobsters less than 25 cm and berried female lobster are prohibited for fishing. Lobsters is a difficult species to overexploit due to the reef topography providng natural habit protection. It is felt that the demand for lobster will grow in S. Atoll when the resort which is underway starts operating.

Sea cucumber fishing in also a recent activity carried out in the reef within the protected area. It's a profitable business providing income earning opportunities for the people. Sea- cucumbers are often bought for Rf100-Rf200 per sea cucumber

weighing around 800 grams. Four different types of sea cucumbers are taken. Sea-cucumbers are processed by boiling it in salt water, burying it in the soil for 12 hours and then cleaning it with a brush. Then it is cut open, smoked and sun dried for selling. Processing takes about 5 days.

The processed fish is sold to Male' where the demand is very high for exporting.

7.3 Other reef related activities

Other types of fishing is conducted in the regions, including reef fishing using lines and nets. Reef fishing is often conducted for semi- commercial purposes. The tuna fishermen complained that often harmful substances such as insecticides are used by some of the fishermen. User conflict between the bait fishers and the reef fishers were highlighted. Many of the fishermen stated that its often the fishermen from other atolls or other regions that exploit the resources within the area. For subsistence fishing the community uses the area almost everyday. Even women engages in fishing in the lagoon in order to meet food and income needs of the household.

7.4 Sand rubble and pebble mining

Sand mining is illegal except from the shallow lagoon 400ft away from the eastern side of the Hithadhoo. Further south along the beach on the western side of Eidhigali Kulhi heavy sand mining is undertaken illegally. During the field observation conducted in January 2001 over forty bags of sand were observed as being transported back into the village.

Ali used to take lobsters for the fun of it. Later he realized that he can sell it and earn an income from it. His investment for the work includes snorkeling gears, rechargeable batteries and lights. Ali with his team of 4, leave at sunset for lobster fishing and return during early hours of the morning. The usual season is during November to March, which is the relatively calm Northeast Monsoon. The green colored lobsters known as painted rock lobster. (Panulirus Versicolor) fetches a good price and are found on the reefs. Ali and his group catches 20 per day and selling it for Rf90 are earning an income of Rf13500 per month for each of them. They sell it to the Equator Village in Gan and on some occasions to Male. Ali believes that lobsters are limited and can be taken around 4 months of the year when the weather is calm enough to dive and snorkel in the reefs. Thus, he feels it is difficult to expand the business.

While collecting lobster he used to collect sea Wile collecting lobster he uses to collect collecting sea cucumbers too. He has sold the sea cucumber to a Singaporean who visited Hithadho actively involved in sea cucumber collection. He believes it is good business where the demand is high in Male'.

On one occasion, it was observed that 3 pickups loaded with sand bags were going from the Koattey area to Hithadhoo. Each pickup was carrying approximately 20 bags of sand. At the Koattey area around 15 people were actively involved in collecting sand from the beach. Women men and children of different ages were digging and separating the pebble type of sand from the ordinary sand. As enough sand was not found on the bank people were digging for the sand using tools. This was causing severe disturbance to the consolidated embankment and contributing to erosion. It was observed that many of the holes were filled with big coral stones

Sand mining;
The collection of sand and rubble is a major cause of coastal erosion along the coastline

Sand mining;
Sand and rubble mining is an economic activity on the beach west of Eidhigali Kulhi

The sand collected is used for construction purposes in the island. It is also sold to other islands within the atoll, to other atolls and in some cases sold to Male'. The price is between Rf60 per bag. Adjacent to the sand mining area collecting "akiri" (rubble) is also common. Rubble are sold for Rf 10 per bag. Both sand and rubble are used in construction activities. This work is undertaken as a group activity.

Collecting pebbles are also done illegally. This is collected from the Koattey area adjacent to the sand mining area. The area is locally known as the Eidhigali area. The frequency of rubble collection is highest 3 month before "Ramazan". It is done mostly by women both as group activity and individually. The price varies according to demand from about Rf12-Rf26 per bag. Generally this is done as a tradition to decorate the floor, but as more and more houses are being built with stone floors this practice is undertaken to a lesser extent than before. However as there is still demand for this type of rubble it is an income earning activity for some women who are able to spend time on it. It is believed that rubble is also sold to nearby island and atolls as well as to Male'

7.5. Waste Dumping

All around the Kulhi organic and inorganic waste matter are thrown around. During the focus group discussion the issue was discussed in detail. During the discussion the pickup drivers who used to carry these waste highlighted that although the island office has allocated a certain site for waste dumping in practice this is not a feasible or an easy alternative to implement. The allocated site is far away from certain areas of the community. In addition, waste collected in the site has piled up without being destroyed and people tend to dump the waste near the edge. As a result, waste has been accumulated near the edge and the drivers prefer not to go to that site because if they try to go further inside the area the vehicle tends to get damaged. Individual people highlighted that it is

expensive to hire a pickup and dump it to the allocated area. For many of the community members a cheap and easy option is to dispose the waste in Eidiglali Kulhi and Koattey area.

7.6. Agriculture and collection of firewood

Firewood is collected from the Odessa Region located within the Eidhgali Kulhi and Koattey area. The area is leased to two community members who pays an annual fee of Rf9500 and Rf4500. The areas are leased through the atoll office under the MAA. The money from the leased area is paid into the IDF which is an account created in MMA through the SRO. The money from the IDF is used for community development activities which are approved by the IDC.

Firewood when taken by individuals is free and is locally known as "boludharu" but when taken in truckloads cost money for the community. A truckload of coconut frond cost Rf50-80 and a truckload of coconut husk cost from Rf100-150. Collecting firewood before Ramazan is more frequent than during other times of the year as firewood is used to prepare snacks. Firewood is mostly used to smoke the fish as more and more households are using gas and kerosene oil for cooking.

The leaseholders also sell coconut from the area. Moreover, the leaseholders have subleased the area for agricultural activities. Corn and tomato are grown in the field plots in the Odessa Region. Farming for local and subsistence purposes is carried out with just a single plot near the centre of the site. Crops noted at the time of the survey included corn, tomatoes and chillies. Bananas were growing adjacent to the plot exhibited. Vandalism by young children is a common problem encountered in undertaking the work effectively. Traditional medicinal plants are also found in the area and are utilized by the traditional healers of the region.

Rubbish Dumping:
Dumping rubbish to Eidhigalhi Kulhi and Koattey area is a cheap and easy option for waste disposal for many people in the community

Rubbish Dumping:
The site contains household waste both organic and inorganic

Firewood:
Collection of firewood is a widespread activity within the area

Firewood:
Removing the husk and using it as firewood is common

On a typical day, early in the morning at 8 am 2 women were observed on their way back home carrying sand bags in a wheel barrow. Garbage is dumped in the southwestern side of Kulhi. A bit later at around 8.30 one woman is carrying a bag of pebbles.

At the beach one woman is sorting pebbles. Nearby piles and piles of sand has been collected. Some of these piles are large and if quantified could 10, 6 , and 5 wheel barrows of sand.

At the western side of Kulhi banana, coconut trees and scavelo and pandenus trees are burnt.

A small dhoni is heading to the western side while a bigger dhoni is observed line fishing. Black turns are flying over the dhoni

7.7. Recreation

Going for picnics to the Koattey area is a common practice of the island community in particular such an outing before Ramazan is almost a must for most the people in the region. Family and friends gather and cook and enjoy themselves while the children use to play in the shallow waters. Fishing using lines is also a common recreational activity

7.8. Stakeholders and resource use

Table 4 highlights the stakeholders or people who directly used the resources and their actions that may affect the resources within the protected area. Understanding these values of the resources and the traditional practices can be used to evaluate the benefits and costs of alternative development, management and conservation scenarios.

Table 4: Stakeholder and Resource Use

Activity	Stakeholders	Key points
Fishing	Bait fishers, reef fishers recreational fishers	Big and small vessels were observed fishing. In addition, few people were using nets and lines for fishing. On one occasion one women was observed fishing for subsistence use.
Rubbish dumping	Community living adjacent to the area	Garbage being dumped around the Kulhi are observed everyday.
Motor cycling	Island community	Using motorcycles and bicycles were observed significantly .
Coconut husk removing	Coconut collectors	Use as firewood.
Flying kites and playing	Children	Children were flying kites on some occasions
Collecting sand and rubble	Sand, pebble and rubble miners	Everyday people were collecting sand, pebble and rubble.
Removing trees and clearing vegetation	Farmers	Banana trees were observed being removed on days while clearing forests were observed on a number of occasions
Farming	Farmers	Farming activities were conducted on some days
burning	Farmers	Burning the rubbish is also frequently done.
Collecting firewood	General community	Collected firewood was observed on a number of occasions

Ten different activities were observed being conducted during the field observations. Sand, pebble and rubble mining was conducted most. On certain days more than one group of women were observed engaged in different activities relating to sand and coral mining. This includes sorting, collecting, carrying, loading to pickups. Collection of sand, pebbles and rubble were being observed from the shore and the lagoon. People who are collecting sand stated that they come there early morning between 5:30 & 7:00 am and work for 3 to4 hours. Most of them are living near kulhi area. Pick-ups are used to carry it back to their homestead. Use of bicycles and motor cycles were common. Line fishing for subsistence purposes is also common. To some extent S. Hithadhoo women also engages fishing in the lagoon in order to meet the food needs of the household.

Dumped rubbish is observed all around the Kulhi every day. Firewood and coconut husk collection and coconut husk removing are common practices. While removing trees and clearing, vegetation was observed to a lesser extent. To a limited extent farming, burning of rubbish was observed.

The area is rich in bird life but there is human disturbances. During the field observation 15 species of birds were observed within an hour. Disturbing the bird

Rubble mining:
Rubble mined for construction purposes

Bird life:
Disturbing the bird life by throwing sticks and stones were observed during the field trip

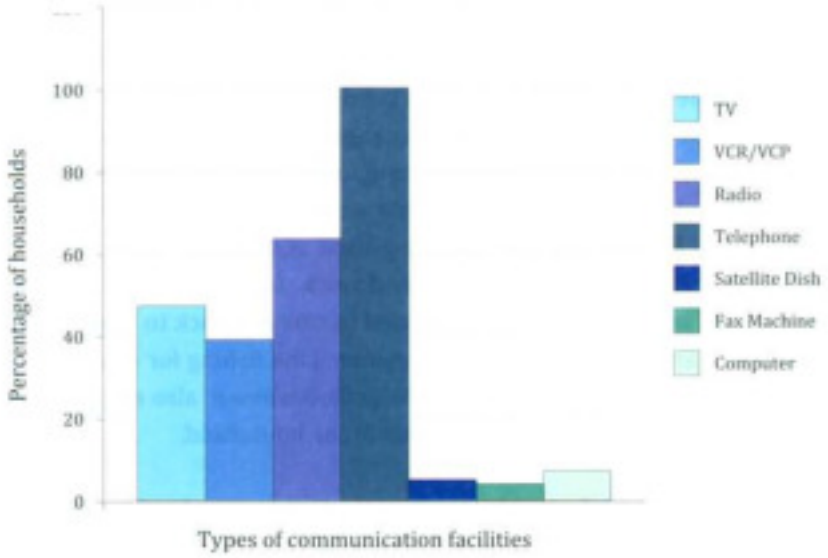
life by throwing stones and sticks was also observed during one of the field trips.

8. Awareness and perception of the community

Communication facilities existing in the island includes TV, VCR/VCP, radio, telephone, satellite dish, newspaper, fax machines and computers. The television, newspaper and the radio are common sources of information which has increased the general awareness of the people .The VOM broadcasts a variety of educational and entertainment programs as well as news for about 16 hours a day. The Television Maldives also telecast news and similar programs 11 hours daily.

The daily newspaper Haveeru has a local office in Hithadhoo and is a good source of information.

Graph 14: Existing communication facilities and its usage pattern



Graph14 depicts the usage pattern of some of the communication facilities by the households of Hithadhoo. As seen from the graph 47% household uses TV on a regular basis while regular use of radio is as high as 63%. The level of awareness on environment is linked to the regular use of the radio, television and the newspaper Environmental programs are broadcast weekly by the Voice

of Maldives, and Fehivina program telecasted weekly programs updating the environment of different atolls. Environmental issues are often expressed in the newspaper which has a very positive effect in raising the awareness of the people in this area.

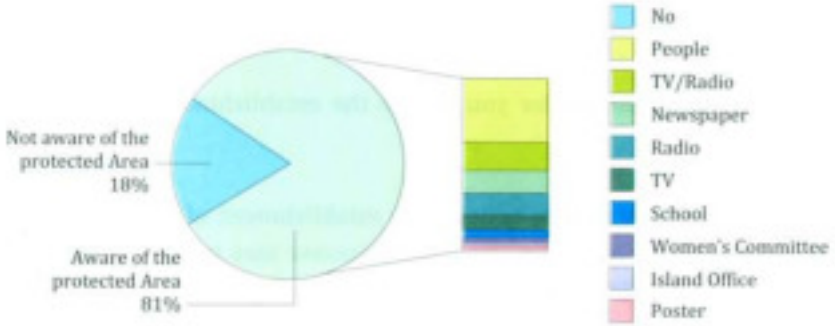
Specific issues regarding the environment were raised during the survey and the respondent's responses are reviewed.

8.1. Proposed protected area

Are the people of the household aware of the proposed protected area and if so in what way?

Out of a sample of 100, 81% of the respondents stated without hesitation that they are aware of the proposed protected area of Eidhigali Kulhi and Koattey. Over 39% of the people came to know about it by word of mouth. Friend, family members neighbors have told or discussed about it.. This is not surprising as few of the respondents mentioned that they have raised the issue of the deteriorating environment of the site with the Island Office and with IDC before the MPAS project. One respondent mentioned that he even wrote a proposal for the protection of it and had proposed it to the MAA. Another respondent stated that he had this plan to develop the site to attract tourist and generate money to protect and conserve the site. In addition to the answer many voiced their feeling and concerns for the worsening environment of the Eidhigali Kulhi and Koattey area. They highlighted the previous natural beauty of the Koattey area.

Graph 15: Sources of awareness about the proposed protected area



Television/radio was mentioned as the next leading source of information (16%) followed by radio only (13%), newspaper (13%) and television only (8%). Many of these respondents mentioned news as the main program, which updates them on environmental issues.Out of the total 18% mentioned that they were not aware of the protected area. Some of them stated that they have not heard about it at all.

According to one respondent her family just shifted to Hithadhoo after living in Male', after a number of years and she was not yet familiar with what is happening in Hithadhoo.

Awarness program: Scale model built as part of the awareness program

8.2. Scale Model

Are you aware of the scale model that is being built?

Under the MPAS project a scale model of the site was being built as a major part of the community consultation. This model is housed in the open space in front of the Island Office sheltered with thatch roofing. The model house was being built during July 2002 and during the time of the survey the model has taken shape and was in its final stages of completion.

Out of the total, 54% of the respondents stated that they were aware of the house with thatch roofing while 46% of the people was not aware of it. People who has seen the model being constructed were able to say that it is a map of the Eidhigali and Koattey area. As the model has taken shape very recently, most were not aware of the purpose of the model. Some related the model as work of the RDP and stated that it is model of how the area will look in the near future. Nonetheless, almost all the respondents were very curious and very eager to know more about the purpose of the model. The housing with the thatch roof in that location has created a curiosity within the community which is leading to positive expectation. The community seems to feel that things are going to start happening and take shape. They are seeing something physical in relation to their protected area of Eidhigali Kulhi and Koattey .

8.3. Opportunities

What are the opportunities for you due to the establishment of the protected area?

Over 95% of the respondents believe the establishment of the protected area will give rise to good opportunities. This response was probed to gain further information. Around 20% of the people who expected good opportunities related to employment opportunities. A couple of people mentioned jobs and recreation together. It is felt that there is a widespread concern for issues of income and employment especially for the young school leavers who are on the increase every year. Some stated that development of the area as conservation and recreational reserve would attract tourists and open up opportunities for them. Some even mentioned possibility of selling snacks and souvenirs for the visitors.

The majority of people although hopes and expects good opportunities they were unable to identify it. Some felt that it is too early to hope for positive things and related the example of Viligili which has been planned to be developed as a tourist resort 10 years ago. Very few were quite cynical when expressing these views. Others feel that they still need more information and to understand the concept of protected area management to generate more ideas and to discuss about.

Graph 16: Perception of the community regarding opportunities in relation to the establishment of the protected area

Source: Socio - Economic Survey, 2002

8.4. Problems

What are the problems that might come up for you due to the establishment of the Protected area?

Over 95% stated that no problems would occur due to the establishment of the protected area. Within this group some stated that government would not initiate a program if it would be detrimental for the community. When related to the fisheries aspect these respondents stated that all around the atoll good fishing grounds exist so limiting fishing from one area would not harm the fishermen much. It is important to observe that these thoughts were voiced by respondents who are not fishermen and were voiced only when probed.

One respondent mentioned he has no idea about the problems which might come across while two respondents mentioned that the opinions of the fishermen are essential for the fisheries issue. Difficulty in getting firewood was also mentioned as possible problems by one respondent.

It is interesting to note that the respondents who were sand miners did not mention banning of sand mining would be an issue. When directly asked about it they agreed they undertake the activity but for cultural purposes on a minimal manner and that banning sand-mining from that area would not be such a big issue because there are other areas where sand mining is undertaken in a more intensive manner.

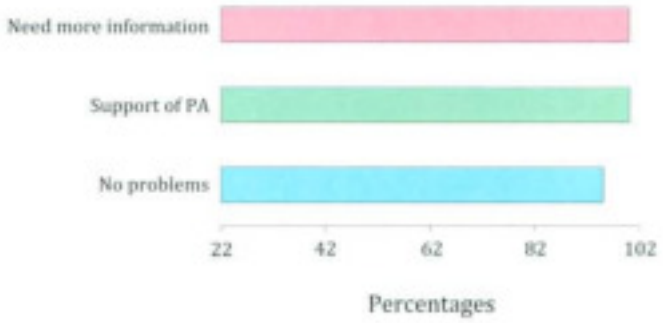
8.5. Support and information

Do you support the establishment of the Protected Area although it might restrict some activities that are undertaken there (yes no).

Are you interested in finding out more about the Protected Area?

For these two questions all respondents reacted positively. (graph 17). Most of the respondents said that it is vital for them to know more about it and understand what benefits could be achieved from it. They stated that part of the reason for the respondents were not able to discuss more about it is the lack of information. One respondent showed the poster of the project which was distributed at the beginning of the project and highlighted the importance of leaflets and brochures.

Graph 17: Some perception of the community regarding the PA of S. Hithadhoo



8.6. Involvement

Has anyone in your household been involved in any environmental activities (specify)?

Except for 6 respondents the rest were not involved in NGO or any other form club or association. Yet over 77% of the respondents involve themselves in environmental activities organized by the island office and school. The most recent event was the cleaning of the island organized by the Island Office for the President's visit to Addu Atoll during April 2002. Each household stated that they have participated if possible whenever a cleanup was organized. Most of the time women seemed to have participated more than the men. The community also supports similar cleaning campaigns organized by schools for the parents.

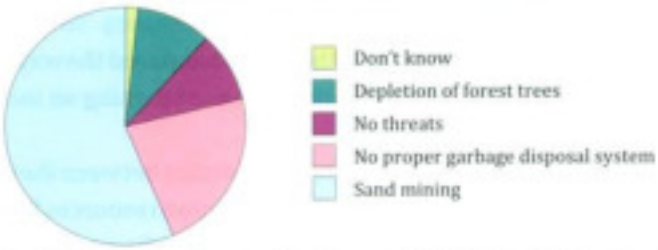
8.7. Perception of the environment

What do you think of the state of the environment of your island or Atoll?

What do you consider to be the most significant threat to the local environment?

Over 55% of the respondents are not satisfied with the state of the environment they were living while 43% believe that it is satisfactory.. Although 43% believe that the environment is satisfactory they still perceive negative impacts of human inter-relationships with the natural environment such as sand mining, waste disposal and deforestation as significant threats to the local environment

Graph 18: Community perception regarding the most significant threat to the environment



Sand mining is believed to be very detrimental (56%)to the local environment but which has been undertaken for a long time. Many believe that people undertake this activity as an income earning alternative which was due to lack of job opportunities which is prevalent throughout Addu atoll.

Next is rubbish dumping (22%) which many people again perceive in association with poverty. To some household the demarcated area to dispose the rubbish is too far away. For some household taking rubbish to the dumping ground cost money which some people could not afford. Cost of hiring a pickup and dumping it to the dumping ground is beyond their capacity. When this is the case garbage is being dumped to the closest area possible. Such practices are particularly pronounced in the protected area of Hithadhoo. Placing rubbish bins in closer location within the community was suggested as a solution by a few.

Other threats mentioned include depletion of trees in the bush.. Traditionally, the principal cause of the deforestation was also the use of firewood as the source of cooking. But with change to kerosene and gas today this is not the main cause. Clearing land which has ecological and historical significance such as the Eidhigali Kulhi, Koattey area and Maamigili (another brackish pond) areas was highlighted as significant threat by 8% of the respondents.

9. Conclusion

S. Hithadhoo with a population of 12000 ranks high in terms of infrastructure and services compared to other islands of the country. However the study revealed that compared to the population, employment avenues are limited and many are pursuing job opportunities away from their home either in Male' or in the tourist resorts. This has resulted in many of the people and in some cases the whole family migrating to Male'. The situation is more evident today after the establishment of the secondary school when more than 100 school leavers start searching for employment opportunities annually. To alleviate this issue the government has planned to develop Vilingili as a tourist resort for which the people of Addu are looking forward as significant potential source of employment and revenue. The community specially the young school leavers hope that this would provide them with the employment opportunities that they are desperately in need. Inequality in income or a rich-poor gap is visible among the community. To some the cash flowing from their business in Male' and in the island has paved the way for a better and an easy life, while the majority has limited means of earning an income.

The assessment revealed that significant interaction occurs between the community and the Eidhigali Kulhi Koattey area. The community draws resources from the land, the beach, the lagoon, reefs and the deep sea within and adjacent to the proposed protected area. From the land within the protected area the community draws firewood and coconuts for home uses. The leaseholder earns money by selling these products. In addition to coconut harvesting the leaseholders subleases the area to undertake agricultural activities though, at a limit scale. From the beach the community collects rubble used as a tradition as well as to earn money. Going for picnic to the Koattey area is common practice for all the people of Hithadhoo. Rubbish dumping within area, a common practice is income to the pickup drivers. To a limited extent tourist visits the area and as part of their recreational activity.

Rubbish dumping, sand, rubble and pebble mining within the protected area are illegal activities conducted by the community. Transporting waste and dumping it to the site is income earning opportunity for the pickup drivers. In order not to spend money to hire pickups community, which live adjacent to the area carries the rubbish and dumps it to the site. Sand mining and rubble used for construction purpose provides an income for a few groups of people. Pebble mining is conducted both as an income earning activity and as a tradition to decorate the floors of the houses. The need for income earning avenues are revealed as the underlying causes.

One of the most controversial issues revealed for the assessment is the issue of bait fishing from the bait fishing ground located within the protected area.

Smaller vessels tend to rely on the particular ground for the bait known as slender sweeper, which is available during certain seasons. Most fishermen particularly from the smaller fishing vessels are not in favor of banning of bait fishing form the area. They highlighted that an alternative arrangement particularly deploying a bait FAD should be considered if banning of bait fish is the management measure to be implemented. It is a well-known fact that scarcity of bait is a limiting factor for the tuna fishermen of the atoll. Attempts were made to verify through analysis of available quantitative data which revealed that the site is used to a limited extent. Quantitative monitoring of longer period of the resource use pattern is important to verify these fishermen's perspectives. Widely held perceptions need to be verified scientifically to prove the perspective and to determine the true local socio economic conditions of resource use community dynamics and stakeholder perceptions.

Reef fishing is also conducted at the reef for both subsistence and semi commercial purposes. User conflict occurs between the bait fishers and the reef fishers as reef fishers tend to use harmful substance while fishing. The tuna fishing grounds are located within half a mile offshore from the reef edge. The study revealed that the islanders use the ecosystem of the area but nothing is put back in terms of management of the resources.

The assessment also revealed that most of the people are aware of environment issues and the on going program of the protected area management system in relation to Eidhigali Kulhi and Koattey area. Media keeps the community well informed of such issues. The Voice of Maldives broadcasts a variety of educational and entertainment programs as well as news for about 16 hours a day. The Television Maldives also telecast news and similar programs 11 hours daily. The daily newspaper Haveeru has a local office in Hithadhoo and is in circulation within the community. It is felt that scarcity of resources and limited employment opportunities more than lack of awareness drives the community to exploit the resources within the protected area causing environmental degradation. This is more pronounced among the poor with limited opportunities almost forced to earn their living through such means.

Appendix 1

Location	No. of Vessels using the site	No. of Hauls	Type of Bait used
Magavari	2	42	Silver sprat, cardinal fish
Arivaru	4	93	Silver sprat, rabaali
Maakandu	7	156	Silver sprat
Farubeyru	1	146	Rabaali
Ganbeyru	2	41	Silver sprat, blue sprat
Vilingilibeyru	3	65	Silver sprat, blue sprat
Hankede	1	11	Silver sprat
Kudakandu	3	15	Silver sprat, blue sprat
Aagala	4	80	Silver sprat, blue sprat
Bubifediye	1	4	Silver sprat, blue sprat
Maahala	3	62	Blue sprat
Dhebeyhala	1	100	Silver sprat, blue sprat
Kandiherabeyru	8	161	Silver sprat, rabali blue sprat
Maradhoobeyru	5	76	Silver sprat, blue sprat, mushimas
Between Gan and Feydhoo	1	5	Silver sprat, blue sprat
Fathikedhibeyru	2	10	Silver sprat, rabali
Koganmathi	1	5	Rabaali
Matheebeury Westside	1	7	Rabaali
Gankandu	1	23	Blue sprat
Lagoon	4	158	Cardinal fishes, fusiliers, blue sprat
Maahaluend	1	8	Silver sprat
Nearhagalu	1	6	Silver sprat
Nearhulhudhoo	1	1	Cardinal fishes
Geradhoo Lagoon	1	10	Cardinal fishes
Hulhudhoo Lagoon	1	21	Cardinal fishes
Halakun	1	23	Fusiliers
Hithadhoo Lagoon	3	117	Cardinal fishes, fusiliers, blue sprat
Ethervari	3	116	Silver sprat
Kudakandu	1	17	Silver sprat
Kalharevillu	1	5	Cardinal fish
Gakedi Lagoon	1	6	Cardinal fish
Theufaalang	1	14	Fusiliers
Reef Front	1	29	Cardinal fish, blue sprat
Hithaavaagandu	1	46	Cardinal fish

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Marine Resource Evaluation

Executive Summary

To evaluate the marine resources of Addu atoll and the Hithadhoo Protected Area (HPA) visual resource survey methods (manta tows, timed swims and strip transects) were utilised. A total of 67 tows (35 lagoon, 32 ocean side) covering 2.1 square kilometres were conducted during the evaluation. Data collected for each tow included; water depth, tow width, tow length, total number of turtles, giant clams, crown of thorn starfish, selected finfish, sea cucumbers, percent live coral cover, percent cloud cover, wind condition, reef condition, dominant benthic forms, dominant hard coral genus and morphological forms and latitude and longitude coordinates for the start and finish for all tows.

A marine monitoring program was developed based on the biological information provided by the marine assessment and recommended for inclusion into the plan of management for the HPA. This program has been designed to provide broad scale long-term baseline biological data on the marine environment within the HPA and Addu atoll to allow long-term sustainable management. All Marine Protected Area System (MPAS) staff members were actively involved in all discussions, the development processes, and have been taught methodologies to implement the program. Considerations have been included for community participation and general understanding of the program. There are five recommended monitoring programs utilising standard scientific marine monitoring protocols and each program has been discussed:

- Coral community.
- Coral reef indicator species.
- Sea grass beds.
- Sediment deposition.
- Lagoon surface water circulation pattern.

The coral reefs of Addu atoll were subjected to a bleaching event in late 1998 resulting in a large-scale degradation and coral bleaching of the atolls hard coral community. The present resource assessment confirms this event. Reef flats and lagoonal reefs revealed lower percent live coral cover than the northern ocean side reef edges and slopes. The ocean side reefs located along the southeastern, western and southwestern sides revealed very low percent coral cover and recovery on these reefs is slow. The large massive coral forms (e.g. Porites) showed less mortality than those smaller hard coral forms (e.g. branching, tabulate, digitate), which were especially noticeable within the lagoon.

The most significant area for live coral communities is located along the eastern fringing reef within the proposed boundaries of the HPA. Similarly, the reefs

further south from the fisherman's channel (southern boundary) to the reef passes of Kuda Kandu and Maa Kanda show high live coral cover and diversity. In addition, an isolated patch of large live massive Porites bommies was located on the western side in the Gan Kandu pass.

All reefs evaluated during the assessment showed clear signs of hard coral community recovery. Dominating the recovery was Acroporidae species (digitate, tabulate and branching varieties) and a single species of a Faviidae (*Echinopora sp.*). The size and rate of recovery of corals does vary within the lagoon with the larger and subsequent older coral colonies located on the reef edge and slopes of the northern ocean side reefs. Protection of these coral communities is discussed.
All existing reefs that have live coral cover are extremely important for the continuation of this recovery process, providing gametes for new recruits.
The major anthropogenic threats to the marine environment within the HPA have been identified and need to be assessed and appropriate marine management plans and protocols developed. These are:

- Habitat destruction (anchors, trampling)
- Habitat alteration (water craft channels)
- Resource exploitation (over harvesting: e.g. sea cucumber)
- Resource extraction (sand/rubble/coral rock)
- Land reclamation and alterations (e.g. Hydrodynamic)
- Increased sedimentation
- Increased terrestrial degradation
- Pollution (human waste, petrochemicals, rubbish)

Physical anchor damage to the reef edge and slope of the HPA by the tuna fishing fleet collecting baitfish is the main destructive activity currently occurring. The affect of the sand mining operations within the atoll and HPA need to be evaluated for their direct impact on reef communities within the HPA and atoll.

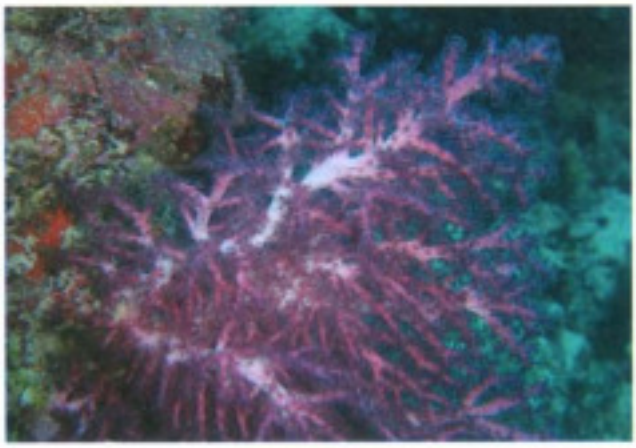
Resource harvesting for subsistence purpose within the HPA and the atoll appears to be minimal. Reef fish and reef-associated invertebrates (e.g. Mollusc) are not the preferred protein source of the communities and therefore survey results clearly indicated abundant mature stocks of these organisms with reproduction and recruitment occurring. Sea cucumber, grouper and lobster support commercial fisheries within the atoll. The former have been overexploited whilst biological information lacks to determine exploitation levels of grouper and lobster stocks. Brief descriptions of each fishery including monitoring options are discussed.

Population numbers and identification of important commercially targeted and indicator reef finfish were included in the resource assessment. In particular,

the commercial species of the family Serranidae: the grouper (*Epinephelus polyphekadion, E. fuscoguttatus, Variola louti Cephalopholus argus*) and coral trout (*Plectropomus laevis, P. pessuliferus, P. areolatus*) were surveyed to provide information on fish populations. Additional data was collected on the giant humphead wrasse (*Cheilinus undulatus*), family Labridae.

Stock populations of the Serranidae appear to be decreasing and additional marine monitoring of these finfish is required to provide biological information. Clarification of the location and timing of spawning aggregation sites is a priority for the management of these finfish. Stock populations of giant humphead wrasse (*Cheilinus undulatus*) are high with a wide range of age cohorts located throughout the survey. For all species of finfish utilised for commercial purposes a management protocol should be introduced. These protocols could include catch size limits, gender limits, spatial and location limits and protection programs for breeding purposes.

Three species of tropical lobsters were located during the resource assessment, *Panulirus penicillatus, P. longipes fermoristriga and P. versicolor.* Commercial fishermen target these animals for sale into the nation's tourist industry. There is limited data collected on the lobster fisheries in Addu atoll, (numbers collected, species, sex ratios) and therefore, no biological recommendations can be made on the affect of this activity on the standing population stocks within and outside the HPA. A biological assessment of this fishery needs to be undertaken and a sustainable management plan developed.



Ten species of sea cucumber were located (*Holothuria atra, H. noblis, Actinopyga mauritiana, A. miliaris, Bohadschia argus, B. graeffei, B. marmorata, Stichopus variegatus, S. chloronotus, Thelenota ananas*) on the reefs of Addu atoll. All commercially important species (*H. noblis, Actinopyga mauritiana, A. miliaris, B. marmorata, S. variegatus, S. chloronotus and T. ananas*) were found in very low densities in all tows. The very low occurrence of these commercially important

species is a direct result of past and current commercial harvesting. The non-commercially targeted species of Bohadschia argus (Leopard fish) and Holothuria atra (stocks were not recorded) dominated the survey counts. Stock populations of these animals below a water depth of 12 meters are unknown.

Management protocols need to be developed and implemented to preserve the existing stocks of commercial sea cucumbers to allow recruitment and sustainable commercial harvesting. Suggested protocols to consider are: bans on the collection of certain species, bans on collection locations, size limits, season limits and closures.

Two specimens of the Crown of Thorns starfish, *Acanthaster planci*, were found and therefore, are not considered a threat to the reefs at this present time.

Two species of giant clams were located during the resource assessment, *Tridacna maxima and T. squamosa*. Population stock abundances of both species were healthy and level of exploitation is very low. No specimens of the tropical black lip pearl oyster (*Pinctada margaritifera*) or the tropical winged oyster (*Pteria penguin*) were located.

A total of 38 turtles were located during the marine evaluation (nineteen Green and nineteen Hawksbill turtles). Size ranges for both species varied indicating a range of ages among the animals within the atoll. Information on active nesting sites, their locations and basic life history data for both species is not presently available for Addu atoll. This information is required to allow a biological assessment and the development of a sustainable management plan. Current exploitation rates within Addu atoll and associated oceanic waters is unknown.

A formal working relationship between the MPAS project and the Marine Research Centre (MRC) staff under the Ministry of Fisheries, Agriculture and Marine Resources to jointly develop a marine monitoring program for the HPA was agreed. Two monitoring sites with 3 replicates were established and will be monitored jointly. The MRC staff will assist with training the MPAS staff.

A list of recommendations based on the results of this study is discussed for each organism. A monitoring program must be implemented. The monitoring program has been designed to provide baseline scientific information on the life histories of these animals and their abundance. Information gained from this program is essential for the development of an appropriate management plan. The development and policing of the marine reserves recommended should be undertaken immediately. Management plans must be developed for all future commercial fishing and harvesting of marine resources.

Recommendations

The marine resources of the Hithadhoo Protected Area (HPA) and Addu atoll require management. Without an adaptive useable management plan based on ecosystem sustainability, current levels of exploitation will further degrade the atoll reefs, their associated organisms and marine habitats, resulting in reduced biodiversity of the marine ecosystems culminating in the decreased capacity for sustainable management, economic and social development of the marine environment and the resources.

It is therefore recommended that:

- All reefs located on the northern sides of the HPA are to be managed under a regime that prevents anthropogenic activities from damaging and degrading the coral populations. A complete ban on these activities should be considered. It is further recommended that consideration for extending this management regime to include the oceanic side reefs from the fisherman's channel to the reef passes of Kuda Kandu and Maa Kandu and the isolated patch of large massive Porites bommies located on the western side of Gan Kandu pass.

- Physical anchor damage to the northern reef edge and slope of the HPA by the tuna fishing fleet collecting baitfish is the main destructive activity currently occurring. The physical damage is reducing biodiversity and live coral cover in these areas. Anchor usage along the ocean side of the HPA for the collection of baitfish should be banned. An extension of this ban to include the reef south of the HPA to the reef passes should be considered. There are several options to address these concerns:

- The placement of mooring buoys with or without bait Fish Attracting Devices (FAD) along the reef edge and slope.

- Ban bait-fishing activities all together within the HPA. Additional bait fishing ground will need to be located and the deployment FADs and mooring sites will be required.

- All reef and associated coral communities that posses good live coral cover and coral diversity within the atoll and the HPA must be protected to allow the natural coral reef recovery process to continue. These reefs are extremely important for the continuation of this recovery process, providing gametes for new recruits. Information must be gathered to determine which coral communities and reef regions are providing the

juveniles for recruitment both within the HPA and atoll. An appropriate management plan is required to protect these organisms.

- Identification of seawater surface circulation patterns and hydrodynamic forces within the atoll needs to be assessed to predict coral larval dispersal and recruitment and transportation and deposition of suspended sediments. An appropriate management plan needs to be developed for marine sediment (sand, rubble and rock) extraction. A sediment trap study should be included.

- The recommended monitoring program should be implemented. This program has been designed to provide baseline scientific information on life histories and population abundance of a range of indicator marine organisms, provide information associated with the surface water circulation patterns of the atoll, lagoon and HPA and provide an understanding of the level of sedimentation within the lagoon. The monitoring program will detect broad scale changes within the marine environment. The marine environmental components required to be monitored for the MPAS project are:

    - Lagoon and barrier coral reefs.
    - Sea grass beds.
    - Commercial fishing activities (e.g. baitfish, lobsters and grouper; the live food fish trade)
    - Commercial coral/rubble/sand extraction programs.
    - Sea water circulation patterns and
    - Sedimentation rates and transportation.

- Marine resource stock surveys (as undertaken in this evaluation) should be repeated, at least on an annual basis, to provide information on the population structure and abundance of marine organisms within the lagoon over time.

- The collection of basic life history data for each organism as outlined in this document is imperative to allow the MPAS project to successfully manage these resources. Data required has been outlined in the report.

- These activities should form part of the MPAS teams' work plan. The MPAS project should provide marine education and awareness training programs for the community on all aspects of coral reef management and conduct regular community based meetings to discuss the management program with the community.

- A marine evaluation is required to determine the spawning aggregation sites of the dominant Serranidae fish species and an appropriate management plan developed and implemented.

- The development of a list of all fin fish species located within the HPA and atoll should be considered.

- Information pertaining to the commercial lobster fishery within the atoll should be undertaken. Basic life histories data, numbers collected, species and sex ratios should be collected to allow a biological assessment and the development of a management plan for this fishery.

- Information on active nesting sites, nesting seasons, female fecundity and basic life history data for both green and hawksbill turtles within the atoll should be undertaken and a sustainable management plan developed.

- Immediate conservation measures should be implemented to prevent further exploitation of commercial sea cucumber stocks and a long-term management plan is undertaken.

- All new commercial marine harvesting activities should be prohibited until such time that sufficient biological information has been collected to develop correct management protocols.

Additional marine based information exchange and training is required for all MPAS staff to successfully undertake these recommendations.

1. Introduction

A marine resource assessment of the Maldives Protected Area System (MPAS) pilot project in Addu Atoll was undertaken to provide biological information to allow the development and implementation of a sustainable marine management plan. The marine assessment was completed and a user-friendly long-term marine monitoring program was designed, including time frames and recommended for implementation for the Hithadhoo Protected Area (HPA).

The marine assessment was undertaken utilising standard marine biological methods and was performed by the consultant with the assistance of the MPAS assigned counterparts from the Ministry of Environment, Energy and Water (Mr. Husen Naeem, Mr. Umair Mohamed and Miss Aishath Hameed). Lengthy training courses, open discussions and field activities were undertaken to develop the capacity of the counterparts in all aspects of marine resource assessment, marine evaluation, data collection, analysis, interpretation, and management protocols. This information culminated in the initial baseline biological data collection for the HPA and atoll, which is presented below.

A marine monitoring program was developed based on the biological information provided by the marine assessment and recommended for inclusion into the plan of management for the HPA. All MPAS staff members were involved in all discussions, the development processes and have been taught methodologies to implement the program. The marine monitoring program has been designed to provide broad scale long-term baseline biological data on the marine environment within the HPA and Addu atoll. Considerations were included for community participation and general understanding of the program.

2. Marine Resource Assessment

Three scientific visual survey methods: Manta Tows, Timed Swims and Strip Transect Lines, were utilized during the marine resource assessment. The marine assessment took a systemic approached with all species evaluated within an area before moving to a new reef region. Training courses were undertaken with all the staff to develop the skills required to perform these scientific evaluation tasks and the identification of all relevant indicator species. The training program was continuous throughout the resource assessment.

Additional anecdotal information was obtained through discussions with local fisherman, divers and the general public on stock abundances, reef activities and marine habitat preferences within the lagoon of the indicator species evaluated.

The technologies utilised for the marine assessment and recommended monitoring program have been adopted from English *et al* (1997). In addition, Husen (2002) has provided a comprehensive review of marine environmental survey and monitoring procedures that are employed to evaluate coral reefs with specific reference for the Maldives. Both these documents should be used as references. The resource assessment methodology undertaken during the marine evaluation and the recommended monitoring methodology are documented in Appendix 1.

3. Reef Evaluation and Survey Results

All field data collected during the resource assessment has been tabulated. Appendix 2 presents data collected on water depth, tow width, tow length, total number of turtles, giant clams, Crown of Thorn starfish, selected finfish and sea cucumbers located during the survey for all tows. Appendix 3 presents data collected on percent live coral cover, percent cloud cover, wind condition and latitude and longitude coordinates for the start and finish for all tows. Appendix 4 presents data collected on reef condition, dominant benthic forms, dominant hard coral genus and morphological forms for all tows.

A total of 67 tows were conducted during the resource evaluation. 35 tows were conducted within the lagoon and a total of 32 tows conducted on the ocean side of the atoll, comprising 55 manta tows and 12 timed swims covering a total area of 2.1 square kilometres. All manta tows and timed swims (except Tows 18, 19, 20, 21, 22) were conducted on the section of the reef between the reef edge and reef slope.

Figure 1 provides the location sites of all tows undertaken during the marine evaluation. Each tow number recorded in Appendix 2, 3 and 4 correspond to the same number located on this figure. The Hithadhoo Protected Area (HPA) is highlighted.

The maximum water depth evaluated during the survey was 12 meters. Each evaluation sites was allocated a Global Information System (GPS) coordinates for the start and finish of each tow. Many tows were not straight and therefore the distance travelled is not reflected by a straight line between GPS coordinates.

The specific results for each species and recommended future monitoring activities are discussed in the relevant sections below.

4. Hithadhoo Protected Area

The Hithadhoo Protected Area (HPA) is located on the northern end of Hithadhoo Island, which is located in the north-western corner of Addu atoll. The HPA includes all terrestrial and marine habitats located within this designated area.

The HPA includes the following marine associated habitats: the "Kulhi", located on the western side of the HPA which is composed of a large fresh/brackish water pond and associated mangrove forest; extensive intertidal reef flats and sea grass beds (finer sediments dominate close to shore whilst sand and coral rubble are located toward the reef edge) including several small coral islets that are located on the eastern side of the HPA. A fringing coral reef surrounds the HPA, consists of an intertidal shallow water reef flat that varies in width and percent live coral cover (refer below) terminating on the seaward side with a pronounced reef edge and reef slope. The waters surrounding the HPA and the atoll itself are oceanic and are deep.

The north and western sides of the fringing reef are exposed to oceanic swells and are dominated by spur and groove formations close to shore terminating offshore with a pronounced reef edge and a very steep sided reef slope. The eastern side of the HPA is protected from these swells and lacks spur and groove formations. A short reef flat that terminates with a pronounced reef edge and steep sided reef slope also dominates this region. The majority of the reef slopes found within the HPA have angles greater than 70 degrees.

Tides are semi-diurnal and have a range of less than 1.5 meters within the HPA. The tides generate strong currents both within the lagoon and outside the reef. Strong tidal generated currents are associated with the north eastern and northwestern points of the HPA with current speeds of 3-5 knots common. Surface seawater temperatures (<1m from surface) range from 29-310Celcius during the evaluation.

Tilapia (*Oreochromis sp.*) has been introduced into the Kulhi and currently large populations of this non-endemic species are present. The affect of this introduction on the local endemic species of fauna and flora within this system has not been document. The Kulhi is currently closed to the marine environment and the water has a low salinity. However, in the past this system has had periods of water exchange with the marine environment and at such time may have been a breeding ground for several species of fish e.g. milkfish (*Chanos chanos*) and mullet (*Mugil sp.*). The management plan should address the affect of this introduced species on this important and rare ecosystem habitat.

5. Coral Reefs

The coral reefs of Addu atoll were subjected to a bleaching event in late 1998 (reported to be initiated from increases in seawater surface temperatures, Clark, *et al.* 1999) resulting in the degradation and coral bleaching of the atolls' hard coral community. The present resource assessment evaluated coral diversity, percent age of live coral cover and coral condition on the reefs of the HPA and Addu atoll and the result obtained (Appendix 2, 3 and 4) confirm this event, with a high proportion of reef recovering from large scale mortality. Reef flats and lagoonal reefs revealed lower percent live coral cover than the northern ocean side reef edges and slopes. The ocean side reefs located along the south-eastern, western and south-western sides revealed very low percent coral cover and recovery on these reefs is slow. The large massive coral forms (e.g. Porites) showed less mortality due to this event than those smaller hard coral forms (e.g. branching, tabulate, digitate), which were especially noticeable within the lagoon.

The proportion of coral mortality witnessed during the current evaluation attributed to the bleaching event is unknown, however it is suggested that other anthropogenic activities undertaken within the atoll, especially within the lagoon may have also contributed to this degradation (e.g. reef substrate extraction). These anthropogenic activities are still ongoing within the atoll.

All reefs evaluated during the assessment showed clear signs of hard coral community recovery. Dominating the recovery was Acroporidae species (digitate, tabulate and branching varieties) and a single species of Faviidae (*Echinopora sp.*). The size of recovery corals does vary within the lagoon with the larger and subsequent older coral colonies located on the reef edge and slopes of the northern ocean side reefs.

All existing reefs that have live coral cover are extremely important for the continuation of this recovery process, providing gametes for new recruits. It is thus imperative that all reef and associated coral communities that posses good live coral cover and coral diversity within the atoll and the HPA be protected to allow the natural coral reef recovery process to continue.

Macroalgae beds, a feature usually associated with high coral mortality, were not located during the evaluation. The high standing stocks of reef herbivores fish (e.g. Scaridae, Acanthuridae and Siganidae) are believed to be preventing these

algal beds from dominating the reef substrate. The absence of macroalgae on the reef substrate provides a suitable settlement area for coral recruits. In several areas (Tow numbers, 45, 46, 47) large beds of Corallimorphs dominated the benthic community with several tow sites possessing percent live cover in excess of 60 percent.

Several areas within the atoll were located during the resource evaluations that have healthy and diverse hard coral communities (percent live coral coverage greater than 20 percent using broad scale evaluation techniques, e.g. Tow Number 31, 32, 33). Figure 2 provides bubble plots of the percentage live coral cover for tows undertaken during the resource assessment. The most significant area for these coral communities is located along the eastern fringing reef within the proposed boundaries of the HPA. Similarly, the reefs further south of the proposed HPA, from the fisherman's channel (southern boundary) to the reef passes of Kuda Kandu and Maa Kanda show high live coral cover and diversity. In addition, an isolated patch of large live massive Porites bommies was located on the western side in the Gan Kandu pass directly opposite the end of the airport runway.

It is therefore recommended that the reefs located on the northern side of the HPA be managed under a regime that prevents anthropogenic activities from damaging and degrading the coral populations. A complete ban on these activities should be considered. It is further recommended that consideration for extending this management regime to include the oceanic side reefs from the fisherman's channel to the reef passes of Kuda Kandu and Maa Kandu and the isolated patch of large massive Porites bommies located on the western side of Gan Kandu pass directly opposite the end of the airport runway (Tow 12 & 58).

No information was found to determine the location of the mature population of hard corals within Addu atoll that are supplying the recruits that have been located during the survey evaluation. Until such time that data can provide this information, it is recommended that all mature hard coral colonies and associated reefs be preserved and protected for their possible recruitment value. Appropriate management plans therefore need to be developed and implemented. In addition no information was located pertaining to the percentage of coral recruits entering the Addu atoll from coral populations located outside this atoll system.

An aerial visual coral spawning slicks was located within the lagoon and to the north of Addu atoll (less than 1 kilometer from the reef). The origins of the spawning event are unknown, however it appears that stocks within Addu atoll were responsible. Unfortunately the consultant visually identified the spawning slick when leaving the atoll and could not confirm gonad maturation condition of hard coral stocks.

Information is also lacking on seawater surface circulation patterns within the atoll. Identification of these hydrodynamic forces will assist in the prediction of coral larval dispersal and recruitment within the atoll and HPA. A seawater circulation program for the atoll should be undertaken. This information should also be utilised for the prediction of sediment movements within the atoll and the HPA.

There are a number of human activities currently undertaken within the proposed HPA that are degrading the coral reefs and associated organisms. These anthropogenic activities need to be assessed for potential negative impacts and appropriate marine management plans and protocols developed.

The major anthropogenic threats to the marine environment within the HPA are:

- Habitat destruction (anchors, trampling)
- Habitat alteration (water craft channels)
- Resource exploitation (over harvesting: e.g. sea cucumber)
- Resource extraction (sand/rubble/coral rock)
- Land reclamation and alterations (e.g. Hydrodynamic)
- Increased sedimentation
- Increased terrestrial degradation
- Pollution (human waste, petrochemicals, rubbish).

Physical anchor damage to the reef edge and slope of the HPA by the tuna fishing fleet collecting baitfish is the main destructive activity currently occurring. The physical damage has been recorded along the entire eastern reef edge and slope of the HPA and further south along this reef to the passes. The physical damage is reducing biodiversity and live coral cover in these areas.

It is recommended that anchor usage along the ocean side of the HPA for the collection of baitfish be banned. An extension of this ban to include the reef south of the HPA to the reef passes should be considered. There are several options that should be explored and discussed with the community to allow this industry to collect baitfish without physical damage to the reef. They are:

- The placement of mooring buoys with or without bait Fish Attracting Devices (FAD) along the reef edge and slope of the HPA should be considered. This would allow the industry to continue to collect the bait without physical damage to the reef.

- Ban bait-fishing activities all together within the HPA. If this is to be undertaken additional bait fishing ground will need to be located. The

deployment of a suitable number of FADs and mooring sites in the new areas should complement these activities.

- In both cases, an education awareness program for the fisherman and community will need to be undertaken.

Permanent quadrants should be developed by the MPAS to provide direct scientific data to evaluate the timing of recruitment in anchor damaged areas along the reef edge in the HPA. Quadrants need to be placed both in anchor damaged areas and non-damaged areas and photographs taken quarterly. Each consecutive photograph can be compared to previous photographs to provide information on colony growth, survival, mortality and recruitment. The data can be displayed visually for community understanding and involvement with the MPAS project. The methodology for this monitoring program is described in Appendix 1.

In addition, it is recommended that the MPAS project staff undertake a program that maps the area damaged (m2) by anchors within the HPA. This data should be compared through time against total reef surface areas (reef edge and slope) of the HPA to provide direct evidence on coral reef recovery on a broad scale associated with these impacts. This project should be incorporated into the marine monitoring program for the MPAS project.

Marine sand and rubble are extracted daily from the lagoon for commercial activities. The affect of the extraction of material and increased sedimentation associated with these activities must be evaluated for their accumulated impacts on the HPA, especially the inner lagoon and sea grass beds. It is therefore recommended that the MPAS project undertake several monitoring projects to address these concerns. These would include; a map of the sea grass beds, the development of several strip transect lines evaluating the entire intertidal lagoon and permanent quadrants associated with these transects. The methodologies for these programs are described in Appendix 1.

The prediction of sediment transportation within the HPA should be undertaken and the procedures and methodologies required to determine seawater surface circulation patterns are described in Appendix 1. The circulation study should include current pattern for the entire lagoon for both tidal cycles.

The commercial fishery targeting sea cucumber, grouper and lobster within the HPA and Addu atoll should be reviewed and management options developed. Brief descriptions of each fishery including monitoring options are recommended to develop a sustainable management plan. Resource harvesting for subsistence purpose within the HPA and the atoll appears to be minimal. Reef fish and reef-

associated invertebrates (e.g. Mollusc) are not the preferred protein source of the communities and therefore, survey results clearly indicated mature stocks of most of these organisms. However, several species of commercially targeted organisms appear to have been over exploited.

6. Indicator Species Evaluated

6.1. Marine Fin Fish

Population numbers and identification of important commercially targeted and indicator reef finfish were included in the resource assessment. In particular, the commercial species of the family Serranidae: the grouper (*Epinephelus polyphekadion, E. fuscoguttatus, Variola louti Cephalopholus argus*) and coral trout (*Plectropomus laevis, P. pessuliferus, P. areolatus*) were surveyed to provide information on fish populations. Additional data were collected on the giant humphead wrasse (*Cheilinus undulatus*), family Labridae and the bumphead parrot fish (*Bolbometopon muricatum*) from the family Scaridae.

The sub family Epinephelinae includes all species of grouper. These fish are large mouthed, robust in body form, benthic dwellers that range in size between several centimeters to 3 meters in total length and inhabit a wide range coral reef habitats. They are all carnivores of crustaceans and fishes and will readily take a baited hook (Myers, 1991). Epinephelid species are highly prized as food fish and are the target of commercial fisherman throughput their distribution. In recent times these fish have been targeted for the live fish food trade in the Maldives (Shakeel & Ahmed, 1997 and Sluka, 1988). Anecdotal information indicates that this trade has occurred in Addu Atoll in the past and is currently continuing, albeit at lower levels.

The majority of Epinephelid species are sequential hermaphrodites, maturing first as females, and then changing to males. These species of fish aggregate for the purpose of massing spawning. Spawning aggregation events have been recorded for several Serranidae species in the Maldives and are reported to occur during the months of March and April in Laamu Atoll (Sluka, 1998). There was no literature found pertaining to the location and timing of aggregation sites within either Addu atoll nor the HPA.

The ease of harvesting grouper during spawning aggregation periods greatly increases the population susceptibility to over exploitation. Population declines and extinction have been reported through out the distribution of these fish species.

The giant humphead wrasse (*Cheilinus undulatus*) is a long-lived coral reef associated finfish species that is targeted by the live reef fish trade throughout its distribution. Population stocks are susceptible to over fishing with stock abundance dramatically declining when heavily fished. This species is used as an indicator of fishing pressure on coral reef fish communities. This species is protected within the Maldives and is registered on the Convention on International Trade of Endangered Species (CITES) Appendix 1, threatened species list. This species is a major tourist attraction and sought by the diving industry within the nation.

Fishing for subsistence purpose within the HPA and the atoll appears to be minimal. Reef fish are not the preferred protein source of the community; their preference is for the pelagic tunas. Therefore, population stocks of reef fish, especially herbivoures species within the HPA and Addu atoll are healthy with representative of all age classes present. The exceptions are the Serranids, which are targeted for commercial activities (survey results indicate that these species are showing signs of exploitation) and fish species associated with live coral communities (e.g. Chaetodontidae). It is suggested that the low populations of these coral associated species are a direct response to the 1998 coral reef bleaching event, resulting in decreased habitats and food items for these fish. It is anticipated that stock population numbers will increase with coral reef regeneration.

There have been no reports of ciguatoxic fish poisoning within Addu atoll (Marine Research Centre, MPAS pers. com).

6.1.1. Survey Results and Discussion

Of the fin fish indicator species assessed the Serranidae population stock numbers were not abundant (author pers.com) indicating fishing activities within the atoll. Since these fish are rarely targeted for subsistence use the fishing pressure is from the commercial live fish trade. Grouper species were only found in 9% of all tows (6 individuals) undertaken whilst higher numbers of coral trout species were recorded (62 individuals & 40 % in all tows). The peacock grouper (*Cephalopholus argus*) was the most abundant species located (542 individuals located in 70 % of all tows). The commercial live fish trade nor subsistence fishery does not target this species and populations are very healthy. This species does not undertake spawning aggregation activities.

Healthy populations of the giant humphead wrasse (*Cheilinus undulatus*) were recorded, with all ages and classes well represented (64 individuals and 48% of all tows). The location and survey numbers recorded for this species are documented in Figure 3. Numerous large (visual fork length over 1 m) adult individuals were

located throughout the atoll, including the eastern reefs located within the HPA. There appears to be minimal fishing pressure on these stocks. The nation wide ban on the collection of this fish should be continued. This species is very popular among SCUBA divers and could be used as a draw card for the tourist industry in this atoll. Appropriate safe guards need to be included in the management plan for the HPA to secure these populations.

Interestingly, only one specimen of the bumphead parrotfish (*Bolbometopon muricatum*) was recorded during the evaluation. This specimen was a sub-adult and was located within the HPA. Anecdotal information (diving operation) indicates that this species is not abundant in this atoll, however this information has not been scientifically confirmed.

Stock populations of Parrotfish (*Scaridae*) and to a lesser degree Surgeon fish (*Acanthuridae*) although not recorded, showed high population stocks of all age classes for individual species. It is clear, that populations of these species are healthy within the reefs of Addu atoll and fishing pressure is very low.

There was no evidence of grouper aggregation sites during the survey nor was there any specific protocols undertaken to locate these sites. Anecdotal information gained from the diving industry indicated that several species of coral trout (*Plectropomus laevis & P. areolatus*) have been seen aggregating within the deep water passes of Kuda Kandu, Maa Kandu, Viligili Kandu and Gan Kandu within the atoll. No information was provided to confirm aggregations sites for Epinephelid species. Furthermore, anecdotal information indicates that these passes are selectively fished by the live fish trade operators utilising a variety of fishing gears (subsurface nets, hook and line).

Clearly, there is a need to undertake an evaluation to determine the reproductive ecology and spawning aggregation sites of the Serranid species within the HPA and Addu atoll. This information is imperative for the development and implementation of a sustainable management plan for this fishery. Protection of these aggregation sites is imperative for sustainability of these populations. Management should also be considered for all commercial utilization of these stocks incorporating a license system and enforcement. This activity is a priority for the HPA marine management plan, as stocks within the lagoon will have a direct affect on populations within the HPA. SCUBA diving utilising visual survey techniques as described by (Sluka, 1998) should be used to obtain data on abundances and spawning behavior.

A community awareness and education program should be developed by the MPAS team to provide the community, especially schools, with basic information on the biology, ecology and conservation of these animals.

It is also recommended that an up to date list of the more common finfish located within the HPA and Addu atoll be complied by the MPAS staff.

6.2. Crustaceans

6.2.1. Lobsters

All tropical spiny lobsters are Decapod Crustaceans belonging to the family Palinuridae. The tropical species, there are 19 world wide, belong to the genus *Panulirus* (Wright & Hill, 1993). Three species of lobsters were identified during the marine assessment of Addu atoll. They are: *Panulirus penicillatus,* the doubled spine lobster, *P. longipes fermoristriga* the long legged spiny lobster and the painted lobster *P. versicolor*. A fourth species P. ornatus has been reported from the Maldives (Ahmed *et al*, (1997) and Dews pers. com.); however the presence of this species was not confirmed by the consultant nor by the commercial collectors in Addu atoll. Additional information is required to confirm if this species is present.

The species of *Panulirus* occupy a wide range of habitats, however each species responds differently to habitat gradients, such as depth, turbidity, coral cover wave action and food preferences.

P. penicillatus shows the greatest habitat specificity, restricting its distribution to the windward surf zones and reef passages of oceanic reefs. This species has a very strong negative response to sunlight, and, during the day, shelters in dark recesses in the reef in shallow water. At night these lobsters move onto the reef crest and flat to feed.

P. longipes fermoristriga is found on the windward reef slopes, though usually deeper that P. penicillatus and in areas of less wave energy and more coral abundance. This species is also photonegative and shelters in recesses during daylight. This species does not move up onto the reef crest or flat at night to feed, instead it forages on the reef slope.

P. versicolor is most commonly found within lagoons among coral gardens of plate and massive corals. This species can be found in expose reef slopes but rarely and they tend to be deeper than 6 meters. This species is also nocturnal and shelters in dark recesses during day light hours. This species is however, conspicuous during the day as they are often seen aggregated together under live corals with their unique long white antennae protruding (Wright & Hill, 1993).

The three species mentioned above are opportunistic and omnivorous scavengers.

Little documented information is available for specific food items each of these lobsters consume.

The different species of Panulirus have relatively similar consistent life cycles and breeding behaviour. Male lobsters mate with intermoult females that have developing ovaries. The male deposits a sperm package (dark brown to black in colour), via paired penile projections, at the base of the fifth walking legs onto the fourth and fifth sternal plates of the female. The female extrude several hundred thousand eggs from a paired gonophore at the base of the third walking legs in a chamber formed by curving the abdomen over the sternum. The eggs are fertilised as the female releases her eggs by scraping the sperm package. The fertilised eggs adhere to the setae of the pleopods of her tail. The female carries the eggs for about one month before tiny phyllosoma larval are released. The larvae may remain as zooplankton from between 4 - 12 months before they moult into the puerulus stage which looks like a miniature (colourless) version of the adults and is found on the reef.

The reproductive season of these lobsters in Addu atoll is unknown, but it is expected to be continuous, or a slight decrease during the winter months.

The usual methods that are employed by Addu atoll fisherman to capture lobsters include; hand collection whilst reef walking at night, hand collection whilst free diving on the reef crests, reef slopes and within the lagoon (*P. versicolor*) at night. Some spearing of lobster has occurred but is not the normal practice.

There are three commercial groups of lobster fisherman reportedly operating in Addu atoll. Two groups are collecting lobsters along the ocean side of Hithadhoo south to Maradhoo whilst the third group focuses their fishing efforts on the ocean side reefs of Hulhumeedhoo south to Heretere. Each group consists of roughly 4-6 fishers. The majority of lobsters collected are frozen on island and exported to Male for resale to the tourist resorts. The product is frozen in domestic freezers and concerns are expressed regarding their safety for human consumption. The demand for lobster for the domestic tourist trade is high and currently levels of demand for Addu reef is expected to increase with the possible development of a new resort project for the island of Viligili.

Anecdotal information indicates that fishermen from atolls in the north visit Addu and undertake commercial fishing activities, which includes lobster collections. Information pertaining to reef collection locations and numbers of animals collected is unknown. The local fisherman indicated that Addu reefs are damaged due to the collection of lobster and grouper from non-Addu fishermen. This was not confirmed during the resource assessment.

The commercial collection of lobsters within the HPA is limited; however, the favoured location for the commercial collectors is the region of reef on the western ocean side of the atoll directly south of the HPA. The reefs in these areas possess very low live coral cover and therefore limited structural damage from this activity is currently occurring. There is limited data collected on the lobster fisheries in Addu atoll, (numbers collected, species, sex ratios) and therefore no biological recommendations can be made on the affect of this activity on the standing population stocks within and outside the HPA. It is therefore recommended that this information be collected to allow a biological assessment and the development of a management plan for this fishery.

The consultant is in agreement with the conclusion reached by Wright (1992) that tropical reef associated spiny lobsters are difficult to overexploit due to the reef topography providing natural habitat protection from harvesting which provides a stable breeding population and supply of recruits. Furthermore, it is suggested that inter reef larvae transportation may contribute towards larval recruitment within Addu atoll.

The national Fisheries Act states that it is illegal to collect all species of lobsters that have a carapace length of less than 25 cm and all female lobster carrying eggs (berried). From discussions with the fishermen these regulations are followed (the Male middleman will not purchase illegal lobsters); however there have been cases of eggs being removed from suitable size females in the water to allow commercial sale (author pers. com.).

There appears to be no data available on Addu population stocks for any species of lobsters to determine if the minimum size limit imposed by the national Fisheries Act does indeed serve as a successful management tool for the three species located in this atoll. A review of the literature and a monitoring program as described below should be implemented to provide scientific information to address this concern. This activity is not a priority for the HPA marine management plan.

6.2.2. Survey Results and Discussion

Table 1. Biological information on hand collected crayfish collected at night from the eastern ocean side of Hithadhoo.

Crayfish Species	Sex	Carapace Length (mm)	Gonad Condition
Panulirus penicillatus	Female	110.0	Mature, no eggs or sperm packet
P. penicillatus	Female	144.5	Mature, no eggs or sperm packet
P.longipes femoristriga	Male	170.0	Mature
P. longipes femoristriga	Male	180.0	Mature

Table 1 presents data on selected lobsters collected by commercial fisherman during the survey. MPAS project staff were taught all methods to identify individual species, the different sex and reproductive stages of lobsters and how to obtain carapace length measurements.

From the limited number of specimens available all males collected revealed the external adult sex appendages and were classed as functional mature males. All females were mature and showed evidence of recent egg release. No fresh sperm packets were located, however, older used sperm packets were located on these individuals. Additional information on a much larger sample through time is required to provide evidence of the reproductive cycle of the individual species of lobsters in this atoll.

One specimen of *P. versicolor* was located during the survey (Tow 13). The specimen was immature and was not collected.

The collection of basic biological information on the three species of lobsters found in Addu atoll should be undertaken as part of the MPAS marine monitoring program. It is recommended that at least 15 individuals of each species be collected monthly and the following data recorded: date of capture, location of capture, sex, carapace length, and gonad condition of the female specimens (presence or absence of eggs and presence or absence of the sperm packet). This data should be recorded and presented in a similar fashion as Table 1 above.

Data collection should be undertaken from both commercial fisherman catches and from specific field collections of the MPAS project team. Data collection from commercial fishermen will provide information on specimens of legal size only. Additional information on specimens of smaller than 25 cm carapace lengths are needed to provide the information required to develop a management plan. All lobsters collected by the MPAS staff should be returned to the reef alive, once data have been collected. There is no need to sacrifice any specimen for the data collection. The dark phase of the moon at night should be used to collect data.

Information obtained from the monitoring program can then be used to define the annual reproductive cycle, the minimum size of maturity for each gender and population structures within Addu atoll. This data is imperative for the development of a management plan for these animals. Once this information is obtained, specific management protocols can be implemented both for the HPA and the atoll.

A community awareness and education program should be developed by the MPAS team to provide the community, especially schools, with basic information on the

biology and conservation of these animals. Community participation in field data should be considered.

6.3. Marine Turtles

All five pantropical species of marine turtles have been recorded in the Maldives (*Frazier et al*, 2000). The Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*) turtles are located and breed regularly throughout the archipelago. The three other species are rare and information on their life cycles is incomplete for the Maldives, they are: Olive Ridley (*Lepidochelys olivacea*), Leatherback (*Dermochelys coriacea*) and Loggerhead (*Caretta caretta*) (*Frazier et al*, 2000).

A total of 38 turtles were located during the marine evaluation (nineteen Green and nineteen Hawksbill turtles). All other species were not located. Size ranges for both species varied indicating a range of ages among the animals within the atoll. Several large green turtles were visually estimated with shell lengths of greater than 1.5 meters. The numbers of individuals located during the survey work and anecdotal information provided by a local dive master (Mr. Qasim) indicate that populations of these two species are healthy within Addu atoll.

Frazier *et al.* (2000) provides a detailed account of turtles within the Maldives archipelago and should be referred if additional background information is required. There were no data located in the literature evaluated providing information on nesting locations within Addu atoll for any species of turtles. Anecdotal information has indicated several locations for green turtle nesting sites in the villages of Viligili, Gan, Rujjehihera and Hulhumeedhoo however these locations have not been confirmed. Anecdotal information pertaining to nesting locations for Hawksbill turtles was absent.

The current populations of green and hawksbill turtles located both within the lagoon and outside the barrier reef suggest that Addu atoll supports good populations of these species and that the islands and associated beaches within the atoll are used as nesting sites. The large pasture of sea grasses located within the HPA and other smaller location within the atoll provide suitable feeding grounds to support reasonable stocks of green turtles. Equally, the reefs of the atoll support a wide variety of soft-bodied invertebrates (e.g. sponges), which would support stocks of hawksbill turtles.

It is recommended that a program be undertaken by the MPAS with possible assistance from other relevant government agencies to obtain information on active nesting sites, nesting seasons, female fecundity and basic life history data for both green and hawksbill turtles within the atoll. In addition, anecdotal

information should be solicited from the community, especially local fisherman to provide further information to determine the ecology of these animals. This information is required to allow a biological assessment and the development of a sustainable management plan. This activity is not a priority for the HPA marine management plan.

Turtle harvesting rates and the loss of nesting sites within the atoll are the two major threats to the continued existence of these animals within this atoll and the nation. Current exploitation rates within Addu atoll and associated oceanic waters are unknown.

Data should be collected annually on the population numbers of these organisms. This information can be obtained through the yearly manta tow assessments.

All Turtles located in the Maldives are registered internationally as CITES Appendix 1 animals. The nation has currently three major regulator legislations to prevent the over exploitation of marine sea turtles.

- A ten-year ban on the catching or killing of sea turtles in the country initiated in June 1995,
- A ban on the importation of turtles and turtle products into the country initiated in August 1995,
- A ban on the sale of turtle and turtle products in the country initiated in January 1996. (Zahir, 2000)

6.4. Echinoderms

6.4.1. Sea Cucumbers

Sea cucumbers have been consumed as a traditional food in china and other parts of South East Asia for many centuries. Intensive exploitation of sea cucumber stocks has been commercially harvested in the Maldives during the past several decades (Ahmed *et al*, 1997). This reference provides a detailed account of the sea cucumber fishery in the Maldives and should be referenced for additional information.

There are many species of sea cucumbers found within the tropical Indo-Pacific, however less than a dozen species command high prices and are sought commercially. Species that command high commercial values are located within the Maldives and more specifically, Addu atoll. A commercial fishery for sea cucumbers has been operating within Addu atoll for the past decade.

Commercially important species of sea cucumbers are refereed to as bech-de-mer (or trepang). All commercial sea cucumbers are members of the class of Aspidochirotidae and are all relatively large species with thick body walls. A process of boiling, cleaning, drying and in some cases smoking produces bech-de-mer. The finished product, which has a hard rubber texture, is normally rehydrated before consumption (Wright & Hill, 1993). The product is considered a delicacy and an aphrodisiac in China and South-east Asia. The nature of the product, the simple low technology utilised to harvest and process these animals makes them very appealing to remote atoll communities, such as Addu atoll.

The commercial bech-de-mer species are bottom dwellers that feed primarily by digesting organic material obtained from the substrate (deposit feeders). The majority of the organic material consumed is bacteria. Localised distribution of individual species is affected by habitat availability and preference of individual species. The large commercial species (*e.g.: Holothuria nobilis*) tend to have lower densities than the smaller species, such as Holothuria atra.

Sea cucumbers can reproduce asexually or sexually. Scientific information on which species undertake the different forms of reproduction is unknown for the majority of species. Sexual reproduction involves the release of male and female gametes (sexes are generally separate) into the water where the fertilized eggs develop into free-swimming larvae. The larvae metamorphosis several times during the free swimming stage and the duration of the larval cycle varies between species and locations.

Anecdotal information indicates that sea cucumbers are only harvested in Addu atoll for commercial activities; they are not used for any subsistence function.

6.4.2. Survey Results and Discussion

Ten species of sea cucumber were observed (*Holothuria atra, H. noblis, Actinopyga mauritiana, A. miliaris, Bohadschia argus, B. graeffei, B. marmorata, Stichopus variegatus, S. chloronotus, Thelenota ananas*) on the reefs of Addu atoll. All commercially important species (*H. noblis, Actinopyga mauritiana, A. miliaris, B. marmorata, S. variegatus, S. chloronotus and T. ananas*) were found in very low densities in all tows. The very low occurrence of these commercially important species is a direct result of past and current commercial harvesting.

The non-commercially targeted species of *Bohadschia argus* (Leopard fish) and *Holothuria atra* (stocks were not recorded) dominated the survey counts. Interestingly the colouration of *B. argus* is considerably different from stocks in the Pacific as recorded in the references. The animal is a very dark brown with

small slightly lighter colour pigmentation on the upper surface. The scale worm is present.

The results obtained during the survey reflect only those stocks of sea cucumbers that are living in water depths of less than 12 meters. The survey did not evaluate stocks of sea cucumbers deeper than this due to the limitation of free diving. SCUBA and Hooker systems are not used in Addu atoll currently, nor in the past to harvest sea cucumbers and therefore the maximum depth of collection is reflected in the survey results. The majority of the larger commercial sea cucumbers can live in both shallow and deep water (<60m) and therefore, stocks may be present at these depths. The size of these stocks nor the role they play towards recruitment in this atoll is unknown.

Stock populations of all the commercially important species of bech-de-mer are very low within Addu atoll. These low stock numbers are a direct result of commercial harvesting. Anecdotal information indicated that current levels of harvesting are greatly reduced from previous years however specimens are collected if located. The current level of exploitation is not sustainable and therefore it is recommended that the MPAS develop a system to encourage the implementation of a management plan for this fishery and protect the remaining stock populations.

A community awareness and education program should be developed by the MPAS team to provide the community, especially schools, with basic information on the biology, ecology and conservation of these animals.

Sea cucumbers play a vital ecological role on coral reefs by decreasing the organic content of reef sediments. The direct impacts on the reef by the removal of a high percentage of the sea cucumber biomass is unknown, however the process of recycling organic material must be directly affected. In Addu atoll this is further exasperated by the resent increases in coral reef dredging and coral, sand and rubble extraction operations. A relationship between decreasing water quality of the inner lagoonal areas of the HPA and decreased numbers of sea cucumbers may be apparent. Additional scientific investigations and data are required before this can be clarified.

Data should be collected annually on the population numbers of these organisms. This information can be obtained through the yearly manta tow assessments.

6.5. Crown of Thorns Starfish

The Crown of Thorns starfish, *Acanthaster planci*, is found on the reefs of Addu atoll.

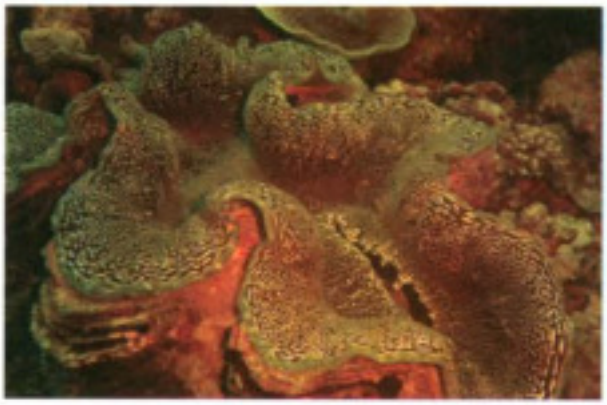
This species of starfish is a predator that feeds on the soft tissue of hard corals. This species has been implemented in major reef degradation throughout the Asian-Pacific region when population numbers reach high proportions. Population densities of 100 or more starfish per hectare are considered detrimental to coral reefs.

Two adult crown of thorns starfish were observed during the resource evaluation. (Tows numbers 46 & 51). Therefore, it is clearly evident that the standing stock of this starfish in Addu atoll is no threat to the reefs at the present time. Data should be collected at least annually on the population numbers of this organism. This information can be obtained through the yearly manta tow assessments.

6.6. Marine Mollusc

6.6.1. Giant Clams

There are eight extinct species of giant clams within two genera that occur within the tropical Pacific and Indian oceans. Two of which are found in the Maldives and are present in Addu Atoll. They are *Tridacna maxima* and *T. squamosa*. Both species are termed "Gaahaka" and a giant clam fisheries based on the wild collection of latter species has been previously undertaken within the nation, resulting in population declines of this species. No reports were located inferring this activiy was undertaken within Addu atoll. The collection of giant clams for export was banned in 1995 (Ahmed *et al.*, 1997).



All species of giant clam share a unique symbiotic relationship with the microscopic dinoflagellate, *Symbiodinium microadriaticum*, also known as zooxanthellae (Copland and Lucas, 1988). Zooxanthellae live freely inside the haemal sinuses (blood passages), which are located in the surface of the mantle tissue of the clam. The photosynthetic products from zooxanthellae are used directly by the clam and many of the nutritional requirements of clams are met by this relationship (Dalzell *et al.*, 1993). Hence, availability of light is the most important environmental factor for determining clam growth and survival. Clams occur from the intertidal zone down to approximately 25m, this lower depth being dependent on the clarity of the water. Each species exhibits different habitat and depth preferences on coral reefs.

All giant clam species are protandrous simultaneous hermaphrodites, generally releasing male gametes before female gametes. Gamete release occurs through the excurrent siphon and in both natural and artificial conditions may stimulate other clams in close proximity to released gametes. Spawning periodicity in lower latitudes is continuous with a percentage of the population possessing ripe gametes all year round. The larval life cycle of giant clams is less than two week in duration near the equator.

The artificial culture of giant clams in both the sea and on land-based facilities has been developed for all giant clam species. To date no commercial farming of giant clams has occurred within the Maldives.

6.6.2. Survey Result and Discussion

Two species of giant clams were found during the resource survey. These were, in order of abundance: *T. maxima* and *T. squamosa.*

T. maxima were found in 75 percent of all survey tows and a total number of 717 individuals were located. Abundance of this species of clam varied considerably between reef regions within the atoll. Highest densities were recorded on the eastern reefs of the HPA (e.g. tow 32). This variability is a normal process on coral reefs.

Stocks of Tridacna squamosa were abundant with a total number of 188 individuals located in 45 percent of the surveys undertaken. This species of clam tends too inhabit deeper water 5 + meters and is found within the lagoon, reef passes and ocean side of reefs. Natural abundance of this species varies considerably between reef regions. This variability is a normal process on coral reefs.

All sizes of both species of clam were located throughout the lagoon, providing clear evidence that both species are successfully reproducing within the atoll and recruitment is occurring. Particular reference is noted to the high number of large *T. squamosa* located, clearly indicating that commercial fishing pressure is all but absent within Addu atoll.

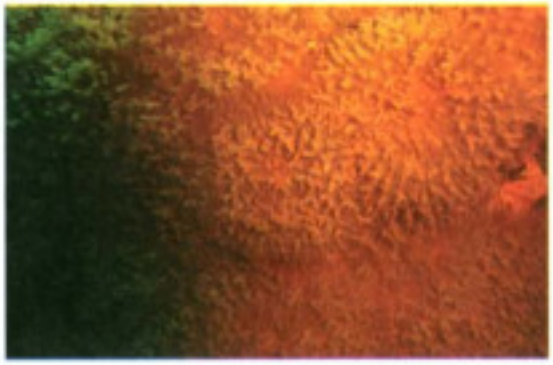
There appears to be little if any subsistence collection of clams within the atoll and as a direct result the standing stock populations of giant clams on the reefs of the HPA and within the atoll are currently not under any anthropogenic threat. Nevertheless stock population abundance should be annually monitored and included in the manta tow surveys recommended for the atoll.

The stocks of both species would provide suitable broodstock for the artificial

culture of these animals for community based alternative income generation activities.

6.6.3. Pearl Oysters

The tropical black lip pearl oyster *Pinctada margaritifera* and the winged oyster *Pteria penguin* were not located during the survey of Addu atoll. Population stocks of these animals may be present in deeper waters. Both these species are artificially cultivated to produce black pearls and "mabe" pearls, respectively.



7. Recommended MPAS Monitoring Program

In order to detect changes in the status of marine resources, data collection programs must be undertaken regularly over extended periods of time (English *et al.*, 1997). Data collection provides information on the distribution and abundances of animal and plant communities. The information obtained can be used to determine the status of the ecosystem, specific organisms and used directly to develop management plans.

It is important to recognise and understand that there is considerable natural variation within marine ecosystems, both spatially and temporally. Any monitoring program will be more effective if a basic understanding of the biology, ecology and behaviour of the organism is known. The development of a well-designed database is also an essential component of a long term monitoring program.

It is therefore recommended that a marine monitoring program be implemented for the MPAS including the marine environment for the HPA and the atoll at large. The recommended monitoring program has been designed to provide baseline scientific information on life histories, population abundance and their changes over time of a range of indicator marine organisms, collect information associated with the surface water circulation patterns of the atoll, lagoon and HPA and provide an understanding of the level of sedimentation within the lagoon. The monitoring program will detect broad scale changes to the marine environment within the HPA and atoll itself.

The marine environmental components required to be monitored for the MPAS project are:

- Lagoon and barrier coral reefs.
- Sea grass beds.
- Commercial fishing activities (e.g. baitfish, lobsters and grouper; the live food fish trade)
- Commercial coral/rubble/sand extraction programs.
- Sea water circulation patterns and
- Sedimentation rates and transportation.

Information gained from the recommended monitoring program is essential for the development of an appropriate long term sustainable marine management plan that is practical and acceptable to all stakeholders and resource users of the HPA and the atoll itself.

A training program was undertaken with the MPAS project staff to develop the marine monitoring program for the HPA and atoll. The program centred around the understanding and the importance of coral reef monitoring, the methods and procedures utilised to collect useable data, the processes involve to interpret and analysis the data and the presentation of the data with special reference to providing this information directly to the communities in a form that they can comprehend. The consultant did not have the time to implement the majority of the monitoring program, this responsibility has been allocated to the project staff to undertake, using the information discussed and documented below.

The monitoring program designed was based on following criteria:

- The questions being asked,
- The site specific conditions,
- Limitations of logistics, staffing and finance,
- Community participation and understanding.

A lengthy literature review of marine ecosystem monitoring protocols, procedures and data analysis has been undertaken by the project (Naeem, 2002). Information discussed in this document is not repeated, however relevant information pertinent to the methods recommended for the monitoring program have been incorporated. Additional background information can be located in this document and references cited.

In total, five (5) marine monitoring programs for the HPA utilizing a range of scientific monitoring protocols are recommended. The methodology for these programs have been documented in Appendix 1 and all procedures have been discussed and taught to all MPAS staff. The monitoring program will provide the biological information required to manage the marine resources of the HPA and Addu atoll. In has been recommended that staff from Marine Research Centre (MRC) and the community be actively involved in the monitoring program. The monitoring programmes are:

- Coral community.
- Coral reef indicator species.
- Sea grass beds.
- Sediment deposition.
- Lagoon surface water circulation pattern.

Appendix 5 provides a detailed summary of the recommended monitoring program including methodologies, frequencies, and detectible limits and executing agencies.

Information pertaining to the recruitment process for reef building corals and associated benthic organisms is a priority goal of the monitoring program. The recruitment of reef building corals both on spatial and temporal scales is especially important information to allow predictions on the recovery rates on the reefs within the atoll. The recovery of damaged reefs over time is extremely important for all income-generating activities associated with the tourist industry within Addu atoll and the nation.

Hard Corals within Addu atoll have suffered very high mortality rates which have been attributed to increased seawater temperatures in 1998 resulting in massive coral bleaching and mortality within the nation (Clark *et al.* 1999). Recovery of reef building hard corals is occurring on all the reefs of Addu atoll and within the HPA. Recovery rates observed during the resource assessment varied both spatially and temporally within the atoll.

All existing reefs that have live coral cover are extremely important for the continuation of this recovery. It is suggested that reefs within the atoll that posses current populations of hard corals are functioning as broodstock for coral recruitment within the atoll. Preservation of these stocks is imperative for the continued existence and recovery of the atolls coral reefs.

Water driven circulation patterns within the HPA and the atoll itself has not been studied in detail. The understanding of the surface water circulation patterns, current and eddies will greatly assist the understanding of coral larval movement and recruitment patterns and the movement and deposition of water born sediments both within the atoll and specifically within the HPA.

The MRC under the Ministry of Fisheries, Agriculture and Marine Resources as part of their work program has initiated a study on hard coral recruitment and survival rates within the nation including Addu Atoll. This program forms a part of a masters degree study program for Mr. Husen Zahir. Discussions were undertaken with MRC staff to formulate a working relationship between both entities and the sharing of information. It was agreed that a coral reef field monitoring sites would be developed and implemented within the HPA utilising the Line Intercept Transect methods (refer Appendix 1). MPAS staff are to be further trained in all monitoring activities undertaken and will be actively involved with data entry, analysis and presentation of all findings.

Table 3 provides a summary of current marine anthropogenic threats and recommended actions related to the HPA and the atoll.

Marine Components	Anthropogenic Threats to HPA
Coral Reef- Ocean	Physical Damage (Anchors, Ship groundings, Resource Over-Harvesting, Trampling). Dredging Operations: sand/rubble/rock extraction, sedimentation. Pollution (human waste, petrochemicals, rubbish)
Coral Reef - Lagoon	Physical Damage (Anchors, Ship groundings, Resource Harvesting, Trampling) Dredging Operations: Sand/rubble/rock extraction, sedimentation. Pollution (human waste, petrochemicals, rubbish). Altered hydrodynamic conditions from dredging.
Sea Grass beds	Physical Damage: Trampling, Resource Harvesting. Altered hydrodynamic conditions from dredging. Increase Sedimentation. Pollution (human waste, petrochemicals, rubbish).
Mangroves	Physical Damage: Resource harvesting, tree felling Increase Sedimentation from marine dredging operations. Pollution (human waste, petrochemicals, rubbish). Altered hydrodynamic conditions from clear felling.

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Appendix 1

Resource Assessment and Monitoring Methodology

The resource assessment methodologies documented below were undertaken during the marine survey evaluation of Addu Atoll and the Hithadhoo Protected Area. All MPAS staff were taught the theory and practical procedures and applications for these methods. MPAS staff will need to undertake these methods to implement the recommended monitoring program. It is recommended that these methods be repeated annually to provide information on the broad changes and species population abundances on the benthic communities within the HPA. The sites undertaken during the consultant visit should be repeated so comparisons of data at an annual level can be undertaken.

The resource monitoring methodologies documented below are designed to provide background information to allow the MPAS staff to implement these strategies. They are therefore used as a guide and should be read in context with the monitoring program.

Manta Tows

Manta tows are used to provide information on broad changes and species population abundances in benthic communities on coral reefs. This method allows visual assessments of large areas of reef within short periods of time.

The manta tow technique used for the marine assessment of the HPA and the Addu atoll involved the securing of a piece of wood across the front of a boat so that approximately 1 meter of wood hung over each side of the boat. Ropes with hand loop were attached to each end of the wood so that observers can be towed through the water. Each observer used the centre of the boat hull as a guide and actual counts were made on each species as the boat moved over the reef. The width that each observer recorded was dependent on local water clarity, water depth and species abundance.

A GPS point (latitude and longitude) was marked at the start and end of each manta tow and the distance travelled was recorded directly from the GPS unit (km). The distance travelled multiplied by the width of the tow evaluated for both members of the survey team provided data to determine total reef area surveyed.

The following data were collected for each manta tow undertaken for the Addu atoll marine survey. Total percent live coral cover, reef aesthetics, dominant benthic organisms and form, dominate hard coral genus and associated morphological

form, tow length, tow width, water depth, cloud cover and wind condition. In addition, total individual numbers were recorded for the following indicator species:

- Turtles: Green (*Chelonia mydas*) and Hawksbill (*Eretmochelys imbricata*).
- Giant Clam: (*Tridacna squamosa* & *T. maxima*).
- Marine Fish: Coral Trout (*Plectropomus laevis* & *Plectropomus punctatus*), Coronation Trout (*Variola louti*), Grouper (*Epinephelus sp* and *Cephalopholus argus*), Napoleon Wrasse (*Cheilinus undulatus*) and the Bumphead Parrotfish (*Bolbometopon muricatum*).
- Sea Cucumbers: *Actinopyga mauritiana, A. miliaris, Holothuria noblis, Bohadschia argus, B. marmorata, B. graeffei, Stichopus variegatus, S. chloronotus* and *Thelenota ananas.*
- Crown of Thorns Starfish (*Acanthaster planci*).

All data collected in the field were transcribed onto data form sheets and entered directly into a computer database (Appendix 2, 3 and 4) for later analysis. All MPAS staffs were actively involved with all aspects of field collection and data recording.

The advantages of this method of survey are (adopted from English *et al.* 1997):

- Large areas of reef can be surveyed in a relatively short period of time. This reduces the possibility of not documenting population changes in space and time (e.g.: dynamite fishing or storm damage),
- It is relative simple to perform after some initial training,
- It does not require expensive equipment (e.g. SCUBA) nor specialised qualifications,
- It can be performed in remote locations with minimal support,
- The observers can cover great distances with minimal fatigue
- It is rapid, non destructive and inexpensive.

The disadvantages are (adopted from English *et al.* 1997):

- If the organisms is cryptic they may be over looked,
- If the organism is fast moving (e.g.: some fish) then they may be overlooked,
- The observer may have too much information to remember and provide inaccuracy in data
- The survey may be conducted over inappropriate sections of the reef because the tow path is controlled by the driver who views the reef from above.

Timed Swims

Timed Swims are used to provide information on broad changes and species population abundances in benthic communities on coral reefs. This method allows visual assessments of small areas of reef within short periods of time. This method was utilised when the Manta Tow method was unable to be employed. In particular, this method was utilised when the boat was unable to be used in shallow water (low tide) and in the presence of large waves and ocean swells on the ocean side of the lagoon were it was unsafe to use the boat.

The observer/s swum (5 or 10 minutes) along the reef, recording actual counts on each species. A GPS point (latitude and longitude) was marked at the start of all swims and an end GPS point was obtained for the majority of swims undertaken. In some cases an end GPS data point was unable to be obtained. The width that each observer recorded was dependent on local water clarity, water depth and species abundance. The distance travelled multiplied by the width of the Timed Swim evaluated for each member of the survey team provided the data to determine total reef area surveyed. Estimation of reef length covered for swims that did not have an end GPS point were made from comparisons of the distance traveled from other swims. Therefore the data obtained for distance traveled and actual area covered is not precise for these data transects.

Data collected for each Timed Swim was identical to data collected for the Manta Tow method reported above and all data collected in the field were transcribed onto data form sheets (Appendix 2, 3 and 4) for later analysis.

The advantages of this method of survey are (adopted from English *et al.* 1997):

- Relatively large areas of reef can be surveyed in a relatively short period of time. This reduces the possibility of not documenting population changes in space and time (e.g.: dynamite fishing or storm damage),
- It is relative simple to perform after some initial training,
- It does not require expensive equipment (e.g.: SCUBA) nor specialised qualifications,
- It can be performed in remote locations with minimal support,
- It is rapid, non destructive and inexpensive.

The disadvantages are (adopted from English *et al.* 1997):

- If the organisms is cryptic they may be over looked,
- If the organism is fast moving (e.g. some finfish) then they may be overlooked,

- The observer may have too much information to remember and provide inaccuracy in data
- The survey may be conducted over inappropriate sections of the reef because the swim path is controlled by the local conditions prevailing (e.g. currents and wave activities).

Strip Transects

Strip transect lines are used to provide information on broad changes and species population abundances in benthic communities on coral reefs. This method allows visual assessment of the reef, but is limited in area coverage and is time consuming. Strip transects will be used to collect data on the intertidal reef flats associated with sea grass beds located within the HPA. Time and weather constraints prevented the consultant and MPAS staff from completing this activity. The Team Leader will undertake this section of the program with the MPAS staff.
A 50-meter measuring tape is laid on top of the reef, secured at one end, perpendicular to the reef edge whilst two observers walk along either side of the line recording data. The transect width used for each survey site is 2 meters each side of the transect line (4 meters in total). The 50-meter tape length is repeated until the entire reef flat is evaluated terminating at the reef crest. Data are to be combined for every 5 meters increments along the transect line to provide a detailed horizontal description of the benthic community across the reef flat. Umair & Husen (2001) should be referred for addition information.

A GPS point is to be marked at the start and at the end of each transect line to allow future identification of the survey site. The total length of the transect (measured by the tape) multiplied by the width evaluated provides information on reef area surveyed.

The following data are to be collected for each strip transect undertaken.

Total percent live coverage of sea grasses, dominant benthic organisms and form, dominate hard coral genus and associated morphological form, transect length, transect width, water depth, cloud cover and wind condition. In addition total individual numbers are to be recorded for:

- Marine Gastropods: including Spider Shell (*Lambis lambis*), Cowries and Cone Shells.
- Giant Clam (*Tridacna squamosa* & *T. maxima*).
- Sea Cucumber: Actinopyga mauritiana, A. miliaris, Holothuria noblis, Bohadschia argus, Stichopus variegatus, S. chloronotus and Thelenota ananas.

All data collected in the field are to be transcribed onto data form sheets for later analysis (refer Manta tow section above).

The advantages of this method are (adopted from English *et al.* 1997):

- It provides quantitative and qualitative data on fast moving and cryptic reef organisms (e.g.: Spider Shells).
- Is a reliable and efficient sampling method for obtaining quantitative percentage sessile benthic invertebrates and marine plants.
- Can provide detailed information on spatial pattern,
- If replicated over time, it can provide information on temporal change.
- It is relatively simple to undertake.

The disadvantages are (adopted from English *et al.* 1997):

- Requires the placement of a measuring rope on the reef that may cause reef damage.
- Results may differ between observes without careful training and comparison activities.
- Is time consuming.
- Organisms may be attracted or actively swim away from the observers affecting data collections.

Line Intercept Transect

Line Intercept Transects (LIT) is used to assess the sessile benthic community of coral reefs. This technique was be used to provide monitoring data on corals within the HPA. The coral community is characterised using Lifeform categories (refer English *et al*, 1997), which provide a morphological description of the reef community. This data is compared through time and provides very accurate data on coral growth rates, survival and recruitment. This method is laborious and is limited in area coverage.

Line Intercept Transects was used to develop the coral monitoring sites jointly implemented by the MPAS and MRC staff on the eastern reef flat and slope within the HPA. A 50-meter measuring tape was laid on top of the reef, secured at each end at a similar depth. Two LIT were undertaken during the survey, one on the reef edge (3 m) and another parallel at 10 meters water depth on the reef slope. The observers swum along the line recording the Lifeform categories as described in English *et al.* 1997. Three replicates for both sites were undertaken and data were collected at each site.

A GPS point was marked at the start of each transect line and each transect location was marked on a map to allow the site to be recorded (figure 1).

MRC and MPAS staff will repeat the collection of data annually at each site. It is envisaged that MPAS staff will eventually take over the full responsibility of these monitoring sites and maintain the data collection program.

English, *et al.* (1997) provides a detail account of the procedures require to collect data and complete LIT and should be referred for additional information.

The advantages of this method are (adopted from English *et al.* 1997):

- The Lifeform categories allow the collection of useful information by persons of limited experience in the identification of coral reef benthic communities.
- LIT is a reliable and efficient sampling method for obtaining quantitative percentage cover data.
- Can provide detailed information on spatial pattern.
- If replicated over time, it can provide information on temporal change.
- It is relatively simple to undertake.

The disadvantages are (adopted from English *et al.* 1997):

- It is difficult to standardise some of the Lifeform categories.
- In general it requires the use of SCUBA equipment and trained personnel.
- Findings are limited to questions concerning percent cover data or relevant abundance.
- Requires the placement of a measuring rope on the reef that may cause reef damage.
- Results may differ between observes without careful training and comparison activities.
- Is time consuming.

Permanent Quadrant Method

The permanent quadrant method is designed to monitor changes in the macrobenthos community through time. The technique involves monitoring the biological condition, growth, mortality and recruitment of corals in a permanently marked (fixed) quadrant located on the reef edge or reef slope. This method is used to compliment the Line Intercept Transect method by providing a detailed record of changes in individual coral colonies and recruitment within a mapped

area. A series of photographs are taken periodically of the quadrant using an underwater camera, which is mounted on a specially designed frame. The photos are combined to form a photo composite of the quadrant.

This method has been designed to compare coral communities in areas within the HPA that have been damaged by anchors and areas with no anchor damage. The information gained over time will provide valuable data on coral survival and recruitment rates.

English *et al* (1997) provides an excellent description of the equipment and methodology required to implement this monitoring program and should be referred for additional information. A summary has been provided below.

A portable quadrant with a basal square diameter of (1 x 1 meter), divided into 25 cm grids with 10 kg test monofilament fishing line and a stable tetrapod stand to hold the camera both constructed out of aluminium needs to be erected by the MPAS staff. The base of the tetrapod must aligned with the 1 x 1 metre quadrant and the camera height approximately 0.8 of metres is required.

Two monitoring sites need to be selected at approximately 3 meters water depth on the reef edge within the HPA. One site should be selected in a disturbed area (anchor damage) whilst the second site should be located in an area that has not been disturbed by anchors. These sites should not be separated more than 5 meters. Permanent markers (1 meter lengths of rebar) should be placed into the reef to ensure photo duplication can be undertaken and GPA coordinates should be assigned to each site.

Each site should have two permanent quadrants for data collection and data is to be collected every 3 months at all sites. The implementation of this program has been assigned to the MPAS staff under the guidance of the information provided and the Team Leader.

Each consecutive photo can be compare to previous photographs to provide information on colony growth, survival, mortality and recruitment. The data can be displayed visually for community understanding and involvement with the MPAS project.

The advantages of this method are (adopted from English *et al.* 1997):

- The sampling is non destructive
- Detailed and careful observations, photography, and mapping of such fixed area provides a good record of what takes place in an area.

- Is a good source of information on population estimates for growth rates, partial mortality, mortality and recruitment of benthic sessile organisms e.g. corals, if sufficiently replicated.
- Provides a permanent record of the site.
- It is relatively simple to undertake.

The disadvantages are (adopted from English *et al.* 1997):

- The method is slow and equipment is cumbersome especially in strong currents.
- The photography requires a relatively flat area.
- The method provides data on a small area only.
- It requires the use of SCUBA equipment and trained personnel.
- Is time consuming.

Sedimentation Project

Sedimentation resulting from land clearing, coastal construction and sand mining (dredging) are potential threats to corals and coral reef communities. While some species are able to tolerate varying periods of exposure to high levels of suspended sediment, heavy sedimentation adversely affects many aspects of coral survival, including coral growth and recruitment. Resulting in decreased coral diversity, live coral, coral growth, coral survival and net productivity on coral reefs (English *et al.*, 1997).

Increased sedimentation due to the above anthropogenic activities has been reported to be occurring within the HPA and Addu atoll (Author pers com). However, there have been no intensive scientific studies undertaken to document the levels of neither sedimentation nor the surface seawater circulation patterns that dictate the sediment movement within the HPA and the atoll.

It is therefore recommended that MPAS project undertake a sedimentation study to document rates of sedimentation over time within the reef systems associated with the HPA. The project should be undertaken with the use of sediment traps. These traps yield time-integrated samples of material settling from the water column.

Sediment traps constructed out of 5 centimetre internal diameter schedule 40 PVC pipe, cut into 11.5 cm long lengths sealed at one end. Three lengths of PVC are attached together and anchored to the bottom. The traps are anchored to the substrate by a length of rebar in approximately 3 meters of water. The base of the sediment traps should be 20 cm from the substrate and the rebar rod should not

protrude above the opening of the pipes. Small gauge (1 cm) wire mesh should be placed on top of the PVC pipe to prevent sediment disturbance and loss due to marine organisms using the traps.

Each sediment trap should be removed and replaced on a monthly cycle for all sites. Before removal each individual trap requires a sealed lid to be positioned to prevent any sediment from being lost. All samples removed from the water should be labelled according to site location and transported directly to the laboratory for analysis. Upon opening each sediment trap, all water and sediment held within the trap must be poured directly through a fine filter to collect the sediment. The sediment is then dried to a constant weight in an oven at approximately 60oC for at least 24 hours. At which time the dried sediment collected is weighed to the nearest milligram for all samples.

The weight of the three samples per site is recorded and averaged. This data is then compared over time to previous data collections. Care must be taken at all times to prevent any loss of sediment and all traps should be thoroughly cleaned before deployment.

In addition, grain size and origin of sediment particles can be analysed to provide additional information on the source of sediment, whether terrigenous or marine in origin.

It is recommended that five (5) study sites, consisting of two sets of three PVC sediment traps with replication should be conducted over at least a period of six months. The site locations site will need to be determined by the MPAS project staff. The sediment traps should be placed in 3 metres of water with the replicated sample not more than 3 meters away.

Water Circulation Program

Information is absent on seawater surface circulation patterns within the lagoon of Addu atoll. The identification and movement of these hydrodynamics forces is an integral component of the dynamics of the lagoon and need to be assessed and clarified. The clarification of water movements within the lagoon will allow the prediction of movement of suspended sediments and assist in the prediction of coral larval dispersal and recruitment within the atoll. The circulation study should include current pattern for the entire lagoon for both tidal cycles.

It is therefore recommended that a seawater circulation program for the atoll be included in the marine monitoring program.

Appendix 2

Marine resource assessment field data.

Tow No.	H2O Depth (m)	Tow Width (m)	Tow Length (km)	Turtle	Clams	COTS	Fish	Sea Cucumber
1	2-5	6	0.3	0	1 Ts 2 Tm	0		1 F
2	2-6	8	0.5	0	1 Tm	0		0
3	3-7	8	0.7	0	3 Tm 2 Ts	0	1a 1d	3B
4	4-8	8	0.4	0	1 Ts	0		0
5	2-7	9	0.4	2A	3 Tm	0	5c 1b	0
6	2-7	7	0.8	0	21 Tm	0	5c	5I 1F
7	2-9	8	0.3	1A	26 Tm 9 Ts	0	1d	4E
8	4-8	8	*	1A	0	0	1b 4c 2d(ju)	0
9	4-8	8	*	1B	0	0	5b 19c	0
10	4-8	8	*	0	1 Tm	0	9c 2d(ju)	0
11	4-10	8	*	0	0	0	6c	0
12	2-6	8	*	0	23 Tm	0	1a 16c 1d	1A, 1D 1E
13	2-8	7	0.3	0	28Tm	0	0	2E
14	2-7	8	0.3	0	27Tm 5Ts	0	2b	4E
15	2-8	8	0.4	1B	23Tm 22Ts	0	3b 6c	4E 5D
16	2-4	8	0.2	0	30Tm 18Ts	0	9c	2E
17	3-15	10	0.6	1A	13Tm 7Ts	0	4b 10c 1d 2e	3E
18	1-3	4	0.3	0	40Tm 1Ts	0	1b 6c	0
19	1-2	3	0.2	0	11Tm	0	1b	0
20	0.5-1	2	0.2	0	6Tm	0	2c	1D
21	2	3	0.2	0	3Tm	0	0	0
22	0.5-4	5	0.2	0	7Tm 2Ts	0	1b 2c 1d (ju)	0
23	2-15	10	1.1	2B	9Tm 11Ts	0	2b 4c 9d (3ju)	4E
24	2-11	8	0.4	0	18Tm 1Ts	0	27c	4D 1E
25	4-10	15	0.5	1B	12Tm 4Ts	0	2b, 10c 1d (jv)	0
26	4-10	15	0.5	2A 2B	40Tm 11Ts	0	1a 3b 25c 1e	0
27	3-10	12	0.5	0	33Tm 11Ts	0	1a 1b 39c 2d	0
28	3-8	8	0.5	1B	51Tm 5Ts	0	3b 38c 1d	2D 3E 1A
29	3-5	8	0.5	0	27Tm	0	30c 2d	1D 2G 1C
30	2-5	8	0.5	0	23Tm 1Ts	0	1b 22c 2d 3e 1f	2G IH
31	2-6	8	0.5	4B	34Tm 2Ts	0	1b 21c 2d (ju)	2G
32	2-8	8	0.5	2A 4B	53Tm 2Ts	0	1a 7b 26c 5d	1D
33	2-8	8	0.7	0	0	0	4b 45c 2d	1C 3D 2E
34	2-7	6	0.4	1A	0	0	13c 2d	0

Tow No.	H2O Depth (m)	Tow Width (m)	Tow Length (km)	Turtle	Clams	COTS	Fish	Sea Cucumber
35	1-7	6	0.3	3A	1Tm	0	1b 3c 1d	2D
36	3-10	10	0.8	0	1Tm	0	1b 23c 1d	0
37	4-10	10	0.6	0	3Tm	0	5b 9c 3d 1e	0
38	5-10	10	0.5	0	0	0	5b 12c 1e	1C
39	4	3	*	0	0	0	1e	0
40	4-8	9	*	0	0	0	1c	1C
41	3-6	10	*	0	0	0	1c	0
42	3-8	12	*	0	0	0	1c	1C
43	2-8	12	*	0	0	0	2c 2d 1e	5A
44	1-8	12	*	0	0	0	2c 2d 1e	0
45	2-10	9	0.4	1A	8Tm 2Ts	0	1b 5c 7d 3e	0
46	2-10	8	0.4	0	6Tm 2Ts	1	2b 4c	0
47	3-8	8	0.3	0	1Tm	0	2c 1d (jv)	0
48	2-11	10	0.4	0	17Tm 19Ts	0	8c 1d	1D 1G 1E
49	3-12	10	0.4	0	17Tm 14Ts	0	8c	7D 1G
50	3-12	10	0.4	1B	10Tm 12ts	0	7c 1d	4D
51	3-12	10	0.2	0	5Tm 4Ts	1	2b 4c 2d 2e	8D
52	3-12	8	0.4	1A	2Ts	0	0	1A 1B 1C 3D
53	4-10	8	0.4	2B	3Tm	0	1e	2B 6C 1D
54	2-10	8	0.4	0	0	0	1i	3C
55	3-10	8	0.4	0	1Tm	0	1e	6P 1D
56	3-10	7	0.4	1A	1Tm	0	0	10P
57	3-10	7	0.4	2A	0	0	0	6P 1E
58	2-8	8	0.5	1A	4Tm	0	1d 7g	4B 6C
59	2-8	6	0.2	0	33Tm 1Ts	0	0	2B 5C 1E
60	3-8	10	0.3	0	4Tm 1Ts	0	1d	1D
61	4-8	10	0.8	0	13Tm	0	1a 12c 2d 1e	3D
62	5-10	10	0.3	0	9Tm	0	9c	0
63	2-10	8	0.4	0	6Tm	0	1b 4c 1d	2D 1F
64	3-10	7	0.3	0	6Tm 3Ts	0	1b 9c 1d	1D
65	3-10	8	0.2	0	1Ts	0	6c	2D
66	6	6	*	0	0	0	6c 1e	0
67	6	6	*	0	0	0	5c	0

Key to abbreviations:

Turtles:	A	= Green (*Chelónia mydas*).
	B	= Hawksbill (*Eretmochelys imbricata*).
Clam Species:	Tm	= *Tridacna maxima.*
	Ts	= *Tridacna squamosa.*
Bech-de-mer:	A	= *Actinopyga mauritiana.*
	B	= *A. miliaris.*
	C	= *Holothuria nobilis.*
	D	= *Bohadschia argus.*
	E	= *B. graeffei.*
	F	= *Stichopus variegatus.*
	G	= *S. chloronotus.*
	H	= *Thelenota ananas.*
	I	= Bohadschia. *Mormoratus.*
Fish:	A	= Grouper (*Epinephelus polyphekadion , E. fuscoguttatus*).
	B	= Coral Trout (*Plectropomus laevis, P. pessuliferus, P. areolatus*).
	C	= Peacock (*Cephalopholus argus*).
	D	= Humphead (Napoleon) Wrasse (*Cheilinus undulatus*).
	E	= Coronation Trout (*Variola louti*).
	F	= Bumphead Parrotfish (*Bolbometopon muricatum*).

Anchor damage sites:

Tow 27 S00o36.40, E73 o07.05, S00o36.40, E73 o07.04
Tow 28 S00o36.31, E73 o06.44
Tow 29 S00o36.19, E73 o06.31
Tow 30 S00o36.03, E73 o06.16.
Tow 30 the entrance for the fishing channel = 100% dead coral.

Appendix 3

Marine resource assessment field data.

Tow No.	% Live Coral Cover	Cloud Cover (%)	Wind Cond. (kts)	Latitude/Longitude Start of Tow	Latitude/Longitude Finish of Tow
1	<1	<10	8	S00o60. 328, E73 o09.853	S00o60. 494, E73 o10.013
2	<3	<10	8	S00o60. 593, E73 o10.115	S00o60.738, E73 o10.288
3	5	<10	8	S00o61.115, E73 o10.623	S00o61.186, E73 o10.686
4	8	<10	8	S00o61.225, E73 o11.031	S00o61.518, E73 o11.123
5	8	<10	8	S00o61.357, E73 o11.241	S00o61.469, E73 o11.459
6	8	<10	8	S00o61.504, E73 o11.818	S00o61.895, E73 o11.578
7	10	<10	8	S00o62.004, E73 o11.577	S00o61.797, E73 o11.937
8*	<1	65	<5	S00o37.39, E73 o22.77	Timed swim, 10 minutes
9*	2	65	<5	S00o37.89, E73 o13.69	Timed swim, 10 minutes
10*	3	65	<5	S00o36.86, E73 o13.70	Timed swim, 10 minutes
11*	3	65	<5	S00o35.99, E73 o14.40	Timed swim, 10 minutes
12*	15	80	<5	S00o41.45, E73 o10.04	Timed swim, 10 minutes
13	5	<5	<2	S00o37.07, E73 o07.06	S00o37.06, E73 o07.33
14	5	<5	<2	S00o37.06, E73 o07.44	S00o37.09, E73 o07.57
15	3	<5	<2	S00o37.16, E73 o07.71	S00o37.21, E73 o07.76
16	2	<5	<2	S00o37.33, E73 o07.64	S00o37.32, E73 o08.07
17	2	<5	<2	S00o37.53, E73 o08.09	S00o37.56, E73 o08.09
18	<1	<5	<2	S00o37.29, E73 o07.99	S00o37.22, E73 o07.88
19	1	<5	<2	S00o37.16, E73 o07.81	S00o37.07, E73 o07.08
20	3	<5	<2	S00o36.87, E73 o07.74	S00o37.86, E73 o07.65
21	<1	<5	<2	Parallel with No 20. 10m.	From reef edge
22	<1	<5	<2	S00o36.93, E73 o07.45	S00o37.00, E73 o07.40
23	10	<5	<2	S00o37.21, E73 o06.95	S00o37.51, E73 o06.69
24	2	<5	<2	S00o37.02, E73 o08.10	S00o37.17, E73 o08.08
25	30	<5	<2	S00o36.44, E73 o08.04	S00o36.43, E73 o07.49
26	45	<5	<2	S00o36.43, E73 o07.40	S00o36.40, E73 o07.24
27	25	<5	<2	S00o36.39, E73 o07.17	S00o36.39, E73 o07.02
28	15	<5	<2	S00o36.36, E73 o06.53	S00o36.26, E73 o06.38
29	12	<5	<2	S00o36.19, E73 o06.31	S00o36.07, E73 o06.20
30	20	<5	<2	S00o36.03, E73 o06.16	S00o35.53, E73 o06.04
31	30	<5	<2	S00o35.50, E73 o06.00	S00o35.39, E73 o05.49
32	50	30	<2	S00o35.35, E73 o05.46	S00o35.21, E73 o05.36
33	35	50	<2	S00o35.14, E73 o05.33	S00o34.52, E73 o05.28
34	8	50	<2	S00o34.50, E73 o05.25	S00o35.04, E73 o05.29

Tow No.	% Live Coral Cover	Cloud Cover (%)	Wind Cond (kts)	Latitude/Longitude Start of Tow	Latitude/Longitude Finish of Tow
35	15	40	<2	S00o35.07, E73 o05.24	S00o34.56, E73 o05.20
36	10	30	<5	S00o34.56, E73 o04.37	S00o34.42, E73 o05.00
37	3	30	<5	S00o35.01, E73 o04.26	S00o35.13, E73 o04.12
38	2	40	<5	S00o35.27, E73 o04.19	S00o35.39, E73 o04.32
39	1	30	<5	S00o35.52, E73 o04.39	S00o35.59, E73 o04.40
40	1	25	<5	S00o36.11, E73 o04.44	S00o36.16, E73 o04.47
41	2	25	<5	S00o36.26, E73 o04.54	S00o36.34, E73 o04.56
42	5	25	<5	S00o36.49, E73 o05.03	S00o36.53, E73 o05.05
43	2	20	<5	S00o37.13, E73 o05.13	S00o37.20, E73 o05.17
44	<1	20	<5	S00o37.39, E73 o05.29	S00o37.45, E73 o05.32
45	3	100	8	S00o37.12, E73 o08.24	S00o37.03, E73 o08.35
46	<1	95	8	S00o37.02, E73 o08.42	S00o37.02, E73 o08.54
47	1	95	8	S00o36.59, E73 o08.55	S00o36.52, E73 o09.00
48	1	80	10	S00o36.04, E73 o10.28	S00o36.12, E73 o10.16
49	15	80	10	S00o36.13, E73 o10.11	S00o36.18, E73 o19.58
50	10	70	10	S00o36.21, E73 o09.52	S00o36.29, E73 o09.41
51	<1	70	10	S00o36.32, E73 o09.36	S00o36.37, E73 o09.27
52	8	30	15	S00o39.07, E73 o07.02	S00o39.17, E73 o07.04
53	5	30	15	S00o39.35, E73 o07.16	S00o39.49, E73 o07.23
54	2	30	15	S00o40.18, E73 o07.45	S00o40.30, E73 o07.54
55	2	20	15	S00o40.46, E73 o08.16	S00o40.53, E73 o08.28
56	2	20	15	S00o41.16, E73 o09.09	S00o41.19, E73 o09.22
57	<1	20	15	S00o41.21, E73 o09.41	S00o41.25, E73 o09.52
58	25	20	15	S00o41.31, E73 o10.05	S00o41.42, E73 o10.19
59	<1	20	15	S00o40.49, E73 o11.12	Not taken, bad conditions
60	35	20	10	S00o36.50, E73 o08.22	S00o37.01, E73 o08.22
61	20	20	10	S00o36.37, E73 o08.27	S00o36.33, E73 o08.53
62	12	20	12	S00o36.19, E73 o09.20	S00o36.13, E73 o09.28
63	3	25	12	S00o39.32, E73 o11.45	S00o39.43, E73 o11.52
64	4	30	15	S00o39.42, E73 o12.14	S00o39.33, E73 o12.21
65	<1	30	15	S00o40.17, E73 o11.47	S00o40.22, E73 o11.52
66*	<1	30	15	S00o40.53, E73 o11.53	S00o40.57, E73 o11.51
67*	<1	30	18	S00o41.16, E73 o11.35	S00o41.21, E73 o11.32

* Timed swims of 10 minutes each Tows 8, 9, 10, 11, 12
5 minutes each Tow 39, 40, 41, 42, 43, 44, 66, and 67

Appendix 4

Marine resource assessment field data.

Tow No.	Reef Condition	Dominant Benthic Forms	Dominant Hard Coral Genus & Morphological Form
1	Very Poor	Sand/Rubble/Seagrass	None
2	Very Poor	Sand/Rubble/Seagrass	20% dead coral
3	Very Poor	Sand/Rubble	20% dead coral,
4	Poor	Sand/Rubble	20% dead coral,
5	Poor	Sand/Rubble	20% dead coral,
6	Average	Sand/Rubble/Hard coral	40% dead coral, Acropora Digitate, Porites massive
7	Average	Rubble/Hard coral	60% dead coral, Acropora Digitate, Porites massive
8	Very Poor	Dead Hard Coral, Coralline algae 40%	Digitate Acropora small colonies
9	Very Poor	Dead Hard Coral Coralline algae 40%	Digitate Acropora small colonies
10	Very Poor	Dead Hard Coral Coralline algae 40%	*Heliopora sp.*, Acropora colonies
11	Very Poor	Dead Hard Coral Coralline algae 40%	*Heliopora sp.*, Acropora colonies
12	Good	Live Hard Coral, massive	Porites massive, Acropora Digitate, Acropora tabulate (small)
13	Average	Dead Hard Coral	Digitate Acropora small colonies, Porites massive (Small)
14	Average	Dead Hard Coral	Digitate Acropora small colonies, Porites massive (Small)
15	Average	Dead Hard Coral	Digitate Acropora small colonies several staghorn patches, Porites massive
16	Poor	Dead Hard Coral Sand/ Rubble.	Digitate Acropora small colonies
17	Poor	Dead Hard Coral Sand/ Rubble.	*Echinopora sp.* Foliose dominate, Porites massive (few)
18	Poor	Dead Hard Coral Sand/ Rubble (80%).	Digitate Acropora small colonies
19	Poor	Dead Hard Coral Sand/ Rubble (80%).	Digitate Acropora small colonies Porites massive (small colonies)
20	Poor	Dead Hard Coral Sand/ Rubble (80%).	Digitate Acropora small colonies. Porites massive (small colonies)
21	Poor	Dead Hard Coral Sand/ Rubble (80%).	Digitate Acropora small colonies Porites massive (small colonies)
22	Poor	Dead Hard Coral Sand/ Rubble (80%).	Heliopora colonies, Fungiidae (Fungia sp. & Polphyllia sp.)

Tow No.	Reef Condition	Dominant Benthic Forms	Dominant Hard Coral Genus & Morphological Form
23	Good	Dead Hard Coral Potential broodstock numbers. Protection Needed	Digitate Acropora small and large patches, Echinopora sp. Foliose dominate, Porites massive (large). Fungiidae numerous (Fungia sp., Polphyllia sp. & Podabacia sp.)
24	Poor	Dead Hard Coral, Macro Algae Slope.	Acropora Digitate (small), Porites (small Massive) Coralline algae (10% cover), Tydemania sp.
25	Very Good	Hard Coral. Potential broodstock numbers. Protection Needed	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose, Porites Massive (large) & Digitate
26	Very Good	Hard Coral. Potential broodstock numbers. Protection Needed	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose, Porites Massive (large) & Digitate
27	Good	Hard Coral. Potential broodstock numbers. Protection Needed	*Echinopora sp.* Foliose dominate, Digitate, Tabulate & Branching Acropora (small and large patches), Porites Massive (large) & Digitate
28	Good	Hard Coral. Potential broodstock numbers. Protection Needed. Anchor damage	*Echinopora sp.* Foliose dominate, Digitate, Tabulate & Branching Acropora (small patches), Porites Massive (small) & Digitate
29	Average	Hard Coral/Dead Coral Anchor damage	*Echinopora sp.* Foliose dominate, Digitate & Branching Acropora (small patches), considerable dead Acropora rubble. Porites Digitate (small)
30	Average Channel S00o36.00, E73 o06.13	Hard Coral/Dead Coral. Anchor damage considerable. Fishermen channel no live coral in mouth (30m wide).	*Echinopora sp.* Foliose dominate, Digitate & Branching Acropora (small patches), considerable dead Acropora rubble. Porites Digitate (small)
31	Very Good	Hard Coral. Potential broodstock numbers. Protection Needed. Extensive anchor damage	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose, Porites Massive (large) & Digitate
32	Very Good	Hard Coral. Potential broodstock numbers. Protection Needed Major anchor damage.	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose, Porites Massive (large) & Digitate
33	Very Good	Hard Coral. Potential broodstock numbers. Protection Needed reduced anchor damage	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose, Porites Massive (large) & Digitate

Tow No.	Reef Condition	Dominant Benthic Forms	Dominant Hard Coral Genus & Morphological Form
34	Poor	Hard Coral Rubble. Higher % live coral on slope (>5m depth)	*Echinopora sp.* Foliose dominate, Digitate, Tabulate & Branching Acropora (small). Porites Digitate (small)
35	Poor	Hard Coral.	*Echinopora sp.* Foliose dominate, Digitate, Tabulate & Branching Acropora (small). Porites Massive (medium) & Digitate (small)
36	Poor	Hard Coral Rubble. % live coral increased towards the eastern end of tow.	*Echinopora sp.* Foliose dominate, Digitate, Tabulate & Branching Acropora (small), Porites Digitate & massive
37	Very Poor	Dead Hard Coral	Porites massive. Digitate & encrusting Acropora small colonies.
38	Very Poor	Dead Hard Coral Spur and Grooves	Porites massive. Digitate & encrusting Acropora small colonies (very small).
39	Very Poor	Dead Hard Coral Coralline algae 10% Spur and Grooves	Digitate & Encrusting Acropora colonies (very small).
40	Very Poor	Dead Hard Coral, Coralline algae 10% Spur and Grooves	Digitate Acropora small colonies
41	Very Poor	Dead Hard Coral, Coralline algae 10% Spur and Grooves	Digitate Acropora small colonies
42	Very Poor	Dead Hard Coral, Coralline algae 20%. Spur and Grooves	Digitate Acropora small colonies. *Echinopora sp.* Foliose. Heliopora sp.
43	Very Poor	Dead Hard Coral, Coralline algae 25% Spur and Grooves	Digitate Acropora small colonies. *Echinopora sp.* Foliose. *Heliopora sp.*
44	Very Poor	Dead Hard Coral, Coralline algae 25% Spur and Grooves	Digitate Acropora small colonies. *Echinopora sp.* Foliose. *Heliopora sp.*
45	Poor	Dead Hard Coral	Corallimorphs (Discosoma ?) dominate on dead coral rubble. Small Acropora Digitate, Porites
46	Very Poor	Dead Hard Coral	Corallimorphs (Discosoma ?) dominate 70 % of substrate) on dead coral rubble. Small Acropora Digitate, Porites
47	Very Poor	Dead Hard Coral	Corallimorphs (Discosoma ?) dominate 70 % of substrate) on dead coral rubble. Small Acropora Digitate, Porites
48	Very Poor	Dead Hard Coral	Small Acropora Digitate& branching, Porites massive (small)
49	Average	Rubble/Hard coral	Small Acropora Digitate & Tabulate large branching stands. Porites massive, Fungiidae (Fungia sp., Polphyllia sp. & Podabacia sp.)
50	Average	Rubble/Hard coral	Small Acropora Digitate & Tabulate Large branching stands. Porites massive. Fungiidae (Fungia sp., Polphyllia sp. & Podabacia sp.)

Tow No.	Reef Condition	Dominant Benthic Forms	Dominant Hard Coral Genus & Morphological Form
51	Very Poor	Rubble/Hard coral	Small patches of Acropora Digitate.
52	Average	Hard Coral Skeleton. Good recruitment (small colonies)	Acropora Digitate & Tabulate and large branching stands. Porites massive, *Echinopora sp.* Foliose. Fungiidae (*Fungia sp., Polphyllia sp. & Podabacia sp.*)
53	Poor	Dead Hard Coral Skeleton	Corallimorphs (Discosoma ?) major bed on dead coral rubble. Small Acropora Digitate & Branching. Echinopora sp. Foliose. Porites small massive.
54	Poor	Dead Hard Coral Skeleton And Sand	Small Acropora Digitate & Branching. *Echinopora sp.* Foliose. Porites small massive.
55	Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Small Acropora Digitate & Branching. *Echinopora sp.* Foliose. Porites small massive.
56	Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Small Acropora Digitate & Branching. Porites small massive. Fungiidae numerous (*Fungia sp., Polphyllia sp. & Podabacia sp.*)
57	Very Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Porites massive (few). Few small Acropora Digitate & Branching.
58	Good	Porites massive	Large dominate Porites massive. Small Acropora Digitate & Branching.
59	Very Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Porites massive (few) few small Acropora Digitate & Branching.
60	Very Good	Hard Coral. Potential broodstock numbers.	Digitate, Tabulate & Branching Acropora (small and large patches), *Echinopora sp.* Foliose. Porites Massive (small) & Digitate
61	Good	Hard Coral. Potential broodstock numbers.	Acropora dominate, Digitate, Tabulate & Branching (small patches), soft corals (*Sarcophyton sp*) *Echinopora sp.* Foliose, Porites Massive (small) & Digitate
62	Poor	Sand/Coral Rubble/ Hard Coral Skeleton	*Halimedia sp* dominate beds, Small Acropora Digitate & Branching. *Echinopora sp.* Foliose. Porites small massive.
63	Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Porites massive dominant. Very small Acropora Digitate & Tabulate
64	Poor	Sand/Coral Rubble/ Hard Coral Skeleton	Small Acropora Digitate & Branching. Porites small massive.
65	Very Poor	Sand/Coral Rubble/ Hard Coral Skeleton dead	Digitate Acropora small colonies, Porites small massive
66	Very Poor	Dead Hard Coral, High Coralline algae cover	Soft Coral (*Sinularis sp.*) Porites small and few Acropora Digitate small colonies
67	Very Poor	Dead Hard Coral, High Coralline algae cover	Digitate Acropora small colonies, Soft Coral (*Sinularis sp.*), Porites small

Appendix 5.

Provides a summary of the Recommended Monitoring Programs.

Monitoring Program	Monitoring Objective/ Action	Evaluation Techniques	Monitoring Frequency	Data Status	Detectable Limits	Executing Agencies
1. Coral Community	% Coral Cover Essential	Permanent LIT Permanent Quadrants Manta Tows/Timed Swims Strip Transect Lines	Once a Year Twice a Year Once a Year Once a Year	1st Data Set Not Started 1st Data Set Incomplete	Broad Scale Fine Scale Broad Scale Broad Scale	MPAS, MRC MPAS Community MPAS, Community
	Coral Diversity Desirable	Permanent LIT Permanent Quadrants Manta Tows/Timed Swims Strip Transect Lines	Once a Year Twice a Year Once a Year Once a Year	1st Data Set Not Started 1st Data Set Incomplete	Broad Scale Fine Scale Broad Scale Broad Scale	MPAS, MRC MPAS Community MPAS, Community
	Coral Growth Desirable	Permanent LIT Permanent Quadrants	Once a Year Twice a Year	1st Data Set Not Started	Broad Scale Fine Scale	MPAS, MRC MPAS
2. Coral Reef Indicator	Population Abundance Essential	Manta Tows/Timed Strip Transect Lines	Once a Year Once a Year	1st Data Set Incomplete	Broad Scale Broad Scale	MPAS, Community MPAS, Community
Species	Grouper Spawning Aggregation Sites Desirable	Manta Tows/Timed Strip Transect Lines Swims	Once a Year Once a Year	Not Started Not Started	Broad Scale Broad Scale	MPAS, MRC? MPAS, MRC?
3. Sea Grass Beds	% Cover Essential	Strip Transect Lines Mapping	Once a Year	Incomplete	Broad Scale	MPAS, Community
	Diversity Desirable	Strip Transect Lines	Once a Year	Incomplete	Broad Scale	MPAS, Community
	% Survival & Mortality Desirable	Strip Transect Lines Permanent Quadrants	Once a Year Twice a Year	Incomplete Incomplete	Broad Scale Fine Scale	MPAS, Community MPAS, Community
4. Sediment Deposition:	% Deposit Essential	Sediment Traps	Yearly Program (Once a month)	Not Started	Broad Scale	MPAS, Community
5. Surface H20 Circulation	Lagoon Water Movement. Essential	Drogues. 24 hour evaluation	Once Only	Not Started	Broad Scale	MPAS, Community

Vegetation Survey

1. Introduction

As part of the AusAID Maldives Protected Areas System Project, a study was undertaken to examine the terrestrial component of a proposed protected area in Addu Atoll.

The Hithadhoo Protected Area (HPA) is situated on the northern end of S. Hithadhoo, the main island within the north western part of Addu Atoll. The protected area also extends offshore around the peninsula to include fringing coral reefs and islands. The Hithadhoo Protected Area site has been selected as a pilot area for the broader Maldives Protected Areas System Project.

This report documents a survey of soils and vegetation in the Hithadhoo Protected Area, conducted in March 2002. The objective of this survey was to identify and document any areas of natural value and significance.

2. Scope of report

The objectives of the terrestrial survey were achieved through the following outcomes:

- Design and conduct training courses in vegetation mapping and soil mapping conduct vegetation surveys
- Document survey techniques
- Develop a database of vegetation, soils and bird species for the pilot sites
- Determine the biodiversity and threats to the biodiversity values of the area for inclusion into the plan of management
- Advise on appropriate management plans for the pilot sites
- Develop a long term monitoring scheme for the pilot sites
- Work with local counterparts to identify local vegetation types
- Conduct training courses on monitoring of the terrestrial environment suitable for community needs
- Provide appropriate information on terrestrial attributes for the scale model being constructed in Addu Atoll

3. Outcomes:

The report covers the following:

- A report of field work undertaken (purpose, places, dates)
- A catalogue of data sets produced

- Analysis of data collected
- A catalogue of hand books and manuals used in the field
- Recommendations for further field work
- A training needs analysis, where appropriate
- On site training carried out
- Training outcomes
- Documentation of training materials
- An evaluation of training activities including feedback from trainees
- Recommendations for further work

4. Methodology

In achieving the outcomes outlined, the following methodology was used:

- Initial site inspection with counterparts
- Mapping of vegetation communities using existing aerial photographs (1996) and other historical photographs
- Ground-truth survey
- Identifying the various types of vegetation as indicated from aerial photograph interpretation
- Describing vegetation community structure
- Determining the composition of species that make up the these vegetation communities
- Identifying threatened and endangered species present or likely to be present on the site, from the literature and consultation with local personnel
- Identification of the vegetation resources used by the community – both present and potential and, if possible, historical and current harvest rates
- Identification of the terrestrial resources other than vegetation used by the community – both present and potential and, if possible, historical and current harvest rates
- Description of the soil types found in the site, based on observations and literature surveys
- Description of the relationship between soils, vegetation and topographic factors such as exposure, water table, salinity

The conservation value of the vegetation structures was determined, in local, regional, and international terms, by:

- Comparison with other local vegetation communities
- Reference to available publications and reports used in the study

- Anecdotal information from sources such as Department of Agriculture, other field personnel and consultants (to be documented)
- Description of the short and long term sustainability of the existing vegetation, outlining existing threats and the level of these threats
- External and internal threats, for example, extreme weather, human threats, future development and weeds
- Manageable and unmanageable threats, for example, human activities such as clearing, walking, removal of coral and dumping of rubbish
- The management options available to the community and government representatives to address these threats were identified
- A cost-effective and appropriate monitoring program, to gather data sufficient to achieve the aims required for the HPA's management plan, was determined
- Documentation of the methodology for counterparts
- Incorporation of the data into the GIS

5. Physical environment

Location

The Republic of Maldives is located south west of India in the Indian Ocean. It consists of a chain of coral atolls extending 860 km north from a point 70 km south of the equator. The total land area of only 300 km2 is divided amongst 1,190 islands. This number varies as islands are eroded and accreted, particularly through wave action during extreme storm events.

Maldives is located on top of two submarine ridges rising from an ocean floor at some 3000 m with 1000 m channels between the atolls. This area is geologically stable.

The pilot site is located in Addu Atoll, which is the most southern Atoll in Maldives. Addu Atoll is horseshoe shaped, approximately 20 km in diameter, with deep channels to the Indian Ocean. As with most atolls, most of the islands are found around the outer edge where they are subjected to the influence of ocean waves. These waves are generally of small size, as significant storm events are rare so close to the equator. During such times when storms do occur, both the inner-facing shorelines and the inner islands can be subjected to significant wave action due to the large fetch and deep water in the atoll.

The study site is located on the north western portion of the island of Hithadhoo at 73O05'E 0O35'S. This is the most northern of the islands connected by a series of four causeways to the island of Gan along the western side of the atoll, an overall distance of 18 km.

Climate

The seasonal year is divided into two monsoon periods. The north east monsoon from December to March is mostly dry with very little wind. The south west monsoon from May to November is characterised by a higher frequency of storms, stronger winds, and higher humidity.

Maldives has little seasonal variation in temperature, with average winter temperatures between 25.1 °C and 30 °C, and summer averages between 26.3 °C and 31.8 °C (Lyon 1997). Maldives has a latitudinal distribution over two hemispheres, however, resulting in differences of rainfall, wind strengths and temperature variations over the country. Monthly rainfall data for Addu for the period October 1957 – October 2000 is reported in MacAlister Elliott and Partners Ltd (2001). Figure 1 shows the annual rainfall pattern for the period 1957-1999. Gaps in 1979 and 1980 are due to missing data.

The annual rainfall variability in Gan is relatively low, with a coefficient of variation (Cv) of annual rainfall (standard deviation divided by mean) of 0.15. The variability of monthly rainfall can be seen in Figure 2, which shows maximum, mean and minimum values for each month, and the coefficient of variation of monthly rainfall.

Figure 1: Annual rainfall 57 - 00

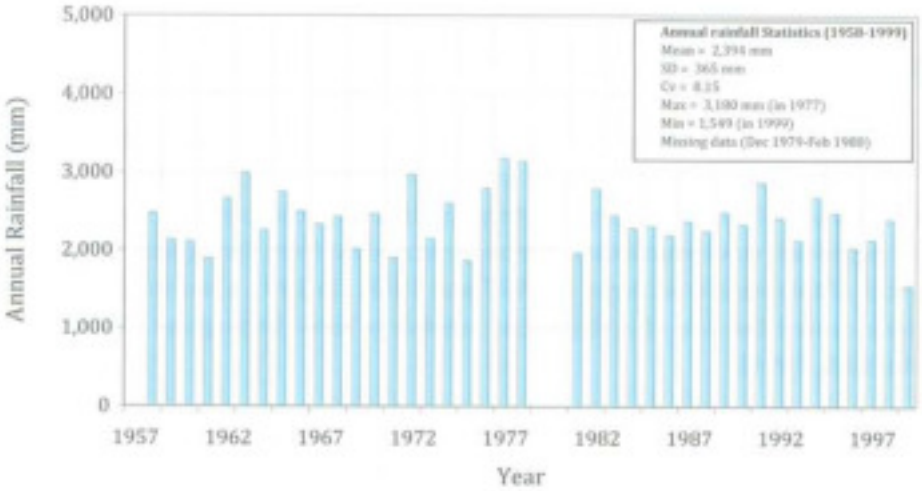
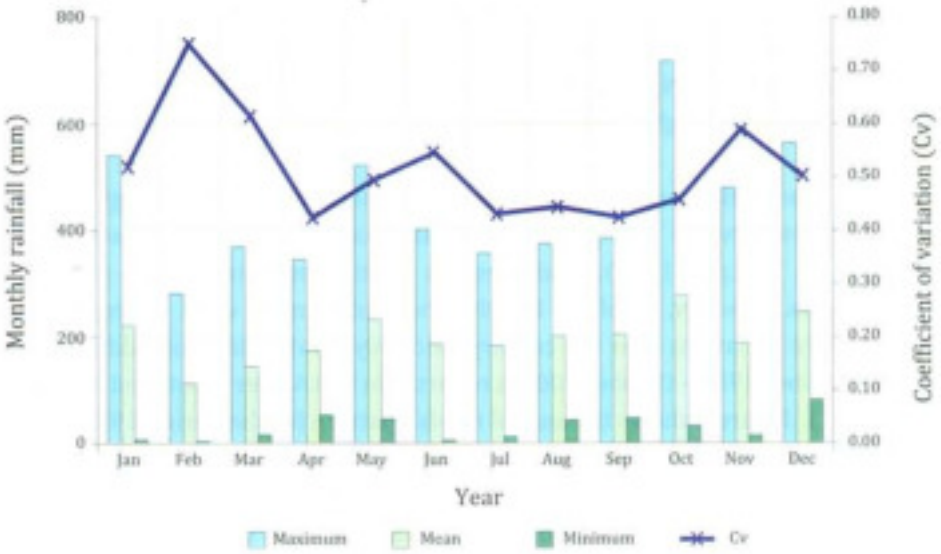


Figure 2. Monthly maximum, mean and minimum rainfall and coefficients of variation using 1957-2000 data



The mean monthly rainfall on Gan is above 100 mm for all months, with relatively uniform distribution throughout the year. The coefficients of variation of monthly rainfall are 0.75 and less, showing relatively low variability. February has the lowest minimum and mean rainfall and the highest variability, coinciding with south west monsoon activities.

Episodic Events

The climate close to the equator is very stable with a general absence of extreme weather events including monsoons and cyclones. However, the low-lying nature of the islands of the Maldives makes them particularly susceptible to storm surges and significant wave events that may be generated far from the region. Significant events of this nature occurred in 1987 and 1988. In 1991 a storm with strong winds caused the loss of a significant number of trees throughout the country (MoPHRE, 1994).

The MoPHRE (1994) report notes that eight major storm events have occurred since 1824. It describes one event in 1814 that resulted in 12 islands having to be abandoned. The MoPHRE (1994) report concluded that 'damage from these events has often been exacerbated by the absence of natural beaches, reclamation of reef flats, and the presence of low flat sea walls which magnified over-topping and flooding'. Addu Atoll residents have reported waves breaking over the western side of the islands of Hithadhoo, Maradhoo, Maradhoo-Feydhoo and Feydhoo during such times (*personal comments*), which may indicate the possibility of sea water entering lagoons within the protected area during these events.

6. Geology and topography

Hithadhoo Protected Area

The Hithadhoo Protected Area site is on the northern end of Hithadhoo, the main island within the north western part of the atoll.

Like all Maldivian islands, the site is low, with a topographic variation of no more than two metres across the area, estimated by visual means. The highest area on the site is the rubble berm along the northern coastal boundary of the area This rubble berm grades into a dunal area with the total width varying from approximately 10 to 20 m, with the narrowest section being adjacent to the centre of a large freshwater lagoon, or kulhli in the north western portion of the site. The widest point is at the northern end of this kulhli.

The northern kulhli follows the curve of the coastline. The benthos of the kulhli is organic clay of variable depth with a coralline base.

A second kulhli is present in the eastern part of the site immediately behind the frontal crest. Being uniformly rectangular it is thought that this may be an artificially created structure, however, evidence of this is not recorded. Like the larger kulhi this holds freshwater after rainfall.

The north eastern portion of the protected area is subject to intermittent periods of high energy wave action. This produces a ridge of coral rubble some between one and two metres higher than the surrounding area. The underlying material in this part of the site is coarse with little soil structure and restricted vegetation diversity.

The remainder of the site is mostly flat with only minor undulations.

Soils

The soils on the site are all of coralline origin and consequently are geologically young and shallow (0 cm to 20 cm in depth). The soils are rather coarse, with substantial quantities of the unweathered coral parent material, coral rock and sand. In some of the lower lying areas and areas subjected to significant mechanical breakdown from human activities such as vehicle tracks, a deeper and/or finer soil structure is present, often with an accumulation of clay. This causes pooling of rainwater. Within the kulhis the depth of clay may be substantial due to the accumulation of material from marine and biological sources over a long period of time.

The coralline nature of the parent material means that the soil is alkaline and nutrient deficient. The pH of the soil would also result in nutrients being unavailable to many plant species. This is confirmed in an agronomy report by Butany (1974). In this report, Butany noted that the soils of the Maldivian atolls are highly alkaline with a pH between 8.0 and 8.8. Chemical analyses, though not extensive, indicated that soils are:

- deficient in nitrogen, both in the form of ammonia and nitrate
- low in potash
- fairly rich in phosphorus, magnesium, and calcium
- lacking in manganese and aluminium
- rich in iron

No further chemical analyses were performed as part of this survey.

Informal, walk-through surveys were also undertaken of the agricultural activities within the boundaries of the protected area site, Gan and Villingilli. The soils of Gan and Villingili are higher in humus, have a deeper soil structure and finer texture. These observations are based on the appearance of the plants, which were of higher productivity than the Hithadhoo site.

The lack of humus across the Hithadhoo Protected Area could not be explained simply by its proximity to the seaward fringe, and may be due to anthropomorphic activities over a long period of time. Activities such as the removal of fallen branches and coconut fronds for use as firewood were observed during the survey.

7. Terrestrial environment

7.1. Terrestrial flora

Introduction

The vegetation communities of the Hithadhoo Protected Area were mapped using 1996 aerial photography. The categories were verified by ground-observations and data recorded using GPS. This was to determine community structure and species composition. In determining the classification system, the techniques of McDonald *et al.* (1998) were followed with only one variation. Trees are classified to be over five metres in height, rather than two metres as prescribed by McDonald. This is due to the growth form of a local species, which usually exceeds five metres before its growth form changes from shrub to tree. At this height an understorey then begins to develop beneath these plants. A full description of the structural definitions is included in Appendix A. Heights were estimated visually.

Historic Impacts

The vegetation of the site has been altered throughout its 2500 year period of occupancy. Human impacts have occurred as a consequence of clearing for settlements and armed defensive facilities during World War II, coconut plantations, collection of firewood and harvesting of timber for construction. Evidence of all of these activities is present. The dumping of rubbish around the site has also had some impact as has the collection and burning of coral for cement, although to a much lesser extent.

Although no long term data (excess of 100 years) are available, the vegetation and extend of the coastline suggest that natural episodic events have impacted upon the area. These may include sea surges that allowed salt water to inundate the lower portions of the site, possible periodic opening and closing of the kulhi to the sea, and the loss of vegetation due to wind damage during storm events. Further research could be conducted to determine the extent of these impacts; however, it is considered that these natural incidents have been of much lesser significance than human interference.

Vegetation Community Types

The categories of species found on the site can be classified as:

- Coastal closed shrubland community of scaevola (*Scaevola taccada*), beach hibiscus (*Hibiscus tilaceus*) and pandanus (*Pandanus tectoris*) with varying dominance of the three in terms of height or density
- Coconut (*Cocos nucifera*) woodland (plantation) with an understorey ranging from bare ground to a dense 6 m-tall mid-stratum species mixture of scaevola, beach hibiscus and uni (*Guettarda speciosa*)
- Pemphis (*Pemphis acidula*) closed shrubland, and scaevola / hibiscus/ uni shrubland
- Barringtonia (*Barringtonia asiatica*) closed forest
- Mangrove (*Ceriops tagal, Lumnitzera racemosa, Rhizophora mucronata*)

In order to develop management plans for each of these categories a more detailed description of each category was undertaken and a series of zones were produced. These vegetation zones are temporal as they reflect recent human intervention through maintenance activities of the coconut plantations. Some areas are currently being cleared and the result is a few grass and herbs in an otherwise bare understorey and groundcover. Other areas have a well-established lower stratum to six metres.

The dominant vegetation communities are described in Table One.

Table 1: List of Hithadhoo Protected Area vegetation community types

Mapping unit	Community type	Structure
1	Coconut closed forest	T7D
2	Coconut open forest with shrubland of beach hibiscus / uni / scaevola	T7M/S5M
3	Coconut woodland with grass understorey	T7M/G3D
4	Coconut woodland with scaevola closed shrubland (Pandanus in coastal strip, and beach hibiscus along edges of tracks in inland areas)	T7M/S5D
5	Coconut woodland with scaevola / beach hibiscus / pandanus open woodland (Beach hibiscus mostly along edges of tracks)	T7M/S5D
6	Scaevola / beach hibiscus / uni shrubland	S5M
7	Scaevola closed shrubland	S5D
8	Pandanus closed woodland / scaevola / closed shrubland (may contain uni)	S5D
9	Mangrove	T5M
10	Barringtonia asiatica closed forest	T7D
12	Pemphis closed shrubland	S4D
13	Pandanus / uni open woodland	S5S
14	Agriculture	-
15	Lagoon island vegetation Coconut woodland with panadus / beach hibiscus / pemphis closed shrubland Pemphis closed shrubland (Most with mangrove woodland on western shores)	T7M/S4D S4D

Scaevola taccada, Hibiscus tilaceus and *Guettarda speciosa* are all rapid pioneer species. In the local Addu climate, scaevola reach a height of six metres in five years following clearing of the understorey below coconut plantations. At that height they take on a shrub-like form. Above six metres, scaevola start to develop a tree-like structure with broad canopies and climax at a height of ten metres. In the Hithadhoo Protected Area, scaevola is present as an understorey in the older coconut plantation areas. They also dominate areas cleared for coconuts about five years ago, where they start to encroach upon the young coconut trees that had only reached a height of one to two metres. In less disturbed areas, such as the uninhabited island of Villingilli, which has had less human influence, scaevola form part of the upper closed canopy, albeit on the edges.

Barringtonia asiatica is found as a closed forest community, probably as a result of its wide canopy, which shades out most other species, and its high fecundity. There is little lower strata and no groundcover. The microclimate under the canopy

within these areas was observed to be cooler and moister than in any other areas of the site.

The small islands of the inner lagoon have narrow vegetation communities between 10 m to 20 m in width. The centre of the larger of these islands consists of coconut woodland. A mixed fringe of panadus, beach hibiscus and pemphis closed shrubland is present on the seaward sides, and a fringe of mangrove grows on the sheltered, inland sides. On the smaller islands, unmodified stands of *Pemphis acidula* are present.

Several grass species were recorded but not identified. Where they are present under trees, the cover tends to be consistent at 60–70%.

Table 2: Dominant vegetation species in the Hithadhoo Protected Area

Scientific name	Local name	Common name
Tree species		
Hamadhia peltata	Kandhu	Jack in the box
Barringtonia asiatica	Kibi	Barringtonia
Cocos nucifera	Ruh	Coconut
Pandanus tectoris	Boa-kashikeyo	Wild screw pine
Shrub species		
Scaevola taccada	Magoo	Sea lettuce tree
Hibiscus tilaceus	Dhigga	Beach hibiscus
Guettarda speciosa	Uni	Nit pitcha
Pemphis acidula	Kuredhi	Pemphis
Calophyllum inophyllum	Funa	Alexander laurelwood tree
Ground cover species		
Stachytarpheta indica	Rakima	Vervain
Ipomea pes-caprae	Bodu veli veya	Cats foot creeper
Wedelia calendulacea	Mirihi	Mexican Sunflower
Grasses	Vina	Grass
Tumera ulmifolia	Bakarinukaa	Sea Almond
Terminalia catappa	Medhili	Sea Almond
	Rangu	Purple fruit vine
Crops		
Zea mays	Zuvaari	Sweet corn
Lycopersicon lycopersicum	Villaathu bashi	Tomatoes
Capsicum frutescens	Mirus	Chillies
Musa spp.	Dhonkeyo	Bananas
Carica papaya	Falho	Papaya
Mangrove		
Ceriops tagal	Karamana	Mangrove
Lumnitzera racemosa	Burevi	Mangrove
Rhizophora mucronata	Ran'doo	Mangrove

Regional Status

The MoPHRE (1994) states that there are 535 species of plants reported in the Maldives, of which 323 or 55% are cultivated. A publication from the Department of Fisheries and Agriculture (1992) notes 416 species. This contrasts with the very low number (24) noted on the site during this survey.

Species number will vary according to total area, previous land practices and the formation of the individual atolls. Within Maldives there is generally a coastal fringe of salt-tolerant species forming a border that surrounds a forest dominated natural woodland. In Hithadhoo this has been cleared and replaced with coconut plantation with a grassland understorey. However, the depressed prices for coconut products have meant little maintenance of these plantations and consequently there is considerable re-growth of the common pioneering shrub species.

Traditionally 15 local species of hardwood timber (Butany 1974) were used in Maldives for dhoni construction. Imported timbers are now used due to depletion of these species. No hardwood species remain on the site and no data were available on their status in Maldives.

Casuarina (*Casuarina spp*) planting is now being encouraged by the government for windbreaks and as a source of domestic firewood (MoPHRE 1994). Experience in other parts of the world suggests that some species of casuarina can readily become a pest, due to their high fecundity, fast growth rates and the acidic quality of the needles, which prevents other species from colonising the understorey. The shallow root structure of some casuarina also makes them unstable in strong winds. Whilst there is a significant buffering capacity in the alkaline soils of the atolls, the endemic species are adapted to a high pH. It is recommended that *Casuarina spp.* not be planted on the site as they are considered to be potentially invasive.

Traditional medicine species

Practitioners of traditional medicine, or Dhivehi beys, have worked within the Maldivian community using local herbs for many centuries. The diagnostic tools are based on the principles of traditional Chinese medicine. Like most traditional practitioners, the knowledge is handed down by word of mouth from the master only to those considered worthy to receive it. BFS (2001) reported that there are more than 41 traditional medicine practitioners in Addu Atoll who see on average four patients per month. No list of species or source of material was listed in the BFS report. The report indicated that the economic potential of commercial production of traditional medicines was not viable; however, local practitioners

have indicated that they use the protected area as an important source of plant material (UNDP workshop).

The continuing collection of such material is likely to be compatible with the conservation aims of the protected area. However, without detailed information on the species, their preferred growing conditions and the required quantities, no recommendations can be made on setting aside specific areas for either seed collection or commercial cultivation. This is a subject for future studies, if required.

7.2. Terrestrial fauna

Ground Fauna

The diversity and abundance of terrestrial ground fauna in Maldives is limited. No evidence from the field site inspection suggests that the Hithadhoo Protected Area has a greater diversity or abundance than other sites in Maldives. Species recorded were mouse, coconut crabs, and two species of lizard and fruit bat. Two species of snakes are reported from the Maldives, however, no evidence of snakes was recorded during the period of the study. None of these species are considered to be rare or threatened, or to rely on the protected area, or to have any particular cultural significance.

Birds

Some 31 species of birds have been sighted in or adjacent to the kulhi in the protected area (Table Three). Most of these species are reported to be migratory species.

Table 3: Bird species recorded from Eidhigali Kilhi

Scientific name	Local name	Common name
Amaurornis phoenicurus (maldivus)	Kabili	Maldivian water hen
Anas querquedula	Reyru	Garganey
Apus affinis	Forikey	Common swift
Ardea cinerea (rectirostris)	Maakana	Eastern grey heron
Ardeola grayii (phillipsi)	Huvadhoo raabodhi	Maldivian pond heron
Arenaria melanocephala	Rathafai	Black turnstone
Bubulcus ibis (coromandus) OR Ardea ibis (Australia)	Iruwaa hudhu	Cattle egret
Demigretta asha	Bodu raabodhi	Indian pond heron
Egretta alba (modesta) OR Ardea alba (Australia)	Bodu lagana	Great egret
Egretta garzetta (garzetta)	Kuda lagana	Little egret
Fregata ariel	Hoara	Lesser frigate bird
Gallus gallus	Kukulhu haa	Domestic fowl
Gygis alba	Dhondheeni	White tern
Numenius phaeopus (phaeopus)	Bulhi thumbi	Wimbrel
Phoenicopterus ruber (roseus)	Gudu gudaa dhooni	Flamingo
Psittacula eupatria (eupatria)	Bodu guraa	Alexandrine parakeet
Tringa hypoleucos OR Actitis hypoleucos (Australia)	Fidhana	Common sandpiper

Regional Status

Neither the numbers of bird species, nor the number of any particular species is significant from a world or regional perspective, including India (Asia-Pacific Migratory Waterbird Conservation Committee 2000). It should be noted that, with a few exceptions, visual sampling in the Maldives has been low and intermittent. The Hithadhoo Protected Area is one site that has some repeatable bird observation data available. This is mainly due to the easy access of the site. The diversity of bird species in the protected area has been described as relatively high compared to that of other areas in the country. Whilst the consequently higher species numbers listed for the site may skew the data in favour of its significance, this should not suggest that its status should be lowered.

The Hithadhoo Protected Area's kulhi is the largest in Maldives and one of several in Addu Atoll. This kulhi has shallow waters (measure) but appears to be highly productive as measured by the abundance of Tilapia sighted on the shore line. Although no gut content studies were undertaken, it is assumed that this abundance of juvenile fish species supports the foraging activities of the resident bird population.

The government has nominated 15 sites throughout Maldives in its National Biological Diversity Conservation Strategy (1998). S. Hithadhoo is one of two protected islands in recognition of its diverse bird fauna.

7.3. Aquatic environment

Aquatic flora

Three species of mangroves were recorded around the fringes of the kulhi and in the area.The presence of mangroves in the larger kulhi suggests an intermittent input of salt water. This has been observed on occasions during large seas that coincide with high tides (*local resident's personal comments*). The smaller kulhi near the eastern end of the protected area is highly ephemeral and consequently supports no aquatic life. This kulhi had water in it during the initial surveys but was dry at the end in spite of some heavy rain during this time.

Regional Status

The Hithadhoo Protected Area's kulhi is the largest in the Maldives and one of several in Addu Atoll. The vegetation surrounding this kulhi is not as diverse and abundant as that of another kulhi on Villingilli, an uninhabited island in the southern end of the atoll. This can be attributed to the fact that the Villingilli kulhi is more stable, being less influenced by the sea and by human activity.

Aquatic fauna

Surveys of the aquatic fauna of the kulhi, to determine the species composition and abundance, were not undertaken. Large numbers of small Tilapia were observed in the shallow waters around the edge of the kulhi during the survey. Japanese introduced this species throughout the Pacific and Indian Oceans as a potential bait fish many years ago, however, the fish proved ineffectual for this purpose. The introduction of Tilapia displaced many of the native faunas. There was no evidence of Tilapia in the Villingilli kulhi.

Regional Status

The Hithadhoo Protected Area's kulhi is the largest in the Maldives and one of several in Addu Atoll. The number of Tilapia observed along its edges suggests that this kulhi's shallow waters are productive. No data was available on the relative species composition of aquatic fauna and no surveys were performed during this study to determine their status. Further studies are recommended for completeness of the planning for the HPA.

7.4. Marine environment

A transect was performed during earlier surveys for this project (2001). It was located in the south east portion of the site and went from the top of one of the smaller islands to the reef edge. The results of that transect are as follows:

Mangroves

Mangroves rely on a number of factors for colonisation. According to English *et.al* (1997), and with reference to local conditions, these include:

- climate (generally constant)
- geomorphology (shallow sediments over coralline base)
- tidal range (approx. 1.2 m)
- freshwater input (relatively small and constant, though significant on an episodic basis)
- soil characteristics (shallow sediments)

Of these, soil characteristics are one of the most important factors directly affecting mangrove productivity and structure. Mangroves prefer a relatively deep soil profile, whereas the soils of the bay were found to be quite shallow (< 0.3 m) with a hard base suspected to be coralline.

Three species of mangrove were identified (Kitamura *et. al*) on the site:

- Rhizophora mucronata
- Ceriops tagal
- Lumnitzera racemosa

The first two species are present in the bay on the southern side of the protected area, with *C. tagal* being found on the landward (shallower) side of this fringe. The height of trees in these communities is generally between four and six metres, with an open-forest structure (crowns touching to slight separation).

L. racemosa is present in the kulhli and around its edge. This distribution is due to its tolerance of a wide salinity range. It reaches a height of six metres and forms a closed forest in the middle of the kulhli.

It is suggested that the mangrove community is probably in the early stages of colonisation. This observation is supported by the even distribution of small, four- to eight- leaved *R mucronata* saplings present throughout the shallow embayment at a density of about two per hectare. Given the stability of most of the aforementioned factors, it is considered that a recent increase in the tidal prism is the main factor allowing their colonisation. The shallower water would enable the fruit to settle into the mud on the low tide. This may be a consequence of the new channel through the reef.

The overall impression is that of a mangrove community in the early stages of succession. It is expected that the bay will steadily fill with small mangroves that will grow in size as they accumulate more sediment, should the given scenario continue (ie. the new channel remain open), this factor being considered to be the main limiting factor at this time. This process would be accelerated by any operation that increases sediment loads into the bay, such as land reclamation or dredging without proper controls.

Seagrass

Seagrasses are found in the shallow sheltered waters of the embayment on the southern side of the protected area and also between the eastern shoreline and the reef crest.

7.5. Agriculture

General

The soils of the Maldives are characterised by a lack of balance in the major soil elements. In particular, the high concentration of calcium significantly restricts the productivity or survival of many plant species. The coarse nature of the soils and the lack of humus limit soil water retention. In combination with the poor nutrient regime, the result is low agricultural productivity.

Hithadhoo Protected Area

The soil composition in the Hithadhoo Protected Area is extremely poor, lacking both good structure and nutrients for most crops.

Agricultural activities in the protected area include subsistence farming of green chilli, papaya, tomato, banana, sweet corn and coconut plantations.

Coconut Plantations

The production of coconuts is limited due to poor genetic stock, close planting and a lack of fertiliser use. This status is typical of the Maldives (MoPHRE 1994).

A significantly higher productivity is evident on Villingilli where there are larger quantities of humus and greater species diversity. The relative isolation of that island has most likely led to less harvest pressure.

The value of coconuts and associated products as an export item has declined since the early seventies when prices began a continuing fall (MoPHRE, 1994).

Farming

Farming for local and subsistence purposes is carried out on a small scale with just a single plot near the centre of the site. Crops noted at the time of the survey included corn, tomatoes and chillies. A larger variety and quantity of produce was observed during October and November 2001, prior to and during Ramadan (*counterparts personal comments*).

Bananas growing adjacent to the plot exhibited signs of extreme nitrogen deficiency, in contrast with those in the urban areas of the atoll and in comparison to crops noted on Gan and Villingilli, which showed much greater vigour. This suggests a significant difference in the quality of the soils in this area compared with the area

in general. The continuing practice of burning the cleared re-growth, rather than mulching or composting and re-using it, is having a deleterious impact upon soil fertility and moisture retention.

Regional status

Available land for small crops is limited in Maldives. Access to agricultural land throughout the country is scarce and thus any open area can be considered valuable for production. Hithadhoo has the second highest population of the country outside the capital.

On the nearby island of Gan market gardens are maintained, however, their species diversity and production is limited. There is a potential for the growth of a diverse range of vegetables in the Maldives, as demonstrated by the home garden of M. Rasheed on Gan. This agricultural expansion may present a potential conflict for the protected area in the future.

A survey was undertaken of the soils where cropping occurs at three sites: the Hithadhoo Protected Area, Gan, and Villingilli. It was noted that the depth of soil and the level of humus were significantly higher at the Gan and Villingilli sites compared with the HPA. This may be a result of the longer period of cultivation in the protected area, or that the soils in Gan are intrinsically better. However, the more luxurious growth and greater species diversity exhibited by plants at the Gan sites are suggestive of superior soils.

Gan is a much more logical place to promote agricultural practices for a number of reasons:

- Large available area
- Good quality soils (by atoll standards)
- Large ground water resource for irrigation
- Ready access to inter-atoll transport with the potential for cheap back-load rates
- Good security associated with the airport

Various reports (Butany 1974, Randhawa 1987) have identified the preference for Maldivian men to undertake fishing as an occupation because it has a 'favourable liquidity / cash flow compared to agriculture where the output involves delays, risks, and insecurity' (Randhawa 1987).

The female population now out weighs the male population on the atoll due to movement elsewhere for work. For these reasons, and from observations of

domestic propagation of plants in the atolls and in other countries, it is probable that the women will plant and cultivate crops with a greater degree of care and industry than their male counterparts. It is suggested that women should be targeted or at least included in any proposal to expand agricultural practices, including any training or land allocation activities.

Use of Fertilisers and Pesticides

There is currently little utilisation of fertilisers or pesticides in Addu Atoll. It is considered that this reflects both the level of education in these products and also their relatively high cost. Butany (1974) noted that significant improvements in crop yields could be achieved, particularly through the use of potash, nitrogen and pesticides. There are concerns about the use of fertilisers in such a porous soil. Leaching of much of the fertiliser into the ground water makes such methods expensive. Contamination of the ground water is also an issue as it is the main source of domestic water. The use of holistic cultivation methods such as permaculture to enrich the low nutrient regime and concurrently minimise pest damage should therefore be encouraged if agriculture is to be permitted on the HPA.

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Notes

Vegetation classifications

Structural Communities

The classification system is based on the following procedure:

Table A.1: The minimum quantitative data set required to classify vegetation

Recognise:	Tallest Stratum Mid-stratum (if present) Lower stratum (if present)
Record:	For at least the tallest stratum and lower stratum Structural formation: Growth form Height Crown separation (cover of tallest stratum) Crown type Foliage cover of the lower stratum Emergents (if any)
	Floristic association: Species present (at least dominants)

Table A.2: The basic steps for classification of non-rainforest vegetation:

Growth form of tallest stratum	Crown separation of tallest stratum	--> Formation class (From Table A.3)
Example: Tree	Crowns overlapping	--> Closed forest
Height of tallest stratum	for at least the tallest stratum and lower stratum	--> Height class
Example: 16 metres	Crowns overlapping	--> Tall
Height class	Formation class	--> Structural formation
Example: Tall	Closed forest	--> Tall closed forest
Dominant species in the tallest stratum	Species present (at least dominants)	--> Floristic association
Example: Barringtonia asiatica	Tall open forest	

Table A.3: Structural formation classes defined by growth form and crown separation for woody plants

Crown separation	D	M	S	V	I	L
	Closed or dense	Mid-dense	Sparse	Very sparse	Isolated plants	Isolated clumps
Field criteria	Touching - overlap	Touching - slight separation	Clearly separated	Well separated	Isolated	Isolated
Crown separation ratio	< 0	0 - 0.25	0.25 - 1	1 - 20	> 20	> 20
Growth form	Structural formation classes					
T Tree	Closed forest	Open forest	Woodland	Open woodland	Isolated trees	Isolated clump of trees
S Shrub	Closed shrubland	Shrubland	Open shrubland	Sparse shrubland	Isolated shrubs	Isolated clump of heath shrubs

Table A.4: Structural formation classes for ground covers

Crown class	D	M	S	V	I	L
	Closed or dense	Mid-dense	Sparse	Very sparse	Isolated plants	Isolated clumps
Foliage cover	> 70	30 - 70	10 - 30	< 10	< 1	< 1
Growth form	Structural formation classes					
G Tussock grass	Closed grassland	Grassland	Open grassland	Sparse grassland	Isolated grassland	Isolated clumps of grass
V Sedge	Closed sedgeland	Sedgeland	Open sedgeland	Sparse sedgeland	Isolated sedgeland	Isolated clumps of sedges
R Rush	Closed rushland	Rushland	Open rushland	Sparse rushland	Isolated rushes	Isolated clumps of rushes
L Vine	Closed vineland	Vineland	Open vineland	Sparse vineland	Isolated vines	Isolated clumps of vines

Table A.5: Growth form

T	Tree	Woody plant more than 3 m tall with a single stem or branches well above the base
S	Shrub	Woody plant multi-stemmed at the base (or within 200 mm of the ground), or if single-stemmed, less than 3 m.
G	Tussock grass	Forms discrete but open tussocks usually with distinct individual shoots, or if not, then not forming a hummock. These are the common agricultural grasses.
H	Hummock grass	Coarse xeromorphic grasses with a mound-like form in the middle.
D	Sod grass	Grass of short to medium height forming compact tussocks in close contact at their base and uniting as a densely interfacing leaf canopy.
V	Sedge	Herbaceous, usually perennial, erect plant generally with a tufted habit and of the families Cyperaceae and Restinaceae.
R	Rush	Herbaceous, usually perennial, erect plant. Rushes are grouped in the families Juncaceae and Restinaceae, and the genus Lomandra.

Table A.6: Height classes and names for various growth forms

Class	Height (m)	Trees, vines, palms	Shrubs	Tussock and hummock grasses, rushes, sedges, ferns	Sod grasses, mosses, lichens, liverworts
9	> 35.01	Extremely tall	NA	NA	NA
8	20.10 – 35	Very tall	NA	NA	NA
7	12.10 – 20	Tall	NA	NA	NA
6	6.01 – 12	Mid-high	Extremely tall	NA	NA
5	3.01 – 6	Low	Very tall	Extremely tall	NA
4	1.01 – 3	Dwarf	Tall	Very tall	NA
3	0.51 – 1	NA	Mid-high	Tall	Extremely tall
2	0.26 – 0.5	NA	Low	Mid-high	Tall
1	< 0.25	NA	NA	Low	Low

Thus T7M/T6S/S4V/G3S = Tall open woodland / with a mid-storey of medium-high woodland / a tall and open shrubland / and a tall sparse grass cover.

PROTECTED AREA OF S.HITHADHOO:

ZONING AS A MANAGEMENT TOOL

1. INTRODUCTION

1.1. Background

The paper is the proposal for establishing a zoning plan for the Hithadhoo Protected Area (HPA) which will be based on multiple uses that currently exist inside the protected area boundary. As important aspects of this proposal, the paper identifies the main issues that will be taken into account during re-zoning of HPA and also identifies how the effectiveness of zoning will be evaluated during management of HPA.

Before proposing zoning plan for the HPA, the paper gives background information on HPA found in Addu Atoll, Maldives. In addition the main issues with regard to HPA management, the management plan, existing zoning scheme and the main issues relating to the current zoning are identified.

1.2. Aims and Objectives

The primary objective of this paper is to propose a zoning plan for the Hithadhoo Protected Area. The main reason for undertaking a zoning plan for HPA is that the current IUCN Protected Area Categories proposed for HPA does not take into consideration of the multiples uses of the Hithadhoo community within the boundary of the Protected Area. Therefore, an important objective of this paper is to propose a zoning plan that incorporates important uses of the community.

2. BACKGROUND TO HITHADHOO PROTECTED AREA

2.1. General Setting and Locality of HPA

Hithadhoo Island is found in Addu Atoll, which is the southern most atoll found in the country (Figure 1). Addu Atoll is isolated at latitude 0o38' south and separated from the nearest northern atoll (Fuahmulaku Atoll) by the deep Equatorial Channel, which is 45nm in length and the nearest southern atoll is Salomon, approximately 320nm further south and part of the Chagos Archipelago, which is not part of the Maldives administrative area (Dews, Quinn and Hameed, 2002). Thus, Addu Atoll is relatively isolated in terms of ecological influence.

The Hithadhoo Protected Area is located on the northern end of the Island, which is locally known as Eidhigali Kulhi and Koattey (Figure 2). The area encompasses the top section of the island and extends offshore around the peninsular to include fringing reefs and islands and extends 2km offshore to capture all the coral reefs found around the area (MPAS, 2000a).

Figure 1: Map of Maldives locating Addu Atoll and map of Addu Atoll locating the HPA

Figure 2: Location of HPA within the Hithadhoo Island

2.2. Biophysical Environment

The area is of conservation significance as it contains regions of relatively open forest, mangrove forest, healthy coral reefs, well-developed Kulhi (shallow, brackish water pond) and seagrass meadows.

Eidhigali Kulhi is located on the northwestern corner of Hithadhoo Island, more towards the seaward side of the island that is formed as an arc-like shape having approximately 1.2 km in its length and 150m in its width (MPAS, 2000b). The Kulhi all around have healthy vegetation (AMSAT, 2002a). In shallower parts of the kulhi, small amounts of vegetation particularly *Suriana maritima* was observed as island-like clumps (MPAS, 2000b).

Ecologically, the site is highly significant. The area is used by a number of bird species as a feeding and resting ground. Large numbers of Eastern gray herons, *Ardea cineria rectrostris* and the endemic Maldivian pond heron, *Ardeola graii phillipsi* occur in the area (MPAS, 2000b; MPAS, 2001). This area is perhaps the largest breeding, feeding, nesting and roosting ground for the Eastern grey heron and the Maldivian pond heron that currently exists in the country (MPAS, 2000b). A freshwater fish *Thillapia* occurs in the kulhi and large shore crabs and mollusks are known to occur on the northern side (MPAS, 2000b).

Healthy coral reefs are distributed across the northern and north-eastern side of the area. Initial field surveys reveal that the coral reefs found in the area is one of the healthiest and most diverse coral reefs found in the country having 50-70% live coral cover and a great diversity of reef fish (MPAS, 2000b and AMSAT, 2002b). Combined with the diversity of coral reef and occasional sightings of marine mammals particularly the melon-headed whales in great numbers (>1,000) make the marine environment highly significant (MPAS, 2000b; MPAS, 2001).

2.3. Socio-economic Environment

The area is used for agriculture mainly for coconut harvesting, vegetables and the collection of traditional medicines. Collection of wood for fuel and the gathering of coral rubble and sand at a household scale also occur within the area (Dew *et al*, 2002). The area is a recreational area for the local community and some boating activities and shore-based fishing occurs within the boundaries. The near shore areas, including the coral reefs, are used by tuna fishermen for bait fish collection using light attractants and lift nets while anchoring on the reef (Dews *et al*, 2002).

Currently, a tourist resort is found on Gan Island (south of Addu Atoll) and

recreational diving occurs within the area and a large tourist resort (1,500 beds and the largest resort in the country) is currently under construction on Villingili Island also situated on the southern periphery of the Atoll (MPAS, 2001; Dews *et al*, 2002).

Koattey is found on the northeastern tip of Hithadhoo. The area is also mostly covered with healthy vegetation. The remains of the old Fort are located in the area. This site is one of the important historical and archaeological sites found in Addu Atoll (MPAS, 2000b).

2.4. Management Issues of HPA

The community found in Hithadhoo Island is a large community comprising of a population of around 12,000 (MPAS, 2000b). The Edhigali Kulhi and Koattey area has a number of uses. Some of these uses may not be compatible within the protected area once the area as been officially endorsed, as these uses may adversely affect the protected area.

Based on a number of field visits to the site, following are the major issues that are associated with the HPA (MPAS, 2000b). They are;

- Large areas around the site including the Kulhi are used as a solid waste dumping site by the adjacent community, which has been identified as the major threat to the site. The main sources has been identified are the household waste and waste due to recreational use by the community
- The coastal areas found on the north-eastern side are heavy used for coral rubble and sand mining by the local community. Although this activity is not undertaken at a commercial scale, continuation of this activity may damage the physical barrier that protects the Kulhi from inundation.
- Access by vehicles to the area causing damage to the local vegetation
- Practice of unsustainable agriculture within the area
- Capture and collection of birds from the area

With regards to appropriately managing the site as a protected area, the above issues need to be addressed so that long-term protection and conservation of the area can be ensured.

2.5. HPA Management Plan

According to the Management Plan, the management objectives of the HPA are (MPAS, 2002);

- To protect the conservation values (flora and fauna) of the HPA from adverse human use
- To protected and enhance the important habitat that support conservation values
- Management activities that have the potential to impact on the things that are important to HPA
- To allow for a range of recreational and commercial activities in the HPA so that they do not conflict with the above objectives
- To identify, manage and present cultural values where appropriate
- Monitor the progress of the protected area through regular surveys of birds, vegetation, reefs and fish
- Involve the community in all levels of management, and
- To manage the HPA so that it supports the preservation of the natural resource for all Addu Atoll

In terms of achieving the above-stated management objectives for the HPA, a protected area management arrangement has been devised, which involves a management structure for the HPA.

The Management Plan developed for the HPA suggests that the protected area should be managed by the Hithadhoo Island Community and proposes a management structure for the protected area. It is suggested that the Addu Atoll Office will undertake the implementation of the HPA management, which is the top government representation at atoll level through active participation of the Hithadhoo Island Community. At policy level, the management will be directed by the involvement of various government stakeholders such as the Environment Ministry, Atolls Ministry and Planning Ministry (MPAS, 2002).

The day-to-day management activities has been suggested to be undertaken through a Protected Area Management Committee, chaired by the Atoll Chief and the suggested makeup of such a committee includes representatives of various stakeholder groups, such as the Island Offices, Women's Development Committee, fishermen, business groups, agricultural lease holders, Island Development Committee, NGOs and elders (MPAS, 2002).

2.6. Existing Zoning Plan

Currently there is no zoning plan as such established for the HPA. However, the HPA is currently zoned for Category II National Parks and Category V Protected Landscape/Seascape consistent with the IUCN protected area management categories with regards to undertaking effective management that incorporates conservation and recreation (Figure 3).

Figure 3: Existing HPA categories

2.7. Main Issues with Existing Zoning Plan/PA Categorization

Based on a number of field surveys, assessments and consultations undertaken on the site during the planning stages of HPA, a number of uses by the local community have been identified including; sand and rubble mining along the northern coast of HPA, subsistence agriculture such as coconut harvesting and small-scale production of agricultural products for local use, reef fishing and bait netting along the eastern reef (Figure 4) (MPAS, 2000b).

Due to the enforcement of IUCN protected area categories II and V throughout

the whole HPA (Figure 3), some of the uses identified above that the community has some dependency may not be undertaken since the management objectives of these categories mainly concentrate on resource and habitat conservation and recreation.

The current PA categorization needs to either change or incorporate to some extent the current uses of the community within the HPA. In this regard community support and involvement can be strengthened throughout the management of the HPA since modern protected areas concentrate on balancing human uses with conservation.

Since there is no user-related zoning developed for the site as to know what areas can be used and to what extent these activities can be undertake, this refrains the community to continue the uses they have been undertaking for years. As a result of this, the community may not support or may not involve in the management of HPA. Therefore, it is necessary that a zoning plan has to be developed after community consultation in terms of identifying to what extent they would agree to limit some of the activities they have been undertaking within HPA.

Also, the other issue is that because their uses have not been reflected on the current PA categorization, encroachment and continuation of some of the destructive uses may increase, which may have difficulties in achieving the management objectives of the HPA.

Figure 4: Current land uses within the HPA

3 PROPOSAL

3.1. Establishing a New Zoning Plan for HPA

According to Day (2002), over the last 25 years a range of management tools, including zoning plans, permits, education, and more recently management plans, have been applied to regulate access and to control and mitigate impacts associated with human use of the GBRMP. He also stated that a multiple-use zoning approach provides high levels of protection for specific areas whilst allowing reasonable uses, and zoning has long been regarded as a cornerstone of marine park management, separating conflicting uses through application of the various zones and determining the appropriateness of various activities.

Thus, a zoning mechanism may effectively work in HPA where certain activities can be separated and the magnitude of certain activities undertaken can be divided into certain zones so that conflicts between resource uses such as fishing and recreation as well as activities that has physical impacts on the protected area such as coral rubble and sand mining can be controlled effectively.

A map has been developed proposing zones where appropriate uses can be undertaken within the HPA. The map is based on the activities that have been identified during the initial planning stages of HPA and activities that currently exist within. The user-related zoning plan proposed for HPA also identifies ecologically significant habitats which will have a number of management restrictions (Figure 5). An activity table has been followed indicating what activities can be and cannot undertaken, what activities require permission, what activities can be continued and what activities have been banned from continuation (Figure 5).

Figure 5: Proposed zoning for the HPA and Activity Table

PROPOSED ZONING PLAN FOR HITHADHOO PROTECTED AREA

Activities	General Use Zone	Recreation Zone	Sustainable Agriculture Zone	Buffer Zone	Preservation Zone
Waste dumping	No	No	No	No	No
Vehicle access	No	No	No	No	No
Sand and rubble mining	Limited	No	No	Permit	No
Bait netting	Yes	No		Limited	No
Reef fishing (local)	Yes	Limited		No	No
Agriculture			Yes	No	No
Boating	Yes	Yes		No	No
Diving/snorkeling	No	Yes		No	No
Collection (birds)	No	No	No	No	No
Collection (corals)	No	No		No	No
Reseach	Yes	Yes	Yes	Permit	Permit
Education	Yes	Yes	Yes	Yes	Yes

3.2. Management Objectives for the Proposed Zones

With regards to appropriately managing the protected area and implementing and enforcing management restrictions on particular zones, it is essential to identify the management objectives for the proposed zones. These include;

General Use Zone - To provide for the reasonable general use consistent with the conservation objective of the protected area

Recreation Zone - To provide for the protection of areas of the protected area while allowing opportunities for their appreciation and enjoyment by the public, free from activities that remove natural resources

Sustainable Agriculture Zone- To provide opportunities for sustainable agricultural practices that does not deteriorate the biophysical environment and respects the conservation objective of the protected area

Buffer Zone - To provide for the protection of the HPA while allowing opportunities for authorized activities to be carried out free from disturbance from other human activities

Preservation Zone - To provide for the preservation of areas of the HPA in their natural state undisturbed by human activities.

3.3. Important Aspects that Need to be Considered

The above zoning scheme is only proposed and is subject to review. The main reason for developing a zoning scheme for the HPA is that it currently lacks a proper zoning plan where the local community can exercise their uses under certain management restrictions in order to achieve the management goal of the protected area. With regards to the above proposed zoning, following is a list of important aspects that need to be considered.

- Large-scale public consultation, involvement and participation in reviewing and approving the proposed zoning scheme
- Undertaking of public awareness and education programmes with regards to promoting the proposed zones
- Mechanism to review implementation of the zoning objectives with participation from all the relevant stakeholders

- Manage human activities in a structured way within the HPA boundaries.
- Develop management of the HPA-related resources based on long-term resource protection and sustainable utilization. Twenty-five years has been the most frequently used planning time-scale.
- Make the aims and goals within the site boundary clear from the earliest stages.

The review of zoning plans and performance should be conducted at intervals short enough for management to respond to problems but not so frequent that it becomes prohibitively expensive – five to seven years is often a suitable period.

Ministry of Environment, Energy and Water
Malé, Republic of Maldives